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ISFT2022 & 2nd RUSiCON

August 16th - 19th, 2022 | Nonthaburi, THAILAND

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The Engineering Institute of Thailand Under H.M. The King's Patronage (EIT)
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Mechanical Engineering (ME)

Off-Line Contaminant Monitoring Sensor Evaluation for Used Lubricating Oil Analysis

Sontinan Intasonti[1*] and Surapol Raadnui[1]

Abstract

It has long been known that the presence of solid contaminants in lubricating oil, whether in a form of wear particles or ingested from the environment are inevitable. The main approach of "before failure" diagnosis or prognosis of the oil-lubricated machinery is to detect lubricant degradation in situ the oil circulating system i.e., additive depletion, physical & chemical oil properties, degradation and solid wear particle generation or dirt ingression. In this particular paper, a solid debris monitoring sensor for used oil monitoring is assessed. The sensor working principal is to measure for the variation of the electrical capacitive responses caused by moisture and solid particles namely dirt and wear particles. The quantitative assessment of this specific sensor is statistically quantified through the utilization of full factorial design of experiment (DOE). The main and interaction effect of moisture, dirt and wear particles on the electrical field response is anticipated.

Keywords: Contaminant monitoring sensor, Full factorial experimental design, Used lubricant degradation

Introduction

Lubricant is a very important component of tribosystems, so its condition and degradation are crucial variables of efficiency and state of the whole machine. Oil analysis may be defined as a routine activity for analyzing oil health, oil contamination and machine wear. It is concerned with a lubricated machine [which] is operating according to expectations. When an abnormal condition or parameter is identified through oil analysis, immediate actions can be taken to correct the root cause or to mitigate a developing failure [1]. Gill oil condition sensor has developed a ferrous particle sensor, which has been utilized in condition monitoring the health of gearbox transmission systems of land-based vehicles, to detect the ferrous wear particles in used lubricating oil [2]. Murali et al. have presented a device for detecting and counting micro metal wear particles in nonconductive lubricating oil inspired by the coulter counting principle, an established technique for counting and sizing debris in an electrolyte solution [3]. In an attempt to distinguish ferrous and non-ferrous metal particles in lubrication oil as well as to eliminate the influences caused by air bubbles and moisture, inductive sensors based on 3-D solenoid coils were designed. The inductance change of the sensor is determined by two variables, namely magnetic permeability and electrical eddy current [4-5]. The acoustic detection method uses single or dual ultrasonic transducers to radiate a large amplitude radio frequency pulse and receive the echoes generated by the wear particle in the flow stream. Solid particle size can be obtained based on the echo signal's amplitude; the larger the amplitude, the larger the particle size. The main advantage of the acoustic detection method is that it is capable of detecting and discriminating solid particle from air bubble [6–8]. Hamilton et al. [9] created a wear particle image system to detect the wear particle morphological analysis. It consists of a light source, a flow channel, and a high-speed web camera. The light source is used to illuminate the flow channel; the webcam constantly

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takes images with a high speed as lubricant with wear particle passes the light source. These images are then processed with MATLAB to get individual wear debris characterization, which are critical to identify wear modes. Wu et al. also developed a similar system to extract the characteristics of wear debris particles [10]. Accordingly, lubricant is a vital source of information in the defect avoidance technique, similar to the importance of human blood in disease detection and prevention. Since lubricant is an essential machinery component in any industry, any fault in the lubricant may result in machine downtime and loss of output. Therefore, this causes problems in the industry This paper presents the new alternative technique using capacitive proximity sensor to measure the contaminant in lubricant. In this particular work, the performance of this specific sensor is assessed systematically through the utilization of statistical design of experiments (DOE). The purpose of this study is to analyze the used lubricant of any abnormal condition such as contaminant ingression, generated wear debris. The sensor response value of the used lubricant will be monitored in a timely manner.

Methodology

The sensor is capacitive proximity sensor. The construction of which is shown in Figs. 1–3, The sensing surface of a capacitive sensor is formed by two concentrically shaped metal electrodes of an unwound capacitor. When an object nears the sensing surface it enters the electrostatic field of the electrodes and changes the capacitance in an oscillator circuit. As a result, the oscillator begins oscillating. The trigger circuit reads the oscillator's amplitude and when it reaches a specific level the output state of the sensor changes. As the target moves away from the sensor the oscillator's amplitude decreases, switching the sensor output back to its original state. Capacitive sensors depend on the dielectric constant of the target. The larger the dielectric number of a material the easier it is to detect. The capacitance of the sensor can be expressed as follows:

$$C = \varepsilon_0 \varepsilon_v A / \delta \qquad (1)$$

where ε_0 is dielectric constant in the vacuum, ε_v is dielectric constant of the oil between two poles, A is the available area of poles and δ is the distance between two poles. Because ε_v, A, and δ are constant in the sensor, the capacitance of the sensor is determined by ε_v, while the voltage is loaded between the emission pole and the detecting circuit is proportional to the capacitance of the sensor [11].

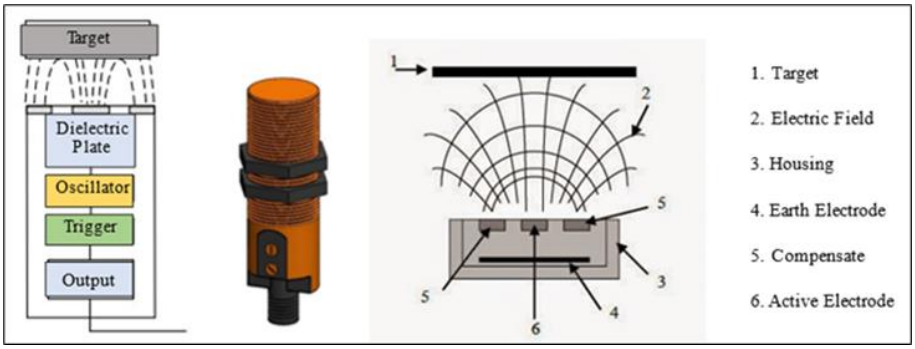


Figure 1 component of the sensor.

In this particular work, the LR Device software is used throughout. In this context, the value readout from the measuring apparatus is directly related to the input concentration. Contamination in lubricant was measured using the NAS 1638 standard by counting the number of particles and dividing the level of contamination into 14 degrees

ranging from NAS 00 to NAS 12. Each degree step increased the number of particles by a factor of two. Table 1 shows how extrapolation can be used to calculate the level of contamination that exceeds level 12 [12].

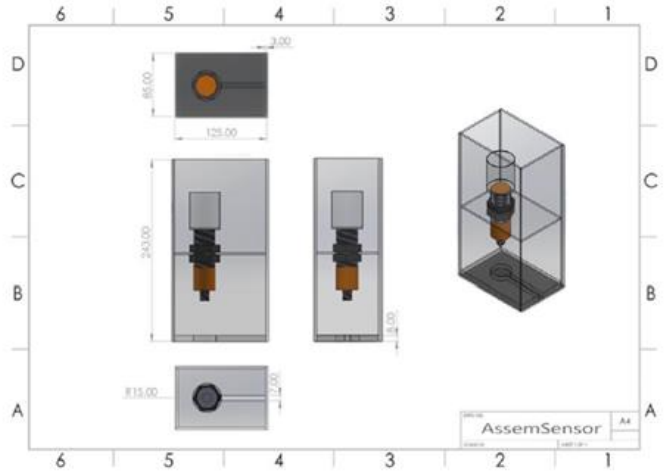


Figure 2 Drawing of capacitive sensor.

Table 1 Weight contamination standard NAS 1638.

Contamination degree	12	13	14	15	16	17	18	19	20	21
mg/25ml	1.25	2.5	5	10	20	40	80	160	320	640
parts per million (ppm)	50	100	200	400	800	1600	3200	6400	12800	25600

Measurements of the sensor response value of oil samples have been preliminary made which show the variation range of the concentration from NAS 12 up to the weight of contaminants in the oil at 1 gram per 25 milliliter or 40,000 parts per million (each measurement was repeated 20 times), in relation to the input variables such as ferrous particles, brass particles, SiO_2 particles and water contamination, as shown in Fig. 6. In addition to the assessment, the design of experiments (DOE) conducted on four kinds of cause variables, namely: ferrous particles, brass particles, SiO_2 particles and water contamination, at two levels of each factor.

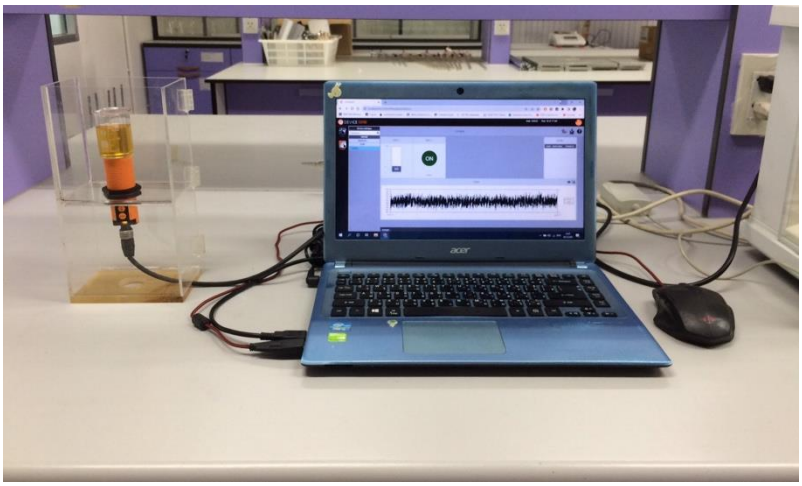
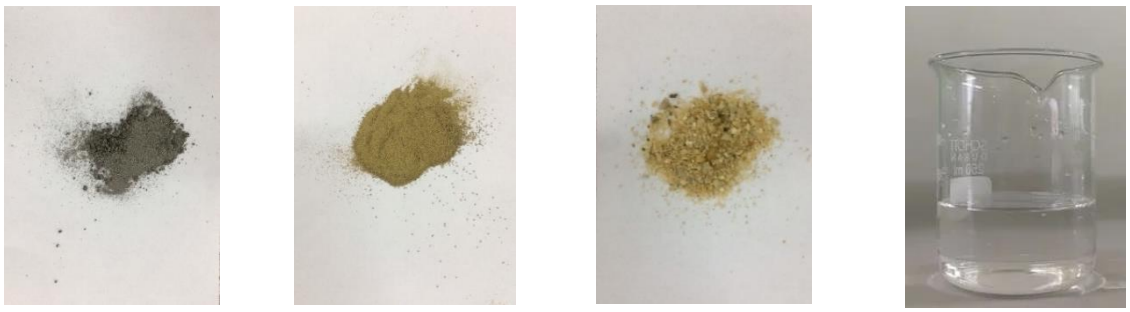


Figure 3 The complete set of a sensor is connected to the computer.

Table 2 Characteristics of cause variable used in this research.

	Ferrous	Brass	SiO_2	Water
Specific gravity	7.9	8.6	2.2	1
Hardness (HB)	> 100	≤ 75	820 (HK)	-
Conductivity (μS/m)	10.1	15.9	-	5
Dielectric constant	14.2	-	4.5	80

Table 2 lists the properties of ferrous, brass, SiO_2 and water. Fig. 4(a), (b), (c) and (d) show typical solid particles and moisture used. Fig. 5 illustrates particle images used in the tests.



(a) Ferrous particles (b) Brass particles (c) SiO_2 particles (d) Water contamination

Figure 4 Solid particles and moisture used in this work.

Figure 5 Typical images of solid (a) Ferrous particles, (b) Brass particles, (c) SiO_2 particles particles used in this study.

Details for each cause variables are summarized in Table 3. In Table 4, Test no.1–16 indicate the conditions of simulated lubricants for each test/measurement. Using a full factorial design is especially efficient for determining important parameters, which have an effect on the dielectric constant/sensor response value. The efficiently of an experiment can be increased by using an experimental method which has been designed as a tool for determining the unimportant parameters and, thus, determining the sensor performance.

Table 3 Detail structure of cause variables for full factorial design.

Cause variable	Level 0	Level 1	Remarks
Ferrous particles (F)	None	1g/25ml	Particle size range <300 µm
Brass particles (B)	None	1g/25ml	Particle size range <300 µm
SiO_2 particles (S)	None	1g/25ml	Particle size range <300 µm
Water contamination (W)	None	1g/25ml	-

Note: SAE 10W30 engine oil is used throughout the test.

Table 4 Experimental design and results of experiments.

Test no.	Input parameters				Output parameter of sensor response value		
	Ferrous particles	Brass particles	SiO_2 particles	Water contamination	First replicate	Second replicate	Third replicate
1	0	0	0	0	430.45	435.60	433.90
2	0	0	0	1	531.90	529.90	534.60
3	0	0	1	0	467.90	465.60	472.25
4	0	0	1	1	596.95	593.95	595.00
5	0	1	0	0	469.75	467.55	467.15
6	0	1	0	1	580.90	581.70	583.00
7	0	1	1	0	495.25	487.85	490.00
8	0	1	1	1	621.20	611.05	620.90

Table 4 Experimental design and results of experiments. (Continue)

Test no.	Input parameters				Output parameter of sensor response value		
	Ferrous particles	Brass particles	SiO_2 particles	Water contamination	First replicate	Second replicate	Third replicate
9	1	0	0	0	477.05	479.00	474.40
10	1	0	0	1	582.00	583.15	583.45
11	1	0	1	0	503.60	504.00	503.00
12	1	0	1	1	632.60	633.95	627.85
13	1	1	0	0	501.85	504.10	498.40
14	1	1	0	1	602.20	604.90	603.85
15	1	1	1	0	521.35	523.15	517.10
16	1	1	1	1	616.95	621.90	617.05

Results and discussion

The plot graph shows the occurrence of a progressive increase in sensor response values. From the plot presented in Fig. 6, it can be seen that the variation of output from the sensor can be initially assessed from 0.001 g/25ml (40 ppm) of contamination onwards, as demonstrated in the plot. In comparison to the NAS 12 range, the system created can efficiently assess the contamination level of solid particles and moisture in lubricant based on the specified standard. Response values increased with addition of concentrations.

The most crucial advantages of using mathematical statistics in the study of complicated technical systems are, among others, the reduction in experimental expenditure and the determination of unknown phenomena enabling to conduct systematic subsequent examination. The experiments were carried out using full factorial designs, which varied the level of four main cause variables of the sensor response value.

A full factorial of four contaminant variables were considered in the DOE. Each contaminant variable was tested at two levels. A total of 16 samples were carried out. Minitab 17 statistical software was used for the test result analysis.

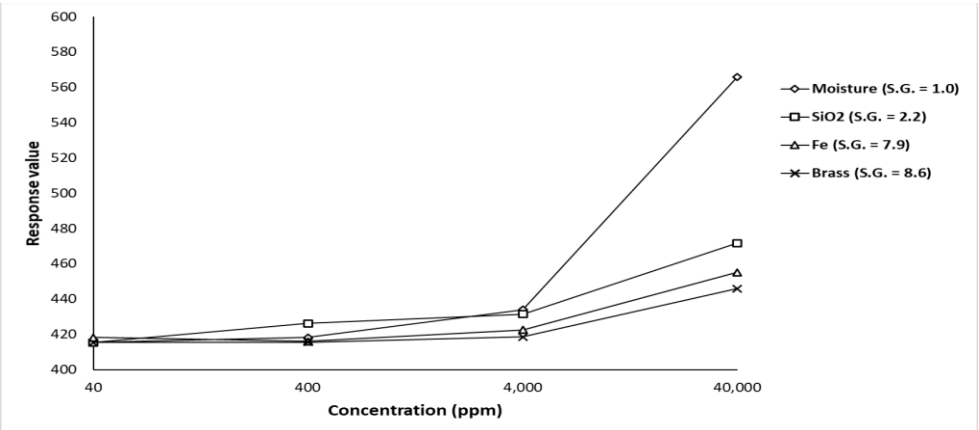


Figure 6 Plot of sensor response value vs. concentration of moisture and solid particles.

The plots of main and interaction effects between cause variables are shown in Figs. 7-9, respectively. In addition, the analysis of variance (ANOVA), as shown in Table 5, was used to assess the significant of the factor main effects and factor interaction effects. The changing the increasing contaminant significantly increased the sensor response value in all cause variables. ANOVA analysis was performed for a level of significance of 5% and for a confidence level of 95%. The level of significance indicates a level of 5%. P value given in Table 5 indicates the level of factor influence, which is 0.05 for a level of significance of 5%. When the P value is less than 0.05, the corresponding factor has a greater influence on the sensor response value. Table 5 shows the model summary of this research investigation. In the last row of Table 5, the r-sq value is predicted as 99.71% and r-sq value is 99.87%.

Table 5 Analysis of variance for three replicates.

Source	DF	Adj SS	Adj MS	F-Value	*P*-Value
Model	15	187708	12514	1650.77	0.000
Linear	4	183077	45769	6037.67	0.000
F	1	11799	11799	1556.41	0.000
B	1	6009	6009	792.65	0.000
S	1	13322	13322	1757.33	0.000
W	1	151948	151948	20044.28	0.000
2-Way Interactions	6	3751	625	82.48	0.000
F*B	1	1196	1196	157.71	0.000
F*S	1	428	428	56.47	0.000
F*W	1	188	188	24.78	0.000
B*S	1	1229	1229	162.08	0.000
B*W	1	66	66	8.76	0.006
S*W	1	645	645	85.08	0.000
3-Way Interactions	4	856	214	28.24	0.000
F*B*S	1	0	0	0.06	0.809
F*B*W	1	442	442	58.3	0.000
F*S*W	1	100	100	13.18	0.001
B*S*W	1	314	314	41.41	0.000
4-Way Interactions	1	23	23	3.02	0.092
F*B*S*W	1	23	23	3.02	0.092
Error	32	243	8		
Total	47	187950			
S = 2.75329, R-sq = 99.87 %, R-sq(adj) = 99.81 %, R-sq(pred) = 99.71%					

From the main effects plot in Fig. 7, it has been observed that when ferrous particles, brass particles, SiO_2 particles and water contamination increases the sensor response value increases. This may be associated with increase the level of contaminants in the oil, which causes for the lubricant degradation increases. It has been also noted that the sensitivity of water contamination for sensor response value is relatively higher than the other parameter.

Table 6 Response table of sensor response value SN Ratio.

Level	Ferrous particles	Brass particles	SiO_2 particles	Water contamination
1	54.31	54.39	54.31	53.67
2	54.84	54.76	54.84	55.49
Delta	0.52	0.38	0.54	1.82
Rank	3	4	2	1

Table 6 shows the table of sensor response values with certain limits. Fig. 8 shows the SN ratio graph for the sensor response values. From the table, Water contamination is the best ranking contaminant compared with other three parameters. From the graph plot, it is clearly explained that the maximum value will be allotted for Water contamination, followed by SiO_2 particles, Ferrous particles and Brass particles have minimum value.

The interaction effects plot is shown in Fig. 9 for sensor response value. The plots provide the mean response of two factors at all possible combinations of their settings. If the lines are not parallel, it is an indication of interaction between the two factors [13-14]. From the interaction plot in Fig. 9, Interaction between factors F&B, F&S, F&W, B&S, B&W and S&W have a significant effect on the response value.

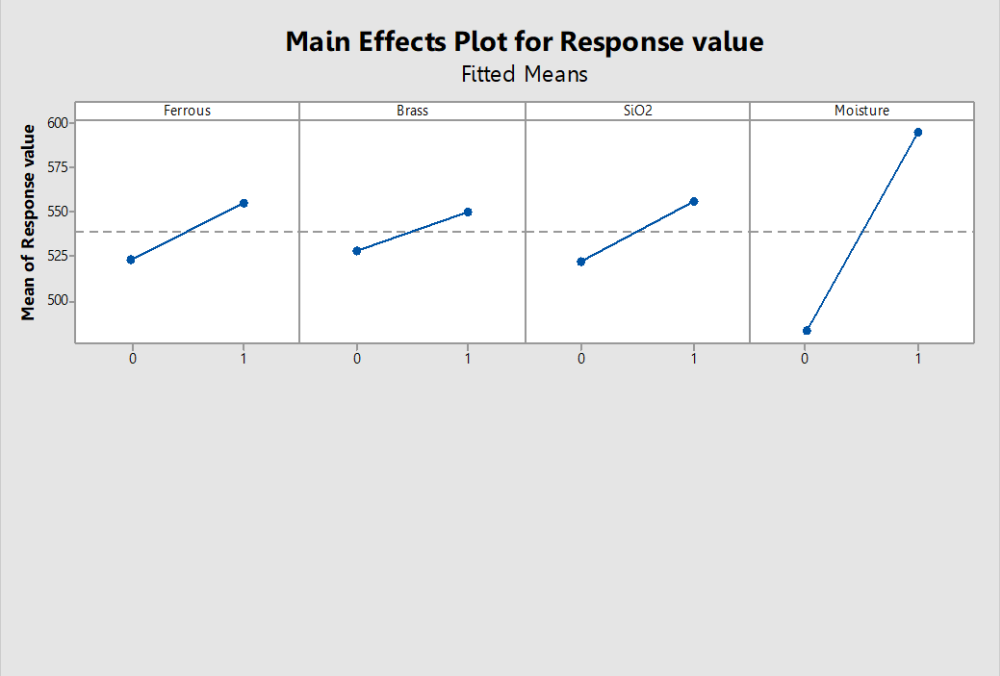


Figure 7 Main effect plots of the cause variables.

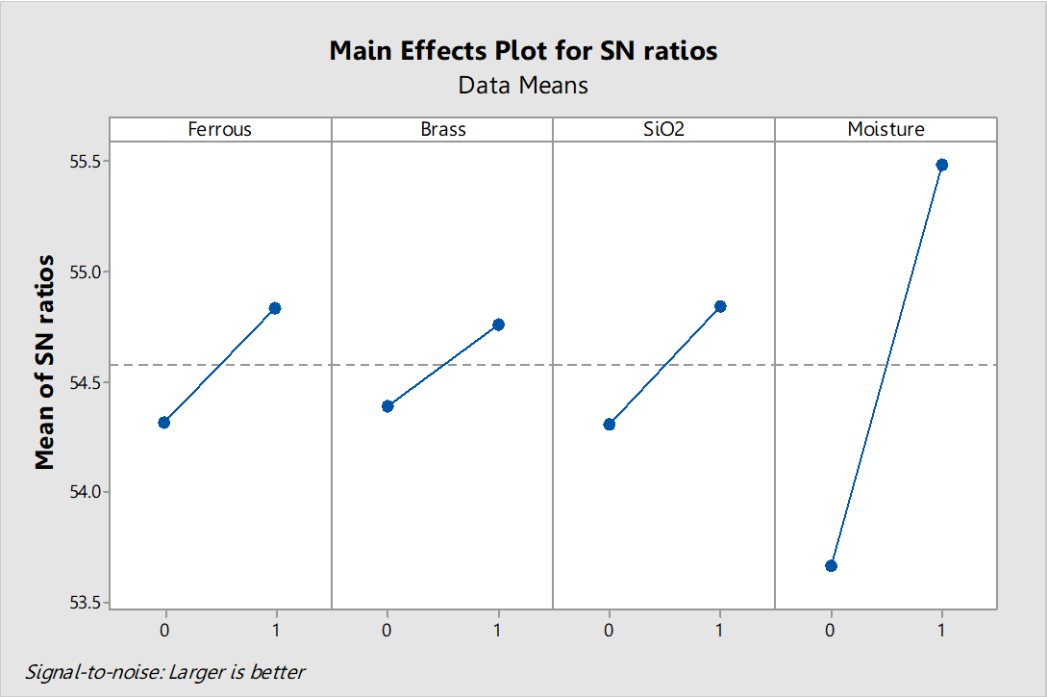


Figure 8 Graph plot of SN ratio for full factorial design.

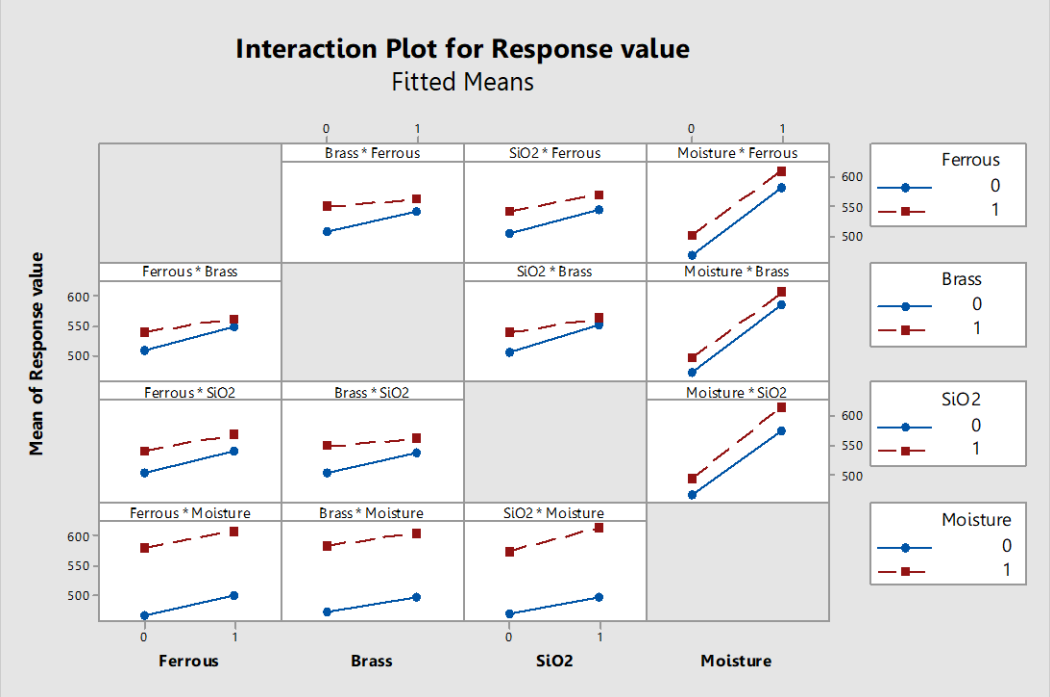


Figure 9 Interaction plots between cause variables.

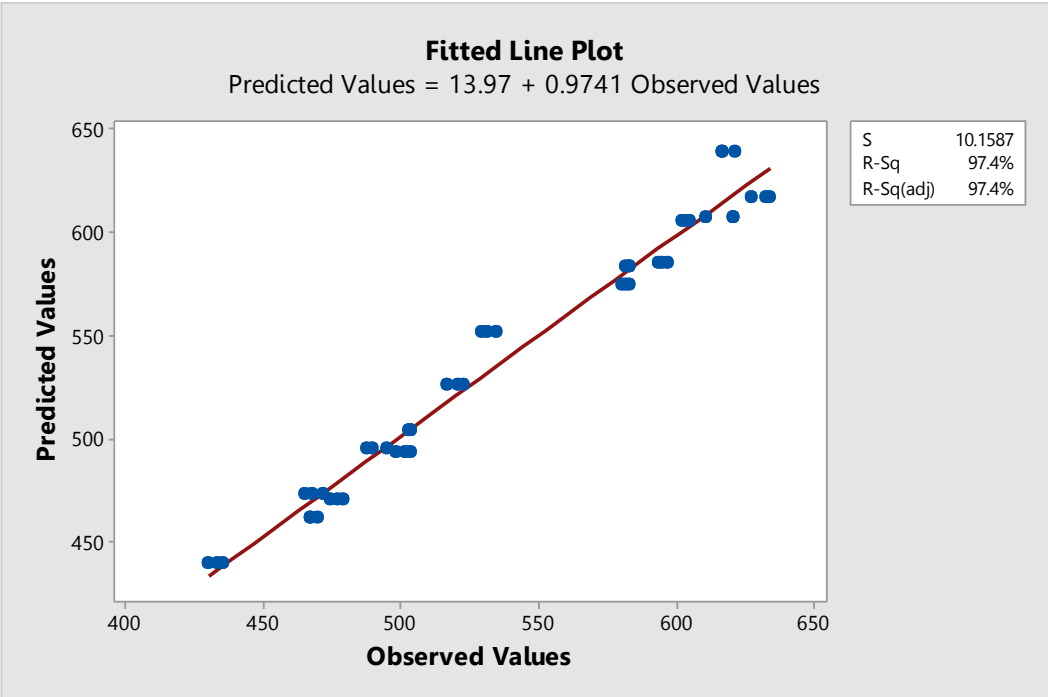


Figure 10 Fitted Line: Predicted Values versus Observed Values

To establish the correlation between the contaminant parameters (ferrous particles, brass particles, SiO_2 particles and water contamination) and the lubricant degradation (sensor response value), multiple regression models were developed using statistical software Minitab 17. Only the terms that are statistically significant are included in the model. The obtained regression equation is as follows:

Sensor response value (R) = 439.40 + (31.36) * Ferrous particles (g/25 ml)
+ (22.38)* Brass particles (g/25 ml)
+ (33.32)* SiO_2 particles (g/25 ml)
+ (112.53)* Water contamination (g/25 ml) (2)

The sensor response value can be calculated by substituting the values of the variables into Eq. (2). The positive value of the co-efficients suggests that the response value increases with their associated variables. The magnitude of the variables indicates the weightage of each of these factors. It is observed from Eq. (2) that the water contamination is the major governing factor on the sensor response value.

Fig.10 demonstrates the observed and predicted values of the sensor response value for the 16 experiments. From these figures it is observed that there is considerable linearity in the relation between the predicted and observed values of sensor response value. The regression equation for predicted values is shown in Eq. (3).

Predicted Values = 13.97 + (0.9741)*Observed Values (3)

Table 7 Result of conformation and their comparison with regression.

Run order	Ferrous particles	Brass particles	SiO_2 particles	Water contamination	Response value	Predicted response value	% Error of response value
1	0	0	0	0	422.30	439.400	4.049
2	0	0	0	0.5	458.60	495.665	8.082
3	0	0	0.3	0	427.10	449.396	5.220
4	0	0	0.6	0.8	509.45	549.416	7.845
5	0	0.5	0	0	439.05	450.590	2.628
6	0	0.7	0	0.4	488.70	500.078	2.328
7	0	0.4	0.5	0	446.40	465.012	4.169
8	0	0.6	0.9	0.7	546.35	561.587	2.789
9	0.3	0	0	0	438.45	448.808	2.362
10	0.5	0	0	0.3	459.35	488.839	6.420
11	0.7	0	0.4	0	451.75	474.680	5.076
12	0.8	0	0.5	0.3	471.30	514.907	9.252
13	0.2	0.4	0	0	433.80	454.624	4.800
14	0.7	0.6	0	0.2	484.85	497.286	2.565
15	0.3	0.7	0.8	0	495.35	491.130	-0.852
16	0.4	0.8	0.9	0.1	490.60	511.089	4.176

A number of test cases were used to validate the regression equations developed for predicting response value. The results of these validity tests are presented in Table 7. The percentage error for responses has been observed to be less than ± 9%. This indicates that the predicted and measured results are in close agreement, as well as the adequacy of the regression model.

Conclusion

The following conclusions can be drawn from this research:

1. The sensor in this work can distinguish the relative variation of lubricant quality caused by simulated contaminants such as ferrous particles, brass particles, SiO_2 particles and water contamination. with significant degree of confident.

2. From Regression data summary, the R-square value is predicted as 99.71% and R-square value is 99.87%.

3. The development of an early failure detection sensor lays the groundwork for assessing used oil condition synthetically. Correlating the oil condition from the sensor output readout for condition monitoring of the oil-lubricated tribological system is of positive present significance.

4. Future research will be required to evaluate other simulated cause variables, such as other metal particles, physical and/or chemical changes. Actual used oil samples from various phases of the oil life cycle must be evaluated with the sensor developed before it can be used in industry.

Acknowledgement

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Effect of cooling rate on solidification microstructure and mechanical properties of the recycled aluminum beverage cans

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Abstract

Recycling is an effective method to diminish these wastes. In this work, the recycled aluminum beverage can ingot was cut and then melted at 750 °C in the electric furnace. The molten aluminum alloys were poured into the refractory and steel molds, then cooled to room temperature at four different cooling rates. The microstructure of the specimen was characterized using a light optical microscope and a scanning electron microscope. The hardness and tensile strength of all the specimens were evaluated using a hardness tester and a universal testing machine, respectively. The results revealed that an increase in the cooling rate resulted in the development of solidified structures and improved mechanical properties of the recycled aluminum alloy. The secondary dendrite arm spacing, and intermetallic phases became refiner as the cooling rate increased. Hardness and tensile strength enhanced with an increasing cooling rate.

Keywords: Recycled aluminum, Cooling rate, Microstructure

Introduction

Metal casting is one of the oldest fabrication techniques which was invented in 3200 BC and is still continuously utilized to produce metal products until now (Sarah, 2009). Because it has many advantages such as it can produce a complex shape metal part, no limit in weight and size of the product, inexpensive process, and so on (Anwar, Muhammad, Zuhar, & Hassan, 2021). Nowadays, the casting process is used to manufacture the complex shape metal product in a wide variety of industries, from jewelry and construction to automotive. Moreover, this process is also used to make metal ingots which are the initial material of almost all metal products. However, the drawback of this process is that the manufactured parts have lower strength and elongation compared to products made from mechanical forming techniques. Several methods were applied to enhance the mechanical properties of the products such as grain refinement (Khamsuk et al., 2014), adding alloying elements (Khamsuk, Nakvachiratrakul, & Chomsaeng, 2021), and heat treatment (Khamsuk, Nakvachiratrakul, & Chomsaeng, 2020). From an economical point of view, grain refinement appears to be a method to improve the mechanical properties of casting products at a low cost. The main factors that influenced the solidification microstructure of the castings were the chemical composition, cooling rate, atmosphere, and casting temperature.

The cooling rate has significantly affected the microstructure and mechanical properties of the casted metal (Zare, Taghiabadi, & Ghoncheh, 2021, Jabbari, Davamia, & Varahrama, 2010, Matic, Mitja, & Primož, 2021, Zhen et al., 2020, Guofang, Yahia, Guoqiang, & Ming, 2018). A high cooling rate led to refining secondary dendrite arm space and intermetallic phases and enhanced strength, which resulted from the increasing nucleation in the molten (Zare, Taghiabadi, & Ghoncheh, 2021, Jabbari, Davamia, & Varahrama, 2010, Matic, Mitja, & Primož, 2021, Zhen et al., 2020). However, many researchers

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observed the growth of the intermetallic phases in the aluminum alloy during the casting process when increasing the cooling rate (Zhen et al., 2020, Guofang, Yahia, Guoqiang, & Ming, 2018). Based on the literature reviews, the evolution of microstructure in the aluminum alloy during the casting process at a high cooling rate was complicated and unclear still. The aluminum alloy recycled from the used aluminum beverage cans could be a promising material for investigating the effect of cooling rate on the microstructure developed and mechanical properties of the aluminum alloy during the casting process. Because of in our previous study has found that this aluminum alloy consisted of complex chemical composition and microstructure caused by the aluminum beverage cans made of two different aluminum alloys (Khamsuk, Nakvachiratrakul, & Chomsaeng, 2021). Therefore, this research work aimed to clarify the effect of cooling rate on the solidification microstructure and mechanical properties of aluminum alloy in a traditional casting technique.

Methodology

The used aluminum beverage cans (defined as used Al cans) were used as the starting materials in this study. The used Al cans were cleaned with water and then compressed into small pieces. The compressed used Al cans were melted in the gas furnace and then cast in a steel mold. The chemical composition of the recycled Al alloy ingot is shown in Table 1 (Khamsuk, Nakvachiratrakul, & Chomsaeng, 2021).

Table 1 Chemical composition of the recycled Al alloy ingot (wt. %).

Mg	Mn	Fe	Si	Cu	Zn	Al
1.261	0.867	0.438	0.283	0.170	0.065	Balance

The recycled Al-alloy ingots were re-melted at 750 +/- 5 °C in an electrical furnace under an ambiance atmosphere (Fig. 1 (a)). The melt was poured into the preheated (400 °C) 14 mm in diameter refractory and steel molds and subsequently cooled to room temperature via four different methods: refractory mold air cooling, steel mold air cooling, steel mold water cooling (30 +/- 1 °C), and steel mold cool water (10 +/- 1 °C) (Fig. 1 (b)). The cooling rate measured using thermocouple was approximately 0.16 °C/s, 0.24 °C/s, 10.63 °C/s, and 19.38 °C/s. After cooled to room temperature, the specimens were removed from the molds, then cut into small test pieces and followed by surface polishing.

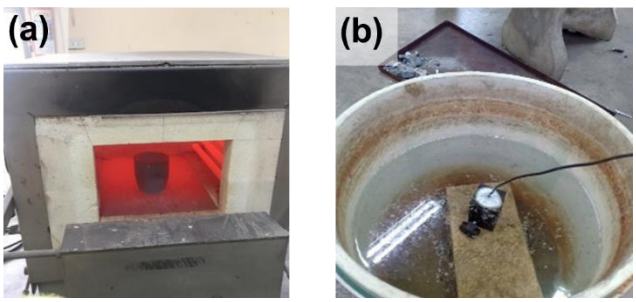

Figure 1 (a) Electrical furnace and (b) cool water-cooling method.

The porosity content of the specimens solidified at various cooling rates was evaluated according to the Archimedes method and computed using Equation 1.

$$\text{Porosity} = (W_w - W_d) / (W_w - W_s) \quad (1)$$

Where:

W_w is weight of dry specimen,

W_d is weight of suspended specimen in the water, and

W_s is weight of water saturated specimen.

The microstructure of specimens was observed using the light optical microscopy (LOM) and scanning electron microscopy (SEM) equipped with the emission black scattering diffraction (EBSD). The LOM and SEM specimens were mechanical groundings using SiC papers up to grit no. 1200 and followed by alumina powders with a particle size of 0.5, 0.3, and 0.05 micrometer, respectively. The hardness testing was performed using a hardness tester of Innova Test Europe BV. The Brinell hardness test with a diameter of 1 mm. applied a load of 5 kgf was applied to evaluate the hardness of the specimen. The hardness test was conducted at 9 different indentations. An average hardness value was computed from 7 values excluded maximum and minimum hardness values. Tensile testing was carried out by a universal testing machine model NRI-TS500-50B. Tensile test specimens were prepared according to the tensile test specimen standard ASTM E8, 6 +/- 0.1 mm in diameter and 24+/-1 mm gauge length (ASTM Standard E8/E8M-16a, 2016). Five tensile test specimens were prepared for each cooling condition. A tensile test was conducted at a constant crosshead speed of 1 mm/min under ambient temperature.

Results and discussion

Porosity measurement

The porosity of the specimens cooled at four different cooling rates measured using the Archimedes method is shown in Figure 2. It can be seen from Fig. 2 that the amount of porosity decreased with an increasing cooling rate. Porosity is a common crystal imperfection in a casted specimen that is caused by the gas bubbles trapped in the specimen and metal shrinkage. The pores generally formed along the grain boundary. Therefore, the decrease in porosity content may be attributed to the reduction of grain boundary size with an increasing cooling rate.

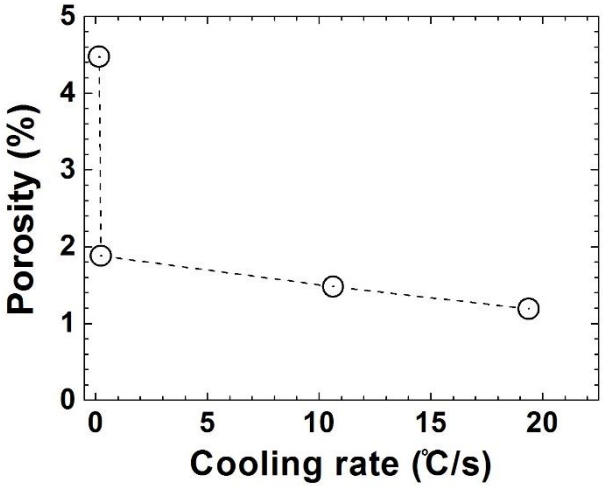

Figure 2 Porosity content plotted as a function of cooling rate.

Microstructure observation

Microstructures of the casted specimen at the different cooling rates observed via LOM are shown in Figure 3. The specimen at a cooling rate of 0.16 °C/s is composed of an al alloy solid solution phase surrounded by three different intermetallic phases (indicated by no.1, 2, and 3) and large irregular pores size (Fig. 3 (a) and Fig. 3 (b)). The pores were formed along the Al alloy solid solution phase grain boundary and intermetallic phase boundary. The average dendrite arm spacing measured from Fig. 3 (a) and Fig. 3 (b) micrograph was 26.67 μm. The dendrite arm spacing decreased to 7.96 μm when increased the cooling rate to 0.24 °C/s (Fig. 3 (c) and Fig. 3 (d)). Increasing the cooling rate to 10.63 °C/s led to refining the dendrite arm spacing, intermetallic phase size, and pore size (Fig. 3 (e) and Fig. 3 (f)). The spherical micropores formed in the specimen at this cooling rate. The dendrite arm spacing measured from this specimen was 5.39 μm. Further increasing the cooling rate to 19.38 °C/s, the structure became finer. Microstructure results indicated that metal cooling rate had strongly affected the solidified structure. An augmenting the cooling rate substantially refined the microstructure of a casted specimen. The main reason for this phenomenon was a rapid cooling rate accelerated a high volume of the heterogeneous nucleation and grain refinement. On the other hand, it was also found that the cooling rate has influenced the pore morphology and content. This could be attributed to the higher cooling rate reduced pore growth and agglomerate time resulting in a high quantity of tiny pores.

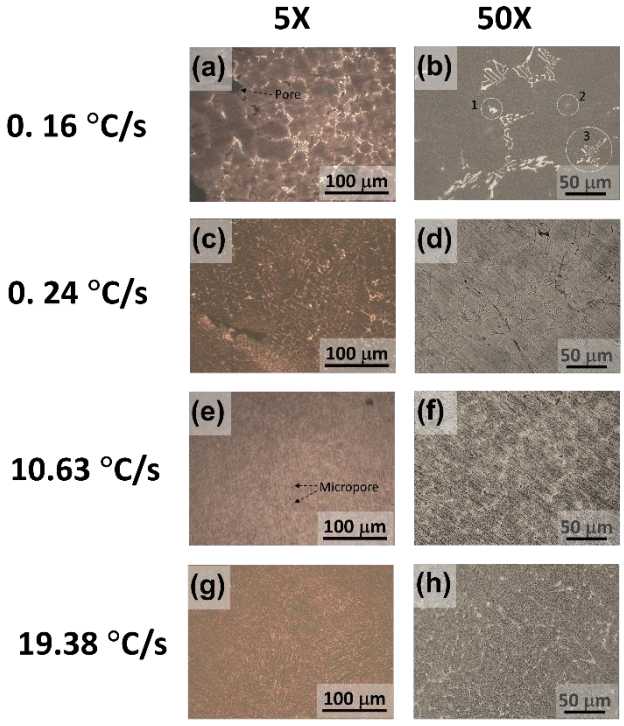

Figure 3 LOM microstructure of the specimens cooling at (a) 0.16 °C/s at 5X, (b) 0.16 °C/s at 50X, (c) 0.24 °C/s at 5X, (d) 0.24 °C/s at 50X, (e) 10.63 °C/s at 5X, (f) 10.63 °C/s at 50X, (g) 19.38 °C/s at 5X, and (h) 19.38 °C/s at 50X.

SEM micrograph of specimen cooled at 10.63 °C/s is shown in Figure 4 (a). The SEM micrograph shows a similar microstructure to the LOM observation. EDS analysis indicated that the intermetallic phase of the Chinese-script particle was identified to be $Al_{14}Fe_2Mn$ phase (Fig. 4 (b)), and a light particle was an intermetallic $Al_{16}Fe_3MnSi$ phase (Fig. 4 (c)) and the light dot particles formed in the line was an intermetallic Al_9Fe_2Mn phase (Fig. 4 (d)).

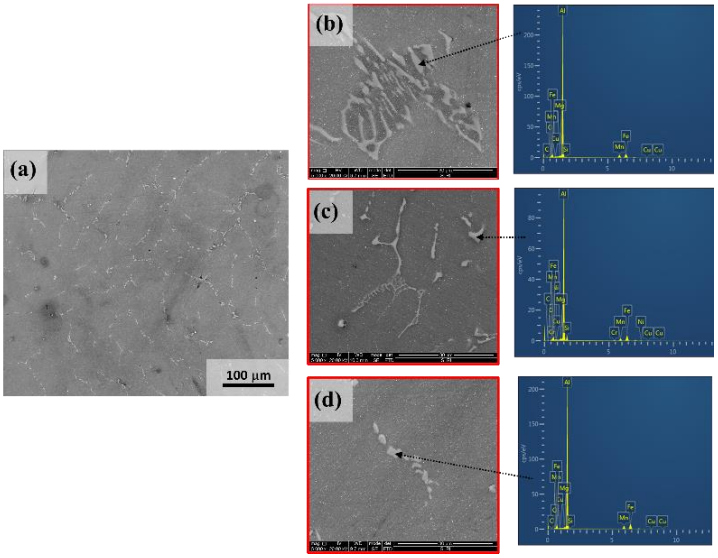

Figure 4 (a) SEM micrograph, (b), (c) and (d) EDS analysis of a 10.63 °C/s cooling rate specimen.

Hardness test

The hardness values obtained from specimens cooled at four different cooling rates are illustrated in Figure 5. It is observed that the hardness of the specimen cooled in a refractory mold with a 0,16 C/s cooling rate was 49.25 HB. The hardness of specimens raised to 54.62, 57.54 HB, and 60.37 HB when the cooling rate increased to 0.24, 10.63 and 19.38 °C/s, respectively. This result indicated that increasing the cooling rate enhanced the hardness of the casted specimen. This is due to the raising cooling rate leading to acceleration of secondary dendrite arm spacing and intermetallic phase refinement, and enhanced volume fraction of dendrite boundary and intermetallic phases; those presented dendrite boundaries and intermetallic phases inhibited dislocation motion.

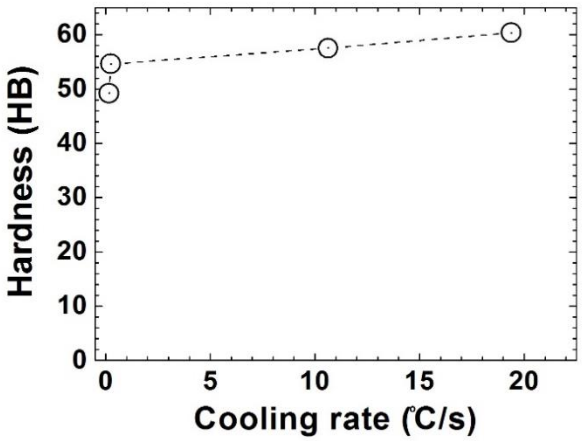

Figure 5 Hardness of specimen cooling at various cooling rates.

Figure 6 shows the stress-strain curves of the specimens cooled at different cooling rates. The flow stress raised monotonously with increasing strain up to the maximum stress followed by failure. It was found that the flow stress and ultimate tensile strength increased with augmenting cooling rate. The tensile test results were well consistent with the hardness property. The increased tensile strength is caused by the rise of the volume ratio of fine grain boundary and secondary phases when the cooling rate increases. Therefore, the tensile strength of the specimen was enhanced by grain size reduction and precipitation strengthening mechanisms.

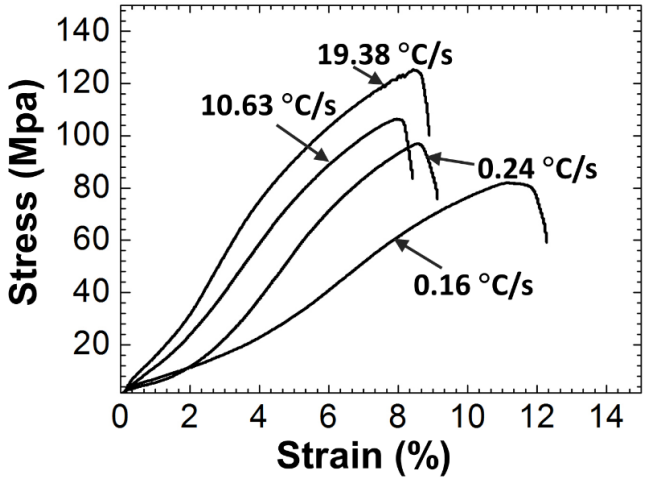

Figure 6 Stress-strain curves of the Al alloy cooled at different cooling rates.

Conclusions

1. The porosity content and pore size decreased when the cooling rate was raised. The morphology of the pore changed from a large irregular shape to a spherical micropore with an increasing cooling rate.

2. The microstructure of the casted used Al cans strongly depended on the cooling rate. An augmenting of the cooling rate substantially refined the secondary dendrite arm spacing and intermetallic phases.

3. The hardness and tensile strength of recycled Al alloy specimens increased with an increasing cooling rate.

Acknowledgement

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Determination of shear angle efficiency of sugarcane harvester blades

Rungroj Kawsringam[1*] and Seksan Chaijit[1]

Abstract

This paper aims to conduct an experimental study on the determination of shearing angle efficiency of sugarcane harvester blades By simulating the operation of sugarcane harvester blades hydraulically, for example, at rpm. 200 rpm, working pressure 120 bar. In the experiment 3 strains of sugarcane were used, U-thong sugarcane. U-thong sugarcane 84-10 and Khon Kaen sugar cane 3 which angles used for cutting were divided into 3 ranges: 15 degrees, 30 degrees and 45 degrees. And these 3 type have the most effective shearing angle is 45 degrees, the moderate shearing angle efficiency is 30 degrees, the least effective shearing angle is 15 degrees or users can shorten the harvesting time faster, resulting in fuel savings. Reduces wear on the sugarcane cutter blades and improves the harvesting life of the sugarcane.

Keywords: cutting angle efficiency, sugarcane species, reduce wear

Introduction

Nowadays, sugarcane harvesters are being used to replace human labor in cutting sugar cane to produce sugar for consumption, which is likely to increase in the operation of sugarcane harvesters. There is an important device that is a base cutting blade system. which the operation of the base cutting blade system Requires centrifugal force for machining from the hydraulic system as the working power The hydraulic pump creates pressure to drive the hydraulic motors. causing support to transfer power to the base cutter system to cut sugarcane stems In the operation of the base cutter, it is often damaged by malfunctions, reducing the service life of the sugarcane cutter blades. The objective of this research is to study the operation of the base cutter system in the sugar cane harvester by modeling the cane cutter blade system using the hydraulic pump power system at high speed. around 200 rpm, working pressure 120 bar. In the experiment, 3 strains of sugarcane were used, namely, U-Thong sugarcane. U-thong sugarcane 84-10 and Khon Kaen sugarcane The angles used in the machining trials were divided into 3 ranges: 15 degrees, 30 degrees, and 45 degrees.

Methodology

Modeling of cutting of sugarcane harvester base cutters using hydraulics as the support of a hydraulic pump at 200 rpm, working pressure 120 bar. In the experiment, 3 species of sugarcane were used, namely, U-thong sugarcane. U-thong sugarcane 84-10 and Khon Kaen sugarcane The angles used in the machining trials were divided into 3 ranges: 15 degrees, 30 degrees, and 45 degrees.

Theory of Shear Stress $\tau = F/A$

τ = The shear stress that occurs

A = The cross-sectional area parallel to the force

F= The shear force acting on the object

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damage theory and Maximum shear stress theory

the material will be damaged When the maximum shear stress in the material is equal to the Maximum shear strength obtained by tensile testing to the yield point of the material.

$\tau_{max} = S_{sy}$ where $\tau_{max} = S_{sy}$, $S_{sy} = 0.5S_y$

Case 1

σ_1 = +

σ_2 = - ⟹ $\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = S_{sy} = \pm \frac{0.5S_y}{N}$

σ_3 = 0

Case 2

σ_1 = +

σ_2 = -

σ_3 = 0 ⟹ $\tau_{max} = \frac{\sigma_1}{2} = \pm \frac{0.5S_y}{N}$

$\sigma_1 > \sigma_2$

$\sigma_2 > \sigma_1$ $\tau_{max} = \frac{\sigma_2}{2} = \pm \frac{0.5S_y}{N}$

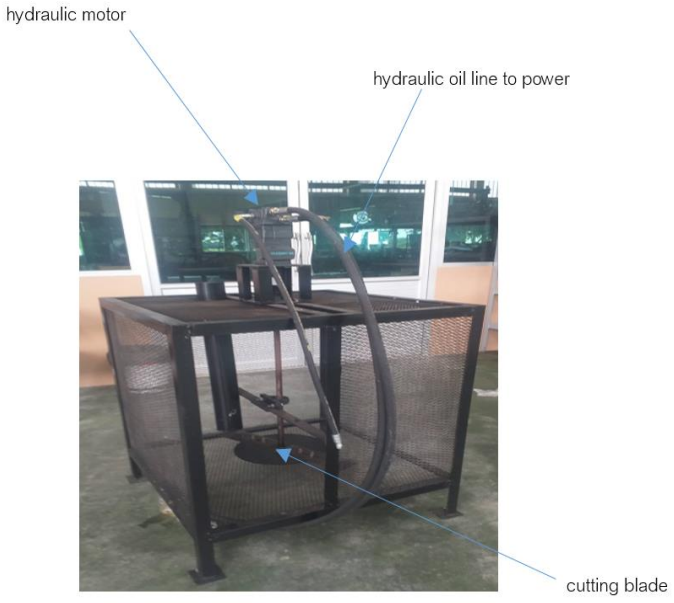

Figure 1 Model of the sugar cane harvester blade system.

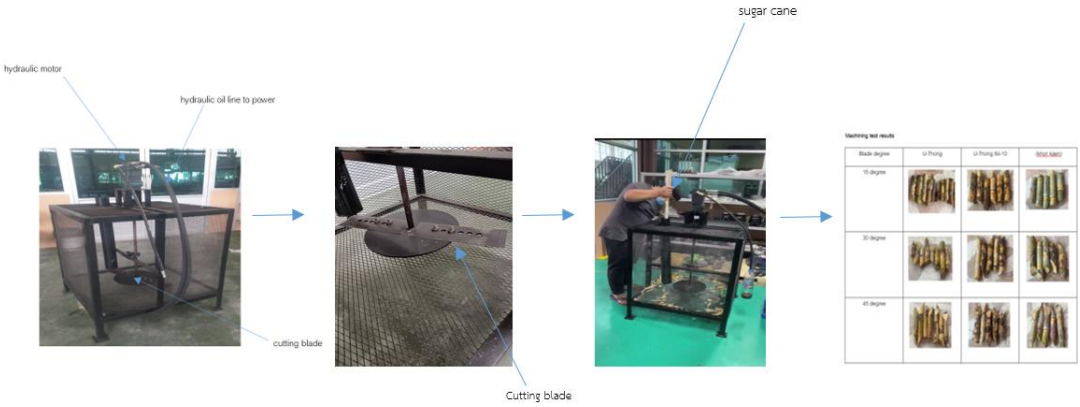

Figure 2 Operation process of sugarcane cutter blade system.

Results and discussion

By designing and constructing a test model of a hydraulically controlled sugarcane cutter blade tester, 200 rpm speed, 120 bar working pressure, can test and know the results of the sugar cane cutting test. U-Thong cane cutting angles 15 degrees, 30 degrees and 45 degrees, U-thong cane 84-10, cutting angles 15 degrees, 30 degrees and 45 degrees, and Khon Kaen cane cutting angles of 15 degrees, 30 degrees and 45 degrees from testing. Each degree of sugarcane cut has been tested that the best degree is 45 degrees, since 45 is the best shearing angle and the most damaged cane cut angle is 15 degrees. The cane breaks and requires more cutting force than a 45 degree angle.

Results from the sugar cane cutting test U-Thong cane, compared to time (60 minutes)

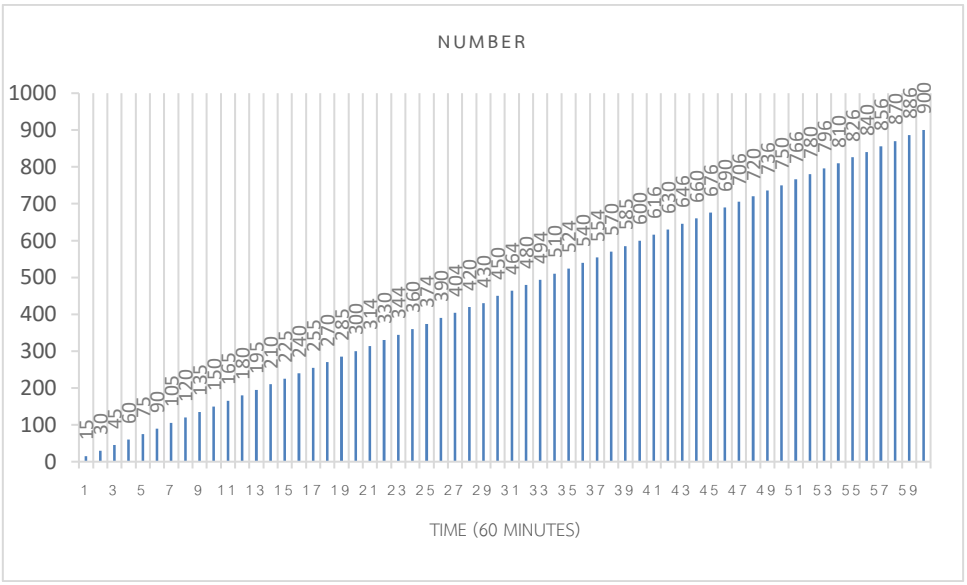

Figure 3 Efficiency shearing angle at 15 degrees (U-Thong) at 200 rpm, working pressure 120 bar. Results of cutting at a 15 degree angle (U-Thong) at 60 minutes, number 900 stems.

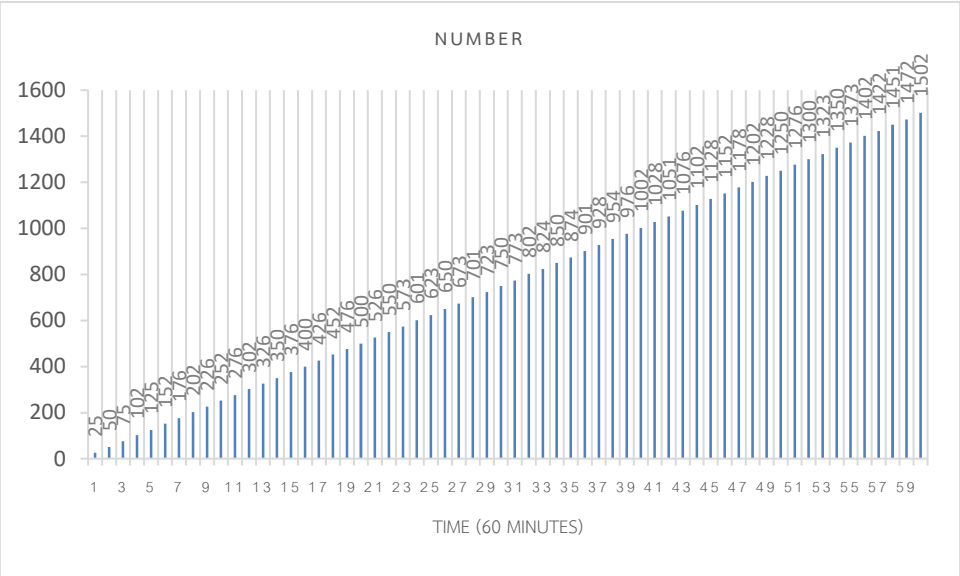

Figure 4 Efficiency shearing angle at 30 degrees (U-Thong) at 200 rpm, working pressure 120 bar. Results of cutting at a 30 degree angle (U-Thong) at 60 minutes, number1502 stems

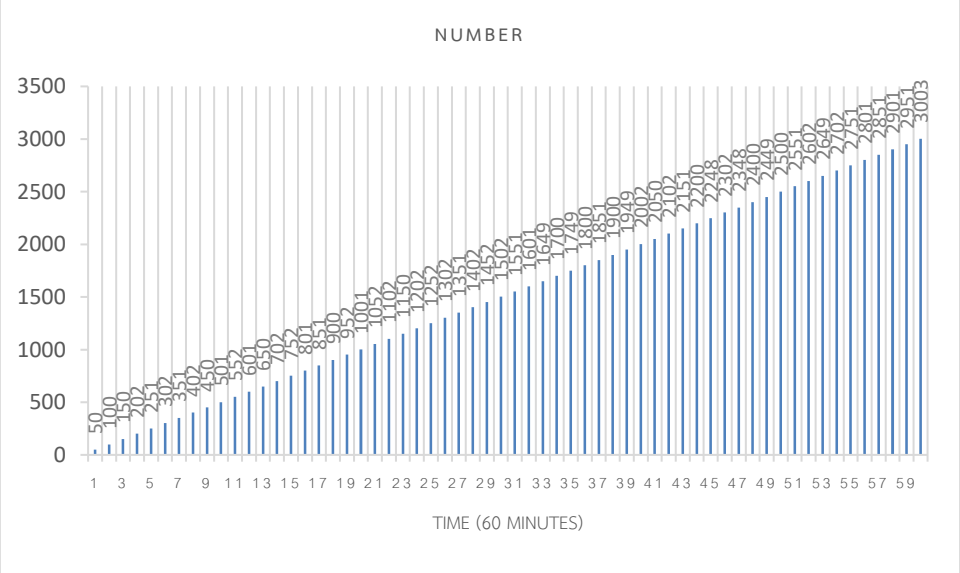

Figure 5 Efficiency shearing angle at 45 degrees (U-Thong) at 200 rpm, working pressure 120 bar. Results of cutting at a 45 degree angle (U-Thong) at 60 minutes, number3003 stems.

Results from the sugar cane cutting test U-Thong 84-10 cane, compared to time (60 minutes)

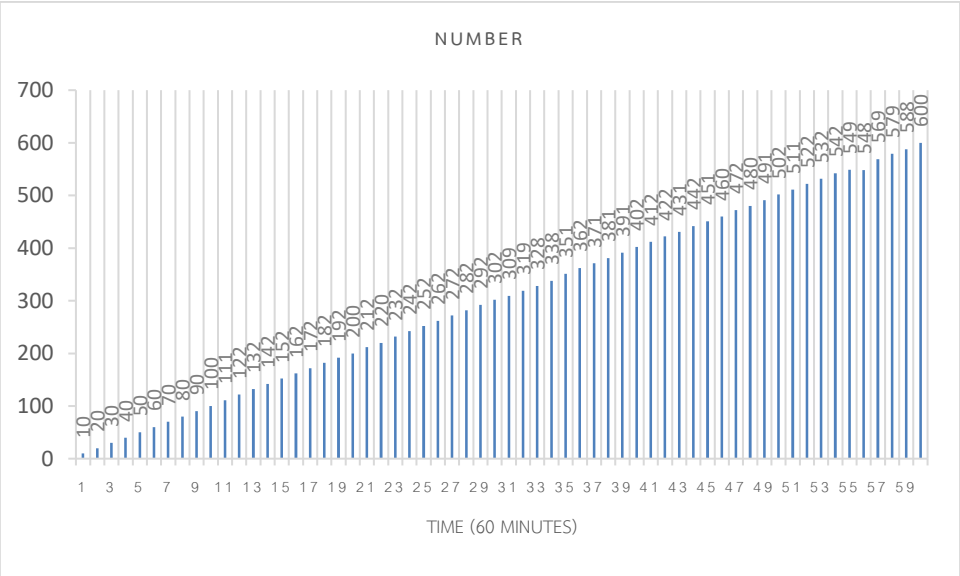

Figure 6 Efficiency shearing angle at 15 degrees (U-Thong84-10) at 200 rpm, working pressure 120 bar. Results of cutting at a 15 degree angle (U-Thong84-10) at 60 minutes, number600 stems

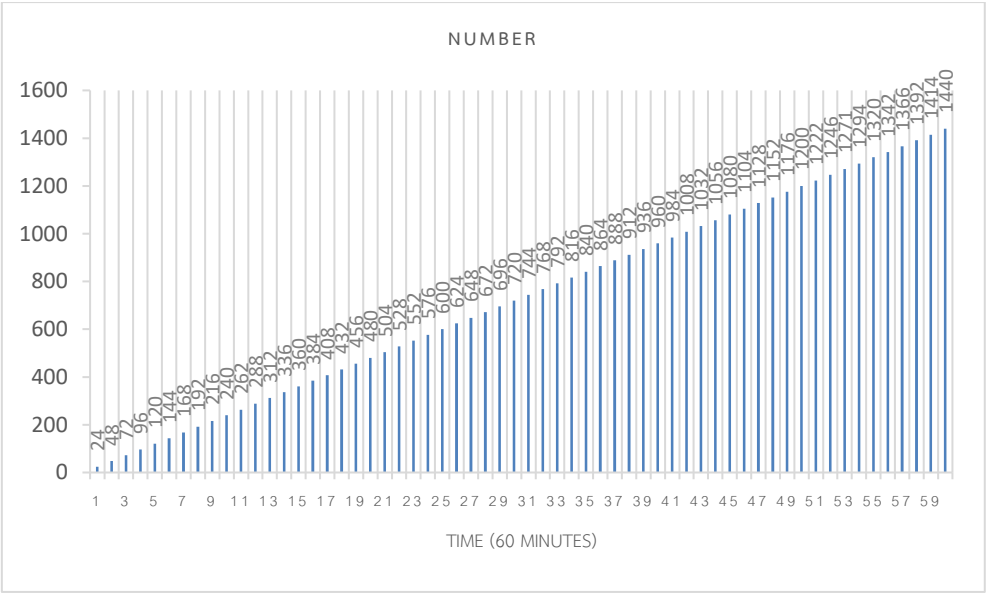

Figure 7 Efficiency shearing angle at 30 degrees (U-Thong84-10) at 200 rpm, working pressure 120 bar. Results of cutting at a 30 degree angle (U-Thong84-10) at 60 minutes, number1440 stems.

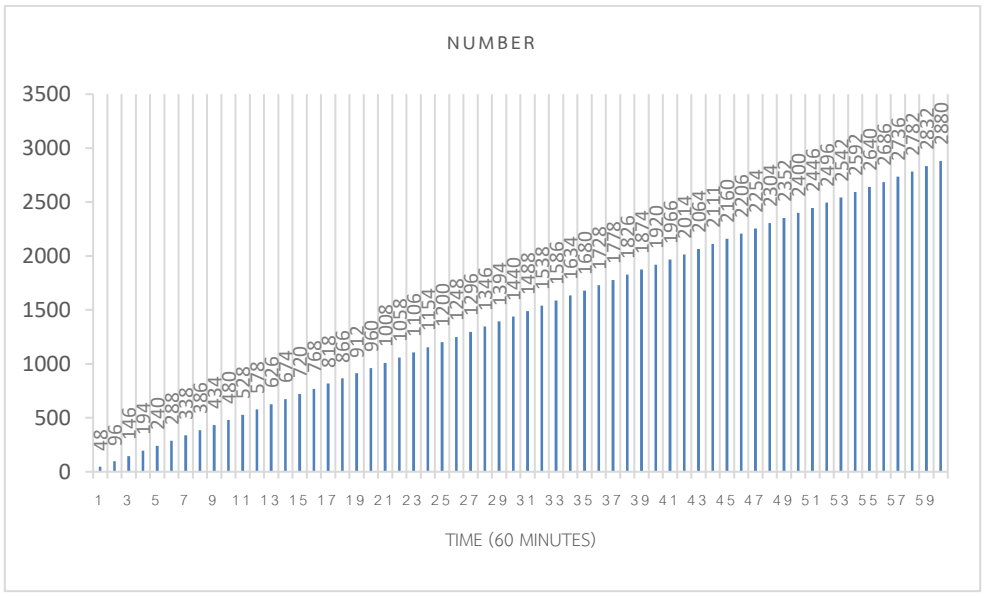

Figure 8 Efficiency shearing angle at 45 degrees (U-Thong84-10) at 200 rpm, working pressure 120 bar. Results of cutting at a 45 degree angle (U-Thong84-10) at 60 minutes, number 2880 stems.

Results from the sugar cane cutting test Khon Kaen cane, compared to time (60 minutes)

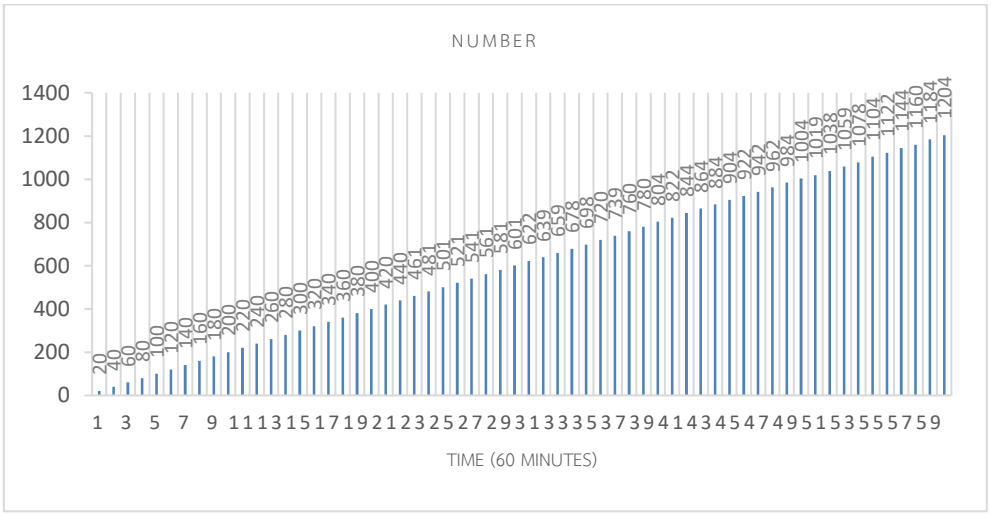

Figure 9 Efficiency shearing angle at 15 degrees (khon kaen) at 200 rpm, working pressure 120 bar. Results of cutting at a 15 degree angle (khon kaen) at 60 minutes, number1204 stems.

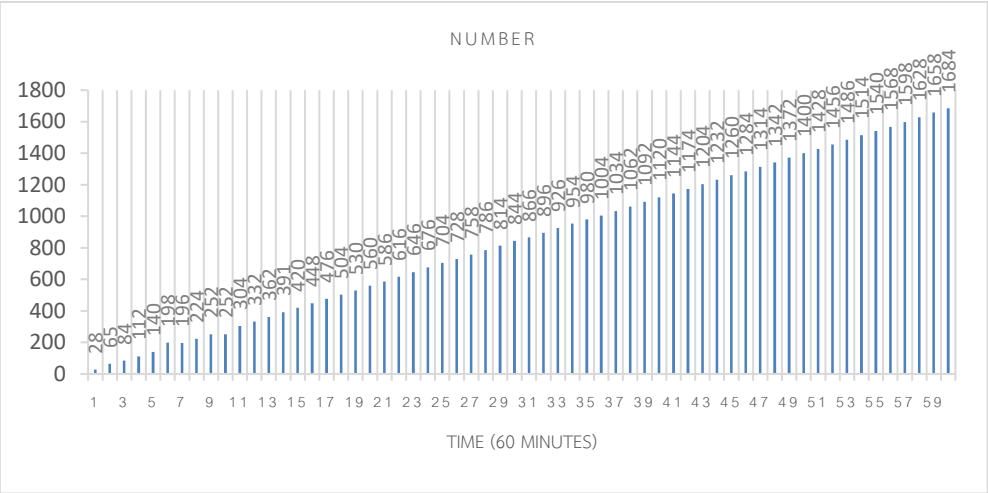

Figure 10 Efficiency shearing angle at 30 degrees (khon kaen) at 200 rpm, working pressure 120 bar. Results of cutting at a 30 degree angle (khon kaen) at 60 minutes, number1684 stems.

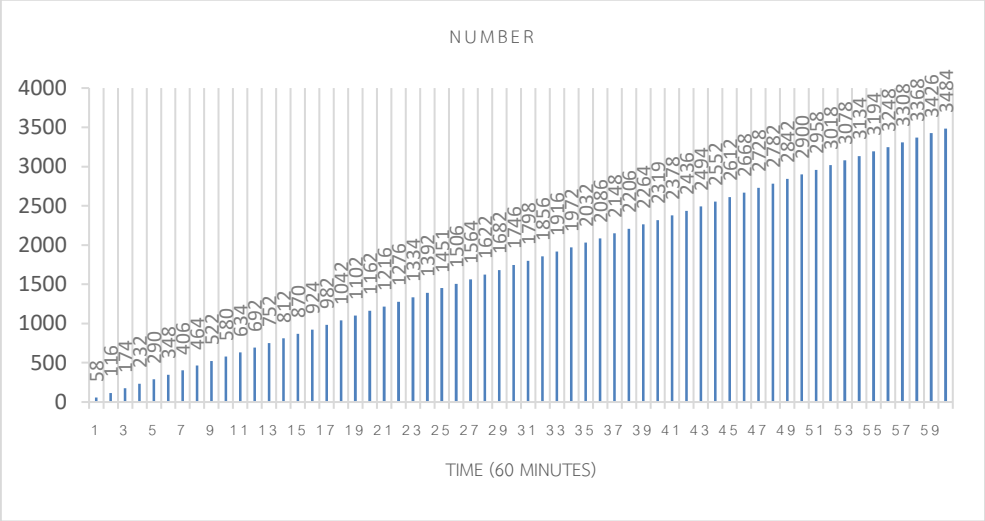

Figure 11 Efficiency shearing angle at 45 degrees (khon kaen) at 200 rpm, working pressure 120 bar. Results of cutting at a 15 degree angle (khon kaen) at 60 minutes, number 3484 stems.

Total efficiency shearing angle sugar cane cutting test

Figure 12 Total efficiency shearing angle at 15 degrees. at 200 rpm, working pressure 120 bar.

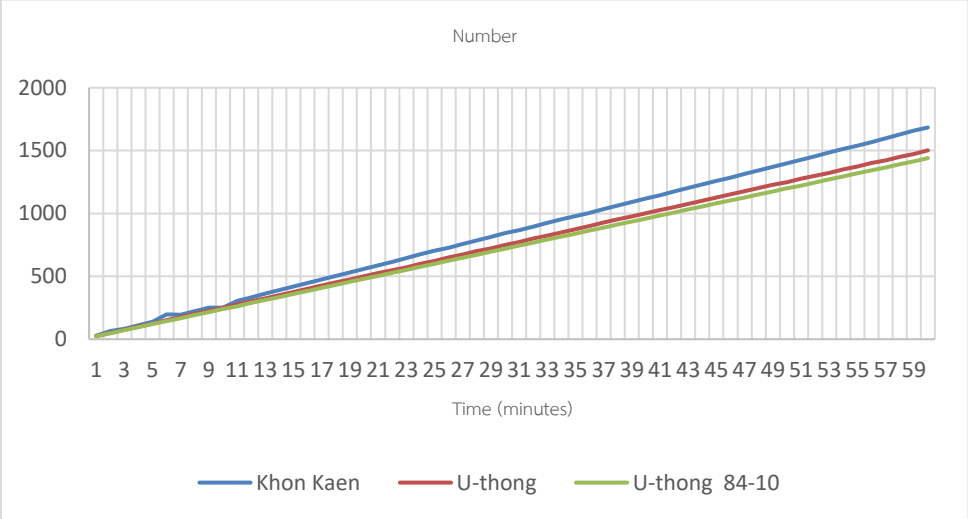

Figure 13 Total efficiency shearing angle at 30 degrees. at 200 rpm, working pressure 120 bar.

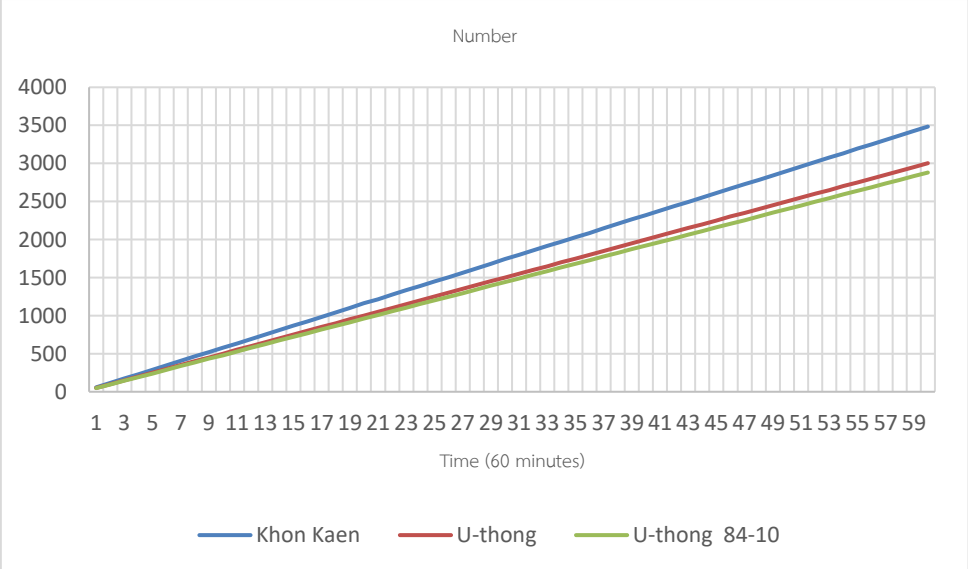

Figure 14 Total efficiency shearing angle at 45 degrees. at 200 rpm, working pressure 120 bar.

Cutting angle efficiency

Table 1 cutting angle efficiency.

Sugarcane/Cutting angle	Number /hour	good	broken	Efficiency (%)
U-Thong				
15 degree	900	462(51.3%)	438(48.6%)	51.3
30 degree	1502	1102(73.3%)	400(26.6%)	73.3
45 degree	3003	2496(83.1%)	507(16.8%)	83.1
U-thong (84-10)				
15 degree	600	296(49.3%)	304(50.6%)	49.3
30 degree	1440	965(67.0%)	475(32.9%)	67.0
45 degree	2880	2370(82.2%)	510(17.7%)	82.2
Khon Kaen				
15 degree	1204	749(62.2%)	455(37.7%)	62.2
30 degree	1684	1254(74.4%)	430(25.5%)	74.4
45 degree	3484	2948(85.6%)	536(15.3%)	85.6

The results showed that the cutting angle efficiency of U-Thong cane at 15 degree = 51.3%, 30 degree = 73.3% 45 degree= 83.1% U-thong cane (84-10) at 15 degree = 49.3%, 30. degree = 67.0%, 45 degree = 82.2%, Khon Kaen cane 15 degree = 62.2%, 30 degree= 74.4%, 45 degree = 85.6%. The results showed that the best efficiency of all sugarcane varieties was the cutting angle at 45 degree. U-Thong at 45 degree= 83.1%, U-thong (84-10) at 45 degree = 82.2%, Khon Kaen at degree 85.6%.

Machining test results

Cutting angle	U-Thong	U-Thong 84-10	(khon kaen)
15 degree			
30 degree			
45 degree			

Figure 13 Model cut cane trunks.

Conclusion

According to the results of the sugarcane cutting test with the model created to machine each degree, the test result obtained the best degree of 45 degrees since 45 is the best cutting angle and the cut angle causes the sugarcane to occur. The most damaging is a 15 degree angle, as the straight angle does not shear forces the cane to crack and requires more cutting force than the 45 degree angle. The most effective shearing angle is 45 degrees, the moderate shearing angle efficiency is 30 degrees, and The minimum cutting angle efficiency is 15 degrees. Optimizing the cutting angle of the sugarcane cutter blades will allow the farmer or operator to shorten the harvesting time faster, resulting in fuel savings. fuel Reduces wear on the sugarcane cutter blades and improves the harvesting life of the sugarcane.

Acknowledgement

The results of this experiment This can be done with great help. From the consultation of the advisor, Asst. Prof. Dr. Seksan Chaijit, Faculty of Engineering Pathumwan Institute of Technology Thank you Research and Development Institute Rajamangala University of Technology Suvarnabhumi for research budget and thanks to the field of Mechanical Engineering Faculty of Industrial Education Suphanburi Center For providing the facilities, tools and support for the research, researchers are highly grateful.

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An Experimental Assessment of Diesel Engine Characteristics using Diesel/Argemone/Corn Biodiesel Blends

Naveen Kumar[1], Vipul Saxena[1,2*], and Raghvendra Gautam[3]

Abstract

The research dealt with production of biodiesel from Argemone and Corn oil with an aim to obtain the diesel/biodiesel blend to overcome the drawbacks of biodiesel blending like increased NOx emissions and decreased performance. The goal of this research is to conduct an experimental analysis to look at engine characteristics with a dual biodiesel-diesel blend. The effects of engine load and biodiesel % on the engine characteristics of a single cylinder, 4-S diesel engine were investigated in this study. To compensate for the drawbacks of biodiesel and ultra-low sulphur diesel, corn oil and argemone oil were chosen for mixing. Argemone oil reduces friction losses due to improved tribological properties, which enhances engine performance and for NOx reduction, Corn oil is beneficial. The test fuels were prepared by blending 10%, 20%, and 30% biodiesel in diesel on a volumetric basis, and were labelled B10, B20, and B30, accordingly. B10 has a 13.56% greater BTE than neat diesel at peak load. Furthermore, the B20 sample performed better in terms of emissions characteristics such as carbon monoxide (0.071%), nitrogen oxides (1160 ppm), and unburned hydrocarbons (5.8 ppm). According to the findings of this study, the B10 sample has the best performance results of all the test fuels, and the emission results are comparable to the B20 sample.

Keywords: argemone oil, corn oil, biodiesel, performance, emission

Definitions/Abbreviations

AMME	Argemone Mexicana Methyl Ester	CO	Carbon Monoxide (%)
CME	Corn Methyl Ester	NOx	Nitrogen Oxides (ppm)
B10	Blend of 5% AMME,5% CME and 90% Diesel	UBHC	Unburnt Hydrocarbon (ppm)
B20	Blend of 10% AMME,10% CME and 80% Diesel	EGT	Exhaust Gas Temperature (°C)
B30	Blend of 15% AMME,15% CME and 70% Diesel	BSFC	Brake Specific Fuel Consumption (Kg/kW-
BTE	Brake Thermal Efficiency (%)	ULSD	Ultra Low Sulfur Diesel

Introduction

As the incessant growth in the field of transportation and technology has seen an expected surge in recent times. The demand to have a source of energy that fulfils the standards laid on various fronts has also increased. These standards to be met requires a source of energy that is sustainable in a long run, compatible, economically viable both at the personal level and on the level of the country as this would reduce the dependence on other counties for the import of fuel which in turn would generate a healthy amount of revenue. (10% blending of diesel can make a profit of 300-400 Cr INR).

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Significant research has been carried out to improve the physiochemical properties of fuel and engine characteristics derived from diverse vegetable oils. Agrawal et al. (2019) used diesel engine with varied mixtures (10%, 20%, 30%, and 40%) of pure diesel and castor oil to test the performance parameters of a diesel engine. They reported an increase in indicated power of 550 Watt. The mean effective pressure and thermal efficiency of the brakes were also improved [1].

In their research, Balamurugan et al. (2018) revealed that corn oil exhibits qualities like diesel. It was attempted to assess the engine characteristics of diesel engines using corn oil biodiesel combined with diesel in various quantities as fuel. Their experiments resulted in a reduction in BTE and an increase in BSFC. Emissions increased as well, while nitrogen oxides reduced by 12% [2].

Singh et al. (2019) investigated engine qualities of CRDI engine powered by argemone biodiesel-diesel mixtures. At full load, they discovered that BTE improved by 5.58 %, but BSFC increased by 7.88%. CO and UBHC emissions dropped, whereas NOx emissions increased [3].

Pali et al. (2019) explored and manufactured an indigenous fuel from a plentiful forest in India using Response Surface Methods (RSM) by optimising key attributes like cetane number, viscosity, calorific value, and cold filter plugging point (CFPP). Break thermal efficiency fell by 2.3 percent, but BSFC rose by 0.4 percent. CO and HC emissions were reduced by 25% and 45%, respectively, whereas NOx emissions increased by 21%. [4]. Kumar et al. (2019) investigated the mixing of two biodiesels. They investigated Argemone and Mahua oil for biodiesel manufacturing, then created blends with diesel for further testing, and identified an increase in BTE on the cost of fuel use [5].

Saleh et al. (2020) investigated the engine characteristics of DI diesel engines working on diesel-jojoba-butanol blends. In terms of BSFC, EGT, and BTE, the blend of 87% diesel fuel, 5% crude jojoba oil, and 8% butanol (DJ5B8) fared the best among the test cases. When compared to diesel fuel operation, the DJ5B8 blend reduced CO and UBHC while increasing nitrogen oxides (NOx) [6].

Sridhar et al. (2014) experimented with two biodiesels derived from pongamia pinnata oil and mustard oil, which were mixed with diesel at different ratios. At changing engine loads, the effects of dual biodiesel work on engine and exhaust pollutants were evaluated. The BTE of blended mixture was found to be higher than diesel. Smoke, hydrocarbons, and nitrogen oxides were all greater in dual biodiesel mixtures than in diesel. Dual biodiesel mixes, on the other hand, exhibited lower exhaust gas temperatures than diesel [7]. Veera et al. (2020) studied the effect of canola oil and snake gourd oil biodiesel combined with diesel. The findings led us to conclude that increasing the biodiesel content in diesel–biodiesel blends reduce engine performance while having some positive effects on emission characteristics. On both performance and emission characteristics, canola oil biodiesel outperformed snake gourd oil [8]. Sumit et al. (2015) investigated the effect of process variables on biodiesel yield and studied the basic fuel qualities of Corn oil and its ester, such as calorific value, density, kinematic viscosity, flash point, fire point, and so on, and compared these attributes to those of pure diesel fuel [9]. Parida et al. (2017) conducted various trials at a fixed compression ratio of 17.5 with argemone Mexicana methyl ester for combustion analysis with a variety of blends and loads. Because of the longer combustion period, a 40% mix produced the highest cylinder pressure. With

increasing engine load, the combustion parameters net heat release rate and cumulative heat release rate rise. As the percentage of biodiesel grows, the net heat release rate drops while the cumulative heat release rate increases. The crank angle position corresponding to maximum pressure shifts away as the proportion of biodiesel increases [10].

All diesel injection equipment relies on diesel as a lubricant, so it's vital to study the lubricating properties of commercial diesel. Due to desulfurization process the diesel fuel does not have a fair amount of lubricity or it tends to lose its lubricating property over a short period, there might be an increase in the amount of wear between metal parts that depend on fuel. So, the need arises to develop a fuel that overcomes this issue as Low lubricity might reduce the engine life [11]. Results through from various experiments show that the concentration of NOx in untreated diesel exhaust gases ranges from 50-1000 ppm. This can have a wide impact, ranging from our health to damaging our environment. So, to reduce these emissions are a matter of real concern. Hence, based on the previous research work that it can be concluded that Corn oil, when blended with diesel, showed good results i.e., emissions decreased by a fair amount.

By altering fuel chemistry and other operating parameters, several experiments have been proposed to improve fuel properties and engine characteristics. It shows certain flaws when the engine was running. However, there hasn't been a lot of discussion regarding the analysis of engine performance and NO_x emissions with ULSD. Overall, the examination of the literature shows that no experimental research has been done to concurrently address these problems. Blends made using argemone and corn oil biodiesel in equal measures to diesel have been created to lessen the drawbacks of biodiesel and ULSD as described in the literature study. In the prepared sample, there are three different levels of blending: 10%, 20%, and 30%. for investigating the engine characteristics. The author compared the outcomes with the results of earlier studies.

Methodology

Sample preparation and characterization

The seeds of corn and argemone Mexicana were procured from the neighbouring marketplace of Delhi, India. Then seeds were treated to separate oil from them as shown in figure 1. Biodiesel was produced using a transesterification process in which, the triglycerides were reacted with methanol in presence of NaOH as a catalytic agent. To start with the process about 5.6grams of Sodium hydroxide (NaOH) was dissolved in 200mL of methanol and stirred vigorously till all catalysts get dissolved in the covered container, forming Sodium Methoxide solution. After that, 1litre corn oil was preheated in a pan, up to 54°C and then 200mL of Sodium hydroxide solution was added into it. Similarly in 1 litre of preheated (up to 54°C) argemone Mexicana oil, 200 ml of Sodium Methoxide was added. To achieve steering at a constant speed, a magnetic stirrer was used as shown in figure 2. Then the mixture is allowed to sit for 24 hours so that the glycerol component of the mixture settles down completely. After 24 hours without disturbing the bottom layer (glycerol), the upper layer of biodiesel was taken out as shown in figure 3. After that water washing was done to remove impurities and to obtain pure biodiesel.

Figure 1 Corn & Argemone extracted oil.

Figure 2 Magnetic stirrer for constant speed steering.

Figure 3 Layers of Biodiesel & Glycerol after 24 hrs.

Sample preparation was done in a similar proportion of Mexicana argemone and corn oil biodiesel with neat diesel. The prepared samples have been designated as B10, B20, and B30. The prepared sample's density, kinematic viscosity, calorific value, and flashpoint were tested. Table 1 compares the physicochemical parameters of several test blends.

Table 1 Physiochemical properties of diesel and blends.

Property	Unit	Diesel	B10	B20	B30	Testing Method
Density @15°C	kg/m^3	830	831.38	832.48	833.82	ASTM D4052
Kinematic viscosity @40°C	Cst	2.8	2.86	2.9	2.96	ASTM D445
Calorific value	MJ/kg	44.5	44.335	44.2	44.085	ASTM D240
Flash point	°C	66.5	65.205	65.96	66.5	ASTM D93

Experimental set up

A 4-S single chamber DI vertical diesel engine was used to conduct the testing. These engines are most found in light-duty vehicles. At 1500 rpm, the engine produces 4.4 kW. The engine's exact features are listed in Table 2. The Schematic diagram of test setup in figure 4.

Table 2 Engine Specification.

Make	Anil
Type	Single cylinder, 4 stroke diesel engine
Compression Ratio	16:1
Rated Power	4.4 kW
Bore	80 mm
Stroke	110 mm
Speed	1500 rpm
Cubic Capacity	1433 cc

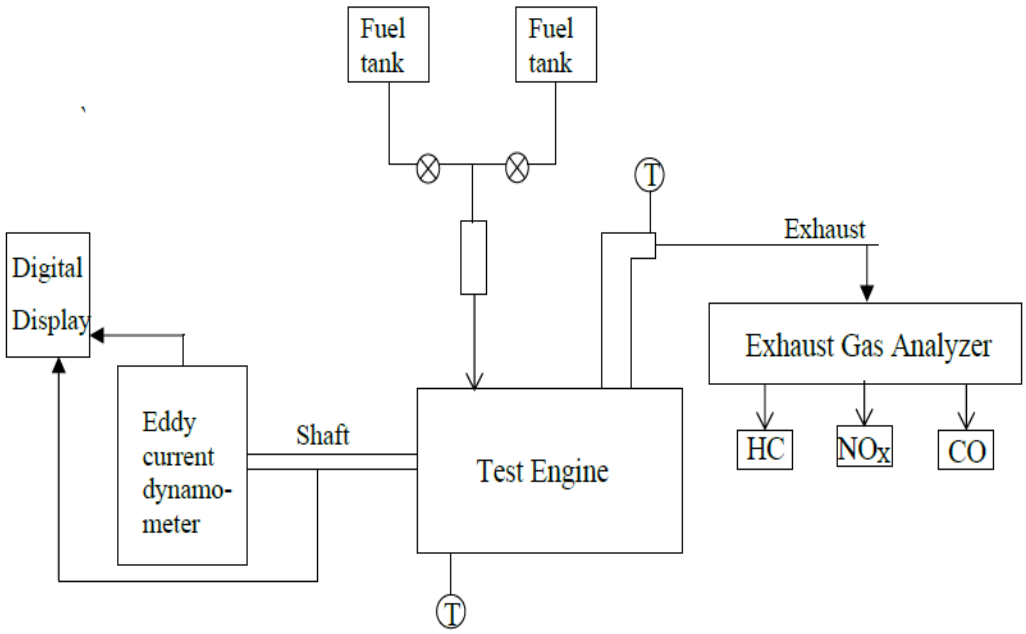

Figure 4 Schematic Arrangement for Experimental Trials.

Data collection

To manage the engine load, the crankshaft is connected to an alternator. The engine exhaust pipe is connected to a K-type thermocouple. The installation of a DITEST MDS 205 gas analyser allows for the measurement of the quantity of discharge gases produced during combustion. The speed is continuously monitored by a speed sensor. With the use of a U-tube manometer, we observed burette readings, and we utilised a digital watch to record the time for each 10 cubic centimetres (cc). The load varied from zero load to 75% loading of rated power. A gas analyser and smoke metre were used to conduct the emission tests while measuring the performance metrics. The measurement of emission

characteristics for each fuel sample under various loading conditions, conclusions have been deduced using illustrated graphs.

Results and discussion

Engine performance characteristics

The variation of BTE, BSFC and EGT with respect to load for various blends and diesel has been shown in figure 5,6,7. It is obtained that BTE increases at higher loads for all blends. Moreover, BSFC decreases with an increase in load for all the blends. At lower loads diesel has more Brake thermal efficiency than that of blends. For blends, B10 has more BTE than B20 and B30. While with an increase in loading efficiency for blends increases significantly and at nearly 50% loading BTE for B10 fuel is more than that of diesel. At higher loading, B10 has the highest BTE compared to diesel and other blends. Diesel is having the least efficiency when compared to biodiesel-diesel blends. Gautam et al. (2015) showed the similar pattern has been found [12].

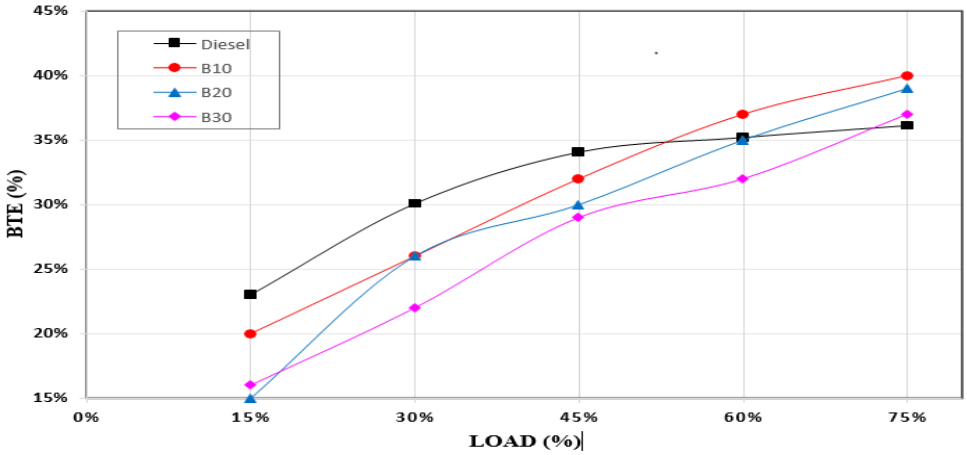

Figure 5 BTE variation in relation to Load (%).

Break Specific Fuel Consumption increases with increase in loading. At low loads biodiesel blends consume more fuel as compared to that of diesel. Among biodiesel blends B30 has highest fuel consumption followed by B20 then B10. Moreover, at high loading B30 is also having highest fuel consumption. For B10 and B20 fuel consumption is less than that of diesel at high loads. B30 is having highest fuel consumption throughout all the loading. Several authors have discovered a similar pattern Gautam & Kumar (2018) [13].

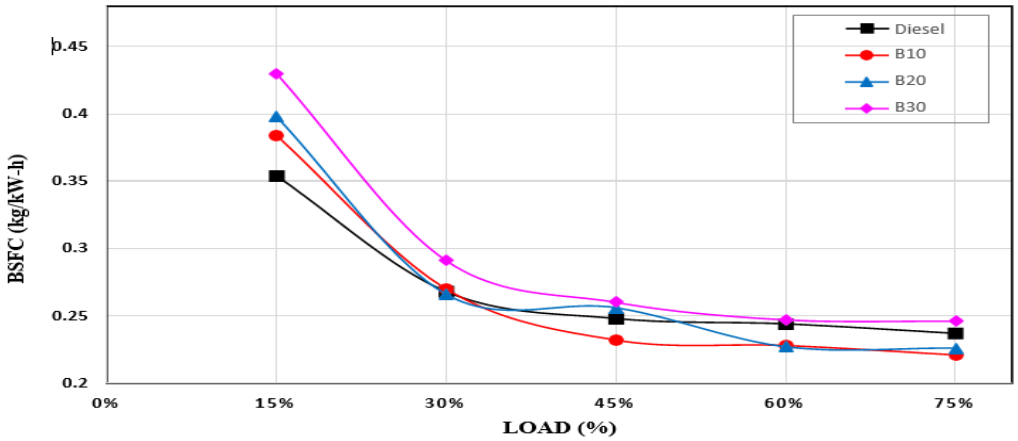

Figure 6 BSFC variation in relation to Load (%).

The variation of EGT with respect to load has been shown in fig. Here EGT increases with an increase in loading. Diesel has a very large temperature at high loads. Biodiesel blends are having very less exhaust temperature as compared to diesel with B20 having the least. At medium loads, all blends have nearly comparable exhaust gas temperatures. For all fuels, EGT is increasing with the load.

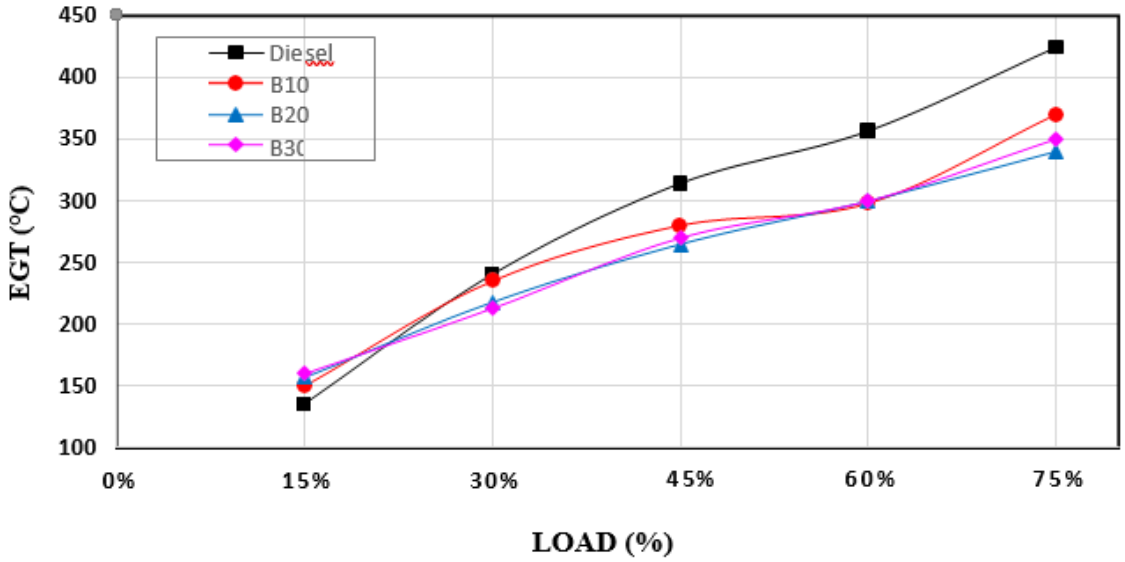

Figure 7 EGT variation in relation to Load (%).

Emission Analysis

Unburnt Hydrocarbon

The variation between HC emissions and load is given in figure 8. These are due to incomplete combustion of fuel, higher carbon to oxygen content. We find that HC emissions decrease with an increase in loading for all fuels. At lower load B10 is having maximum hydrocarbon emissions followed by B30 and then B20. Diesel is having the least emissions at a lower load. While at higher loads emissions are less as compared to a lower load. It can be inferred that biodiesel blends have more hydrocarbon emissions than diesel.

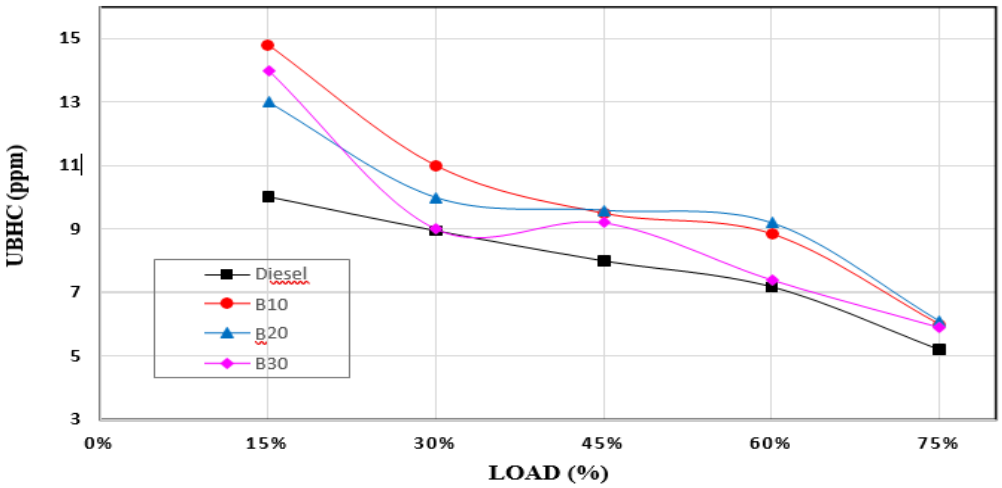

Figure 8 UBHC variation in relation to Load (%).

CO emissions

Figure 9 represents the variation of CO emissions with respect to load. These emissions are due to an insufficient amount of oxygen available for the complete conversion of carbon monoxide to carbon dioxide. With an increase in loading CO emissions increases with the highest of diesel at higher loads. At low load, B20 has the highest emissions than B30 and B10. Diesel having the least emissions at lower load but at high load, diesel has the highest emissions of CO. A similar pattern has been noted by a number of researchers during their research work(Gautam et al., 2016) [14].

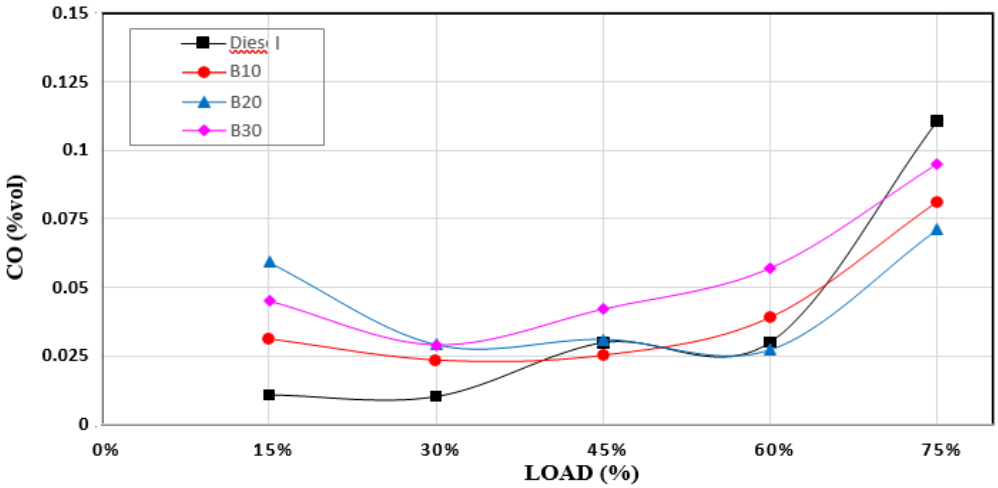

Figure 9 CO variation in relation to Load (%).

Oxides of Nitrogen

Figure 10 depicts the variation of NOx emissions with respect to loading. These emissions are also due to insufficient oxygen available for combustion. Since NOx is the most harmful, hence they need to be controlled.

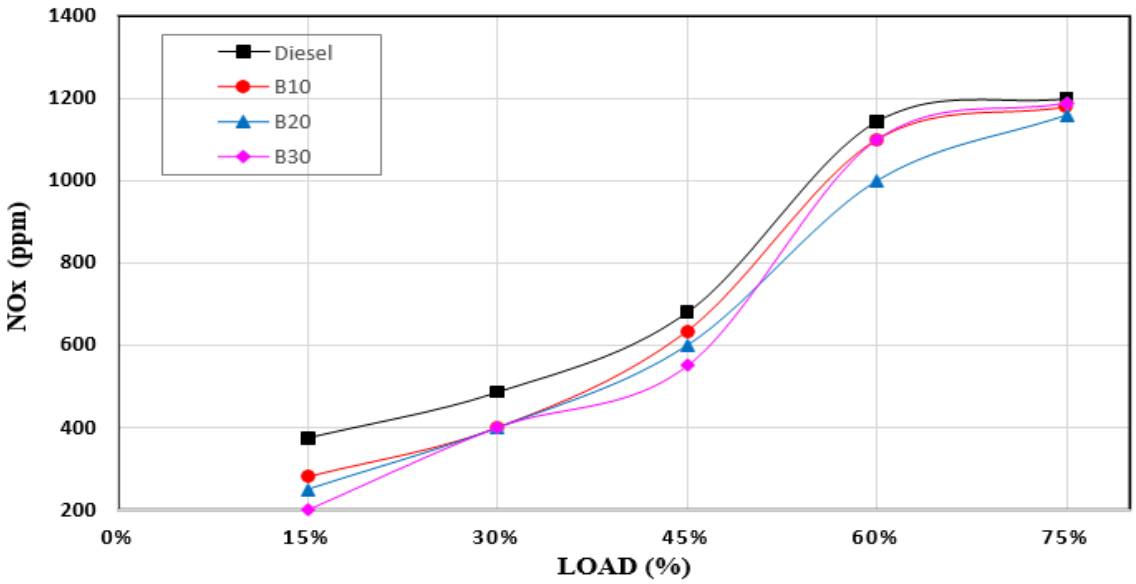

Figure 10 NO_x variation in relation to Load (%).

Here it is observed that NOx emissions increase with loading. Diesel has the highest emissions of NOx at all loads. All biodiesel blends have lower emissions than diesel and this has been only because of corn oil that is mixed to reduce NOx emissions only. At higher loads, B20 has the least emissions than other blends. B10 and B30 emit more than B20. Hence B20 is best for low NOx emissions.

Conclusion

Our research work was focused on preparing biodiesel from the mixture of Argemone and Corn oiland then the primary objective was to compare the performance and emission characteristics of Dieselwith that of the Biodiesel-Diesel blend at various proportions i.e., B10, B20, and B30, and in addition reduction of NOx emission was also under the preview of our research. The production process that was carried out by us ensured the feasibility of the formation of these blends. From our research we concluded the following key points:

– At higher loads, the BTE is found to be highest in the B10 blend, followed by B20 then B30, and diesel has the least amount of BTH among them. Whereas at lower load B10 and diesel arecomparable and highest BTE.

– In the case of EGT, we found that at lower loads, the temperature values are comparable for allblends as well as diesel. But at higher loads, B10 shows a significant decrease in the temperaturevalue followed by B30 and B20 respectively and these were lower than those of diesel. B20 being the best.

–In the case of HC emissions again the results were different for different loads. But a general trend showed that at lower loads, we saw that HC emissions in ppm of blends were almost similar when compared to diesel. But at higher loads, there were a slight increase in the HC (ppm) values of the blends.

– In the case of CO emissions, though at lower loads diesel produced the least amount of CO (ppm), at higher loads B20 produced the least amount of CO whereas diesel produced the highest amount of CO.

– In the case of NOx emissions, the B20 blend showed a significant reduction in NOx, both at higher and lower loads.

Hence, we can conclude that the B20 biodiesel-diesel blend comprising of 10% Argemone biodieseland 10% of corn oil biodiesel is far good when compared to that of other blends of B10 and B30 and that of diesel.

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Computational Analysis of Flow Characteristics and Heat Transfer Process of Flow Past an Oscillating Cylinder

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Abstract

The properties of the flow and transfer of heat mechanism as fluid flows past an oscillating cylinder are studied using a numerical simulation in this paper. One of the most well-known difficulties in this field of study is the analysis of the hydrodynamic effects on offshore pipelines, hot wire anemometers, cooling towers, heat exchanger tubes, constructing atomic reactors with nuclear fuel rods, etc. Additional uses for fluid flow and heat transmission can be seen in the cooling of electronic components and chips with different forms. The Reynolds numbers that are computed for various amplitudes, frequencies, and oscillation angles are Re = 197, 248, 296. The determining equations are solved using the Finite Volume Method (FVM) and SIMPLE algorithm. The results of the simulation are compared to the empirical formula, which is produced using different Reynolds numbers (Re). The amplitude fluctuation has a substantial variation on the varying flow field; however, this is not the case with frequency. The heat transfer improved dramatically with increasing amplitude and frequency, according to the findings. The mechanism of influence of enhancement of heat transfer is studied using the principle of field synergy (FSP). The flow field shows multiple flow regimes at different oscillating angles, and the Nusselt number initially declined and subsequently grew. Furthermore, in the majority of cases, optimal angle was 0 or 90 degrees.

Keywords: Oscillating Cylinder, Field Synergy Principle, User Defined Function

1. Introduction

Heat exchangers are used often in a variety of industries like nuclear, refrigeration, petroleum and electronic industries. Heat is transferred among the fluid medium that passes past it in most heat exchangers and the tube. Vibration concerns affect the ducts of steam generators, and the heat transmission process is affected over the vibration (Vivaldi, 2020). It's a huge task to understand the heat transfer process as well as by what means to improve the efficiency of heat exchanger. As a result, research into convective heat transfer augmentation is critical in today's heat exchanger applications. The method of heat transfer by means of convection is substantially most difficult than heat conduction, and most convection research relies on empirical equations. Guo et al. (1998, 2005) investigated boundary layer's equation of energy and proposed field synergy concept which better understood the mechanism. The Researchers discovered that the complication of convective heat transfer can be seen as a difficulty in conduction through heat origins. Researchers also confirmed that the number of field synergy and improvement of heat transfer are linked. According to Guo's research, methods for improving heat convection include changing the preconditions of velocity boundary, using specifically created inserts. Jiang et al. (2008) examined the flow of fluid and features of heat transfer of a vibrating tube numerically. In accordance with the field synergy theory, they used a method of dynamic mesh to evaluate the field flow surrounding the tube. When heat transfer was greatly enhanced, the temperature and velocity field established a strong synergy, according to results.

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The near-wall flow field is known to have a significant effect on heat transfer through convection. Changing the boundary layer regions is one technique to improve convective heat transmission, and several researchers are looking at the vibrating tube. The water flow inner tube with periodic cosine oscillation was researched by Lei et al. (Rui and Tao, 2018). During Re within 6180 and 14050 (velocity of flow within 0.31 and 0.69 meters per second), the two crucial parameters of frequency and amplitude were examined. Nu decreased at first, then grew as the frequency increased. The influence of bending stiffness upon the structure and size of the gap was examined by Wang et al. (2018a). At various Reynolds values, the greatest amplitude locations were discovered. The structural features and motion models of the vibrating plate were established to be primarily impacted by the low and the high pressure core.

There are two types of study directions in most vibrating pipe exchanger research. The tube vibrates below the flow of fluid, also known as vibration of self-induced, while another vibrates through the help of outside apparatus, which is known as external vibration (actively vibrating). To examine the Vortex-induced vibrations phenomenon, Jiang et al. (2016) presented the Boltzmann-lattice approach. In a Poiseuille flow, the square cylinder is forced to oscillate. Using various movement cylinders, they explored the case and discovered two kinds of self-sustaining oscillation. The hydro-dynamics and the heat transport features of pulsating flow around a cylinder were explored by Mikheev et al. (2017). To express varied flow patterns, they created a new dimensionless number. The testing results showed that the pulsing flow might improve the tube's heat transfer. Izadpanah et al. (2018) investigated influence by vibration of induced vortex upon transfer of heat by the elastic cylinder.

In past few years, novel heat generators have indeed been developed and studied. Martin et al. (2016) and Ji et al. (2016) are two researchers who have focused on the bundle of tube and pipe-in-pipe arrangement within FIV (Matin Nikoo et al., 2018). Wang et al. (2019) investigated the effects of proportion of tube ellipticity, angle of tube revolution, and fin spacing on heat exchangers of angled elliptical fin-conduit. Shi et al. (2014) investigated at how a flexible plate affected thermal boundary layer disturbance. Vortex-induced vibration (VIV) was discovered to considerably improve heat convection as a result.

In this study, a numerical model utilizing a circular cylinder with a low Re is proposed. The existing research concentrates upon transfer of heat and behavior of flow field in an oscillating cylinder as a function of frequency, slope and amplitude. The field synergy idea is beneficial in identifying how the heat convection changes since it’s being utilized to analyze underlying reason of augmentation of transfer of heat.

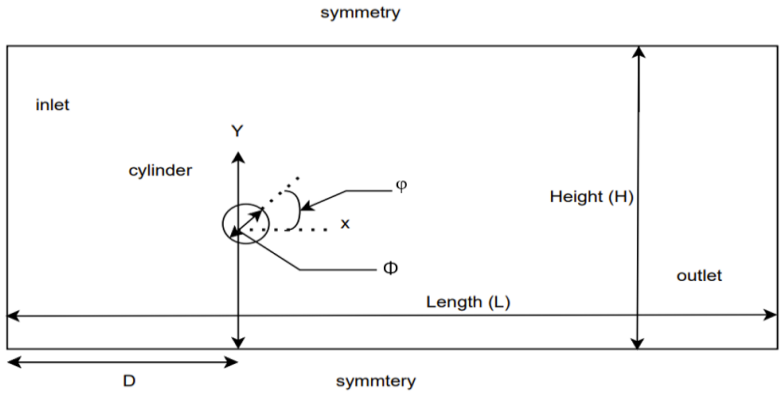


Figure 1 Physical model.

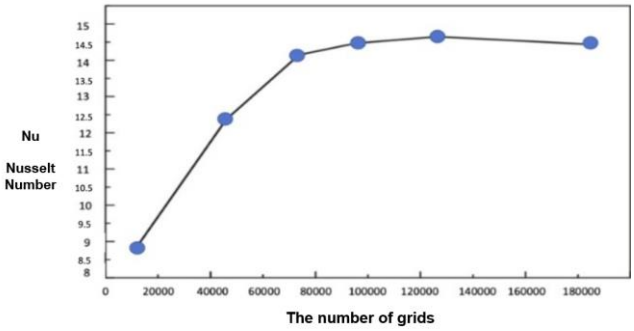


Figure 2 Confirmation of grid independence.

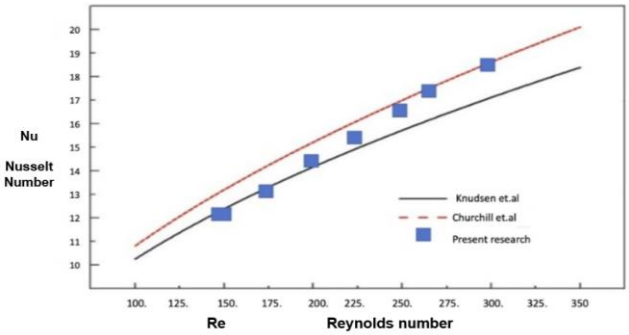


Figure 3 Comparison b/w empirical and numerical equation.

2. Modeling procedure

2.1 Modeling objective and approach

In this work, transfer of heat as well as flow domains are primarily addressed. **Figure 1** depicts the computational model schematically. The width and length of flow domain were denoted by letters L and H, respectively. From the inlet, the fluid flows alongside the horizontal axis. Furthermore, as the fluid flows through cylinder, the vortex region forms near the cylinder and then dissipates. The precise structural parameters are: Flow field Length L (mm) is **200**, Flow field Width H (mm) is **100**, The cylinder Diameter **Φ** (mm) is **8** and tube center and inlet distance D (mm) is **50**. Fluid flows at a continuous velocity past a circular cylinder, which is then permitted to oscillate along multiple directions. Fluid flow with a Reynolds number, Re 300 and a laminar and unstable fluid field are addressed in this work. The tube's vibrating model is controlled by UDF settings in the fluent programme. Since the actual world scenario with heat convection seems to be difficult. Following are the conditions that are proposed to simplify the numerical simulation:

(1) The fluid in motion is regarded as a Newtonian fluid with incompressible characteristics.
(2) In 2-D plane, the buoyancy and gravity related effects are ignored.

Mesh quality and grid numbers have an impact on the model's correctness. Low grid numbers may lead to inaccurate results, whereas a much greater fidelity may consume longer duration when calculating. Since the heat transmission technique is so crucial in this piece, the non - dimensional Nu is chosen as a benchmark for an impartial

examination. The flow velocity at inlet is consistently fixed at 0.021 m/s, as well as the temp of the intake is 20 degrees Celsius. The Nu remains steady & essentially unchanged whenever the mesh zone density exceeds 100001, as shown in the Figure. 2. Furthermore, so as to maintain the precision of the simulation, the mesh (126361 nodes) is utilized for subsequent numerical models. The equations of continuity, momentum and energy must be followed across the whole domain.

2.2 Boundary conditions

At the inlet, the Fluid flow is continuous and isothermal. Symmetrical boundary conditions are utilized on the lower and upper bounds. The cylinder is subjected to a no-slip parameter with a specific temperature. During the flow operation, the wall surface of a circular cylinder vibrates frequently. The wall's motion curve, as shown in Fig. 1, is in accordance with these equations:

$$x = A_o \cdot \sin(2\pi f \cdot t) \cdot \cos \varphi$$
$$y = A_o \cdot \sin(2\pi f \cdot t) \cdot \sin \varphi \quad (2.1)$$

In which A_o denotes the max amplitude, frequency of oscillation denoted by f, t denotes the period of oscillation, and φ denotes the angle of oscillation. At the outlet, the fluid is liberated to outflow. The temperature $T\infty$ is 20 degrees Celsius, and the temperature T_w is 40 degrees Celsius. Subject to all computational domains, characteristic variable with respect to operating substance (water-liquid) corresponds towards the average values within $T\infty$ and T_w. The following are the characteristic variables: Coefficient of Heat Conductivity k (W/mK) = 0.619, coefficient of Dynamic viscosity (Pas) = 0.000801 and Specific heat at constant pressure Cp (kJ/kgK) = 4.175,

2.3 Numerical methods

To meet the dynamic mesh requirement, this study utilizes an unstructured triangular grid. The movement of the cylinder is described by the Used Defined Function (UDF). After that, a basic approach is established based on the amalgamation of Pressure and Velocity which was applied to the model. When boundary displacement has a major impact on temporary mesh characteristic, the mesh could be remeshed to adapt entire grid. The mesh unit would change in response to the model's movement and the appropriate level h_{ideal}. If $h > (1+\alpha_k k)h_{ideal}$, then the grid could divide. As well as the compacted grid's height that fits the h_{ideal} criterion would be combined with the next grid to form a new grid. The collapse factor is α_h, while the split factor is α_k.

2.4 Principle of field synergy

The coefficient of heat convection h, which is a fundamental variable in the heat convection procedure, which is affected by a combination of parameters, making it difficult to analyze. Heat transfer and heat conduction are similar, as in accordance to Guo's findings. Convective heat transfer can be thought of as heat conduction involving thermal sources. The energy equations for a 2d laminar flow included as shown:

$$\rho c_p \left(u \cdot \frac{\delta T}{\delta x} + v.\frac{\delta T}{\delta y}\right) = \frac{\delta}{\delta y}\left(k.\frac{\delta T}{\delta x}\right) \quad (2.2)$$

$$-q = \frac{\delta}{\delta y} \cdot \left(k\frac{\delta T}{\delta y}\right) \quad (2.3)$$

The heat transfer process took place at the B.L., hence averaging across all B.L. zones yield the gives:

$$\int_0^{\delta_1} \rho c_p \left(u \cdot \frac{\delta T}{\delta x} + v.\frac{\delta T}{\delta y}\right) = - k\frac{\delta T}{\delta y} \quad (2.4)$$

3. Model validation

Prior to addressing the convection across a vibrating cylinder, a numerical approach is proposed for a stationary cylinder for verification. The fluid throughout the stationary circular cylinder is examined within Re values observed within the range of 149 (U = 0.015 m/s) to 296 (U = 0.03 m/s) and Pr = 4.52 throughout the investigation. Since method of convective heat transmission is complex, empirical model is indeed utilized in this specific study whenever Reynolds number is between 40 and 4000. On the basis of the available results, Churchill and Bernstein (1997) presented a good fitting graph within the larger range of the computational model.

$Nu=0.683Re^{0.466}pr^{1/3}$ (2.5)

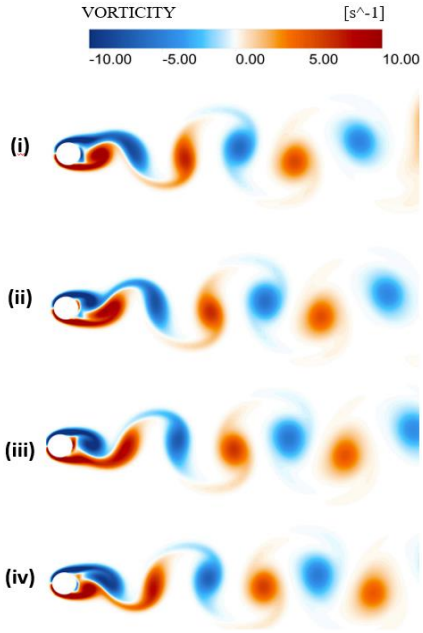
Figure 3 shows the comparison of the numerical simulation results with the empirical equation. Under different Reynolds numbers, the average-surface Nusselt number demonstrates a reasonable agreement as seen in the figure.

4. Results and discussion

4.1 Fluid flow past a stationary cylinder

4.1.1 Flow field variation

First, forced convection is used to transfer heat from a stationary cylinder. As seen in **Fig. 4**, the Karman Vortex phenomenon occupy the flow under continuous flow of 0.02 m/s. Fig. represents the changing behavior of the fluid in one changing phase.



The downward vortex flows from the bottom to the top due to the asymmetrical pressure differential in Fig. 4(i). Until the point of Fig. 4(ii), upward vortex sheds off the cylinder and moves in the flow field wake. In comparison to Figs. 4(i) and (ii), the flow fields in Figs. 4(iii) and (iv) displayed opposing flow patterns.

Two factors (coefficient of lift force and drag) are often examined in the technique of Karman Vortex Street. The drag force is affected by incoming flow and the drag force is perpendicular to the lift force. The lift force coefficient (Cl), which fluctuates as a result of vortex shedding, might be used to demonstrate the vortex's current state as the flow field changes. The Nusselt values are also used to assess convection capacities.

Figure 4 Vorticity contour for stationary cylinder at a period of vibration, a) $t = t_0$, b) $t = t_0 + 1/4$ T, c) $t = t_0 + 1/2$ T, d) $t = t_0 + 3/4$ T.

4.1.2 Investigation of field synergy principle (FSP)

The Nusselt number is jointly determined by either two fields, ∇T and U, or three scalar fields, cosβ, $|\nabla T|$, and $|U|$, under field synergy concept (Guo et al., 1998). The velocity distribution and temperature gradient are examined synthetically to investigate the process of heat convection enhancement. The field synergy degree ξ was used like a reference in this article. The circumference angle (α) from 90 degrees to 270 defines the waterward side, while the remainder defines the leeward side. The waterward side has superior convection capabilities than the leeward side. On the leeward side, the local Nu may increase. In the leeward side zone, the Nu reaches a maximum value of 25 for 180. And the Nu has dropped below 15 in much of the waterward side. Since the cylinder has restricted flow on the leeward side, a second flow will form, considerably enhancing heat convection. However, the regular vortex on the waterward side may sustain the flow in a condition of stability. The substantial variation in field synergy among the two parts of the domain might explain the discrepancies in heat convection capabilities.

4.2 Characteristics of heat transwfer with varying amplitude

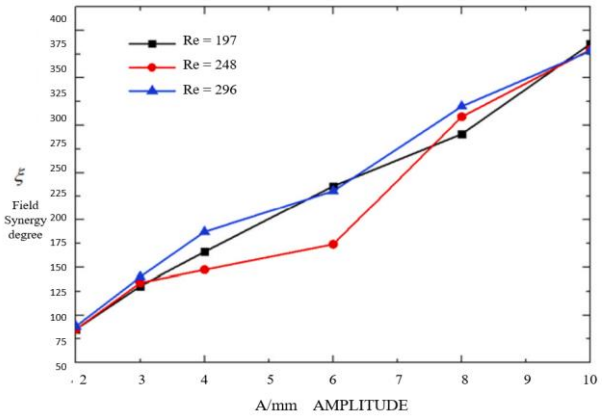


Figure 5 Field synergy degree as a function of amplitude and Reynold number.

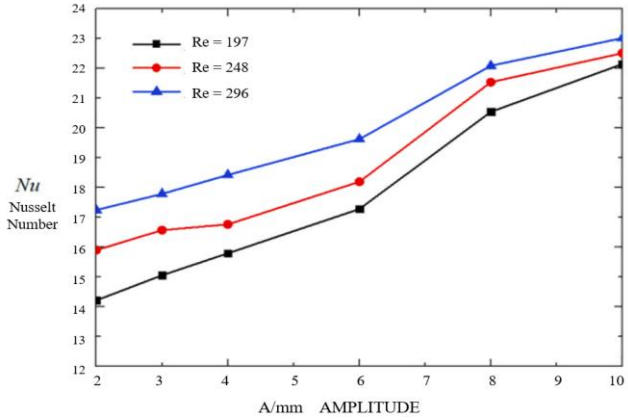


Figure 6 Nusselt Number as a function of amplitude and Reynold number.

Table 1 While the oscillating frequency is 1 Hz, the average Nusselt number in various amplitudes.

u∞(Re)	0.02 m/s (Re=197)	0.025 m/s (Re=248)	0.03 m/s (Re=296)
Station	14.44	16.56	18.57
A=2mm	14.22 (-1.53%)	15.92 (-4.11%)	17.25 (-7.09%)
A=4mm	15.81 (+9.50%)	16.78 (+1.15%)	18.25 (-0.71%)
A=6mm	17.29 (+19.76%)	18.21 (+9.78%)	19.64 (+5.78%)
A=8mm	20.23 (+53.44%)	21.55 (+29.87%)	22.10 (+19.09%)

Simulations show that when the amplitude of the flow field increases, more vortexes emerge. Under the low amplitude operating condition, vortexes displayed linear organization in a smaller region. However, because vortex strength increases with amplitude, vortex dispersion becomes more complicated and chaotic.

Figure 5 depicts the time-based Nu of various vibration amplitudes for three separate Reynolds values. With increasing amplitude, the Nusselt number grows. Table 1 shows the average Nusselt number (Nu) and the growth rate of the various amplitudes at the described Reynold numbers. When the oscillation amplitude was modest, convection did not improve considerably. However, heat convection was definitely greater at the high amplitude. When compared to the stationary cylinder, Nu was observed to rise by 53.44 percent, 35.78 percent, and 24.05 percent at elevated amplitude (10 mm). In accordance to Fig 6, the degree of field synergy exhibits a comparable fluctuating pattern as the Nu number. A higher Reynolds number increases heat convection capacities under varied operating situations. Changing the Reynolds number within the same amplitude has no change on field synergy

4.3 Effect of the varying frequency

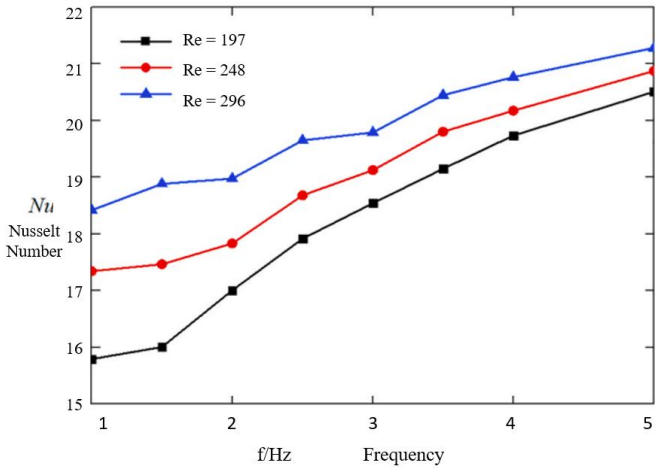


Figure 7 Variation of Nusselt number (Nu) with the frequency and Re.

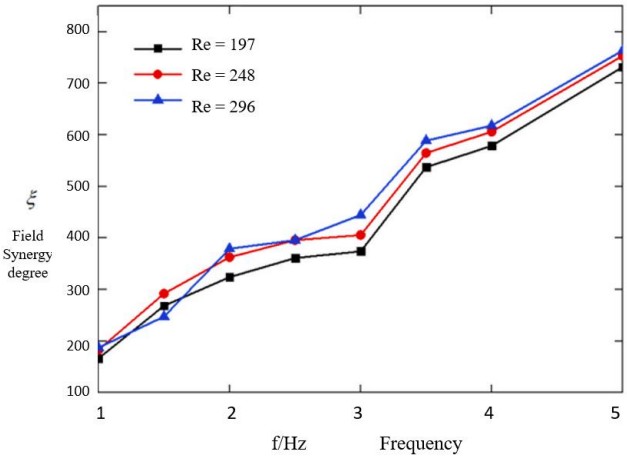


Figure 8 Variation of the field synergy degree with Reynold number and frequency.

Table 2 Amplitude of oscillation equals 4 mm, Average Nusselt number in different frequencies.

U∞(Re)	0.02 m/s (Re=197)	0.025 m/s (Re=248)	0.03 m/s (Re=296)
Station	14.44	16.56	18.57
f: 1Hz	15.78 (+9.44%)	16.78 (+1.16%)	18.43 (-0.71%)
f: 2Hz	17.02 (+17.86%)	17.85 (+7.55%)	18.97 (+2.33%)
f: 3Hz	18.55 (+28.48%)	19.14 (+15.39%)	19.80 (+6.67%)
f: 4Hz	19.75 (+36.82%)	20.18 (+21.66%)	20.78 (+11.98%)

To investigate the influence of frequency on the flow field and convection, the operating amplitude is set to 4 mm and y-axis is chosen as the vibrating direction. Vortex shedding happens on a regular basis, and vortex dispersion results in a single line with varied frequencies. However, as the frequency of the vortexes rose, so did the strength of the vortexes, particularly in the fluid's wake zone.

Figure 7 depicts the effect of 'f' on Nusselt numbers with varying Reynolds numbers (Re). The Nusselt number has improved considerably as frequency has increased. Low Reynold values led in a greater increase in Nusselt values. In Fig. 8, there is a rise in field synergy degree as frequency increases, but the Reynold number (Re) has no influence on field synergy degree. The average Nu and the rate of growth of various frequencies are shown in Table 2. When the frequency of vibration hits 5 Hz, the convection rate augmentation reaches 42.13 percent, 25.93 percent, and 14.72 percent when compared to the station cylinder. Lower Reynold numbers improved convection more.

4.4. Effect of inclination in vibrating cylinder

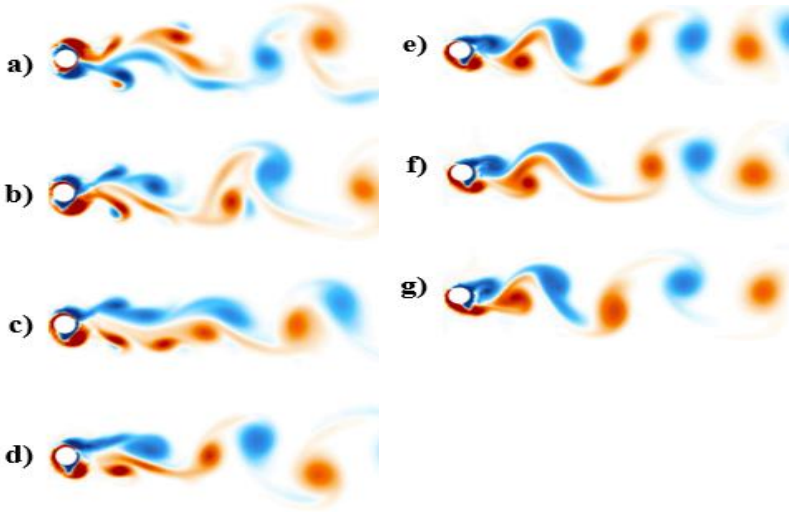


Figure 9 Vorticity contours for different oscillating angles.

An alliteration of the oscillating angle is done with an increment of **π**/12 from 0 to **π**/2 to evaluate effect of slanted oscillation performed by the cylinder. The vorticity contours for various oscillation angles are shown in **Fig.9**. When the oscillation angle (**ϕ**) is zero, vortexes are created simultaneously in opposite directions on both sides. In Fig. 9, dominant vorticity near cylinder's up and down rear borders has a different velocity curl direction (a). Because opposing vorticities generate at the same time, an interference is observed with each other during process of emission, hence producing in a flat shape. All vorticity lines trend slightly higher as the oscillation angle changes from 0 to **π**/2. The parallel biserial vortex eventually transforms into a single-row vortex as the oscillating angle increases.

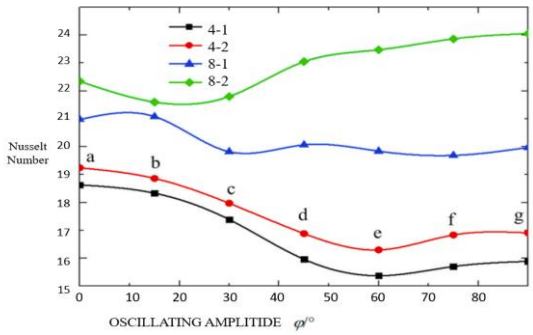


Figure10 Under varied oscillation amplitudes and frequencies, the Nu varies with the oscillating angle (**ϕ**).

Where frequency is 1, 2 Hz and the amplitude being 4, 8 mm for the respective frequencies, **Fig. 10** shows Average Nusselt Number under different working condition with different oscillating angle. In every dynamic process, the tendency for variation reduces first, then increases. The nominal effect of convection of heat occurs at 60 and optimum convection of enhancement occurs at 0 at an amplitude of 4 mm. Heat convection is observed to be maximum when **ϕ** = 90 while frequency being 2 Hz and Amplitude being equal to 8 mm as shown in **Table 3**. When the oscillation

angle is less than 30°, the amplitude and frequency changes have a less impact on the Nusselt number. When the oscillating angle changes from 60 - 90°, there is a large influence between the varied amplitude and frequency.

Table 3: Average Nusselt Number under different working condition with different oscillating angle.

Amplitude (MM)-frequency (HZ)	4 - 1	4 - 2	8 - 1	8 - 2
station	14.43			
ϕ=0°	18.63 (+29.11%)	19.24 (+33.33%)	20.97 (+45.32%)	22.34 (+54.82%)
ϕ=15°	18.33 (+27.03%)	18.86 (+30.70%)	21.08 (+46.08%)	21.60 (+49.69%)
ϕ=30°	17.39 (+20.51%)	17.97 (+24.53%)	19.82 (+37.35%)	21.80 (+51.07%)
ϕ=45°	15.96 (+10.60%)	16.88 (+16.98%)	20.07 (+39.09%)	23.05 (+59.74%)
ϕ=60°	15.37 (+6.51%)	16.30 (+12.96%)	19.84 (+37.50%)	23,47 (+62.65%)
ϕ=75°	15.71 (+8.87%)	16.83 (+16.63%)	19.69 (+36.45%)	23.87 (+65.42%)
ϕ=90°	15.89 (+10.12%)	16.91 (+17.19%)	19.98 (+38.46%)	24.06 (+66.74%)

5. Conclusion

Heat convection has been studied with relation to oscillating amplitude, oscillating angle, frequency and Reynold's number (Re). Mechanism of heat convection enhancement has been investigated using field synergy theory. Around our area of research i.e., oscillating cylinder, Von Karman vortex Street phenomena is studied in depth, together with characteristics of heat transmission and flow field. The following are the key findings of the numerical results:

– The effect of heat convection becomes more noticeable as the oscillation amplitude increases. Lower Reynold numbers resulted in better augmentation of convection of heat.

– There is more heat convection in cases where there is high frequency. It was also observed that variance in the flow pattern of a single vorticity line was not significant, but the vortex's intensity increased as the frequency increased.

– The Nusselt number's variance versus the oscillation angle dropped, then climbed. For frequency of 2 Hz and an amplitude of 8 mm, the most optimal site is related to = 90.

– The high degree of agreement between Nusselt number and the field synergy suggested the application of the FSP to fluid passing through a cylinder.

As a result, the rotating cylinder may achieve a stronger heat convection effect. Based on the principle of field synergy, potential research is possible to determine impact of a complex heat transmission due to the flowing field. In the industrial domain, it can be widely used to enhance heat transfer characteristics in different mechanisms and settings such as biological filters, where airborne particles are captured in large part by the fluid flow characteristics through and around porous filters.

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Real Time Analysis of Material Removal Rate and Surface Roughness for Turning of AL-6061 using ANN and GA

Baibhav Kumar[1*] and Naveen Kumar[1]

Abstract

The paper shows and includes targeted supervision of optimizing machining objectives, Material Removal Rate and surface roughness being important to machining efficacy of any workpiece, simulation-based modeling helps in failure mitigation. The potential of ANN- GA mathematical approach for prediction and optimization of MRR and surface roughness of AL 6061, an analysis based statistical study has been discussed. The computational model between the desired output and the inputs have been configured using Multiple Regression- Genetic Algorithm and Artificial Neural Network (ANN) methods. The closeness in predicted and optimized data sets were mapped using integrational ANN with GA to interpolate efficacy in optimality.

Keywords: Artificial Neural Network (ANN), Material Removal Rate (MRR), Genetic algorithm (GA), Surface roughness, depth of cut, feedrate, Regression analysis, ANOVA

Introduction

The industrial machining requirements calls for the need of precision and manufactured product efficacy. The diverse machining processes and its role in shaping final product has crucial role making products industrially ready. Turning operation on horizontal lathe machine is one of those integral machining operation, where by cylindrical surfaces of required diameter consideration and surface profile is achieved. Turning being work piece driven and single point cutting tool driven machining, economics of industrial manufacturing necessities for optimal machining parameter selection to simulate desired output without any catastrophic manufacturing. ANN being an widely looked up tool where by multiple machining parameter can be architected into input, hidden and output layers, ability to use learning outcomes in training sets. Aluminum 6061 alloyis one of integral industrial friendly alloy which makes its presence in several applications like aviation components, automobile parts, weapon casings, and high vacuum chambers. These industries look for low allowance operational values andutmost precision is desirable in these respective manufacturing. The inclusion of Artificial Neural Networks mitigates with missing data and machining parameters learn by examples, making real-time simulated modelling possible. With exclusively integrating with GA, optimization of Discrete MRR outputs in turning operation can be predicted even with due considerations of minute errors in the inputs, with quick inheritance and good accuracy.

Literature Review

Ramu I. et.al [7] explained and demonstrated a planned procedure of Taguchi method for parameter design and applying it for the data on turning. The next step was to find out the optimal fit for the process parameters depending upon S/N ratio and to asses the significance for each parameter by performing ANOVA analysis.

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T.M. Chenthil Jegana et al. [1] This paper covers an important aspect and brings upon how ANN should be housed with such elements of functionality as storing information, decision making, reasoning, learning, and integration of these into the process. The above considerations in particular, the learning characteristics parameters is a unique feature of the ANN Turning operation optimization.

Tiagrajah V jannharimal et al. [8] discusses important, Multi Objective Genetic Algorithm (MOGA) will be analogous to an optimal operator for the developed model. This way Turning operation input parameters like run elements feed rate, cutting speed and depth of cut were assessed as input variables and corresponding surface roughness, specific power consumption and cutting force were opted as output variables.

S. Nes¸eli et al. [2] discusses the geometrical tool profile upon the surface finish obtained in case of turning of AISI 1040 steel. To asses the effect of tool profile parameters on the surface roughness during turning, response surface methodology (RSM) methodology was considered and formulation of prediction model was related to average surface roughness (Ra) using experimental data. The results reasoned that the tool geometry nose radius was major contributor on the surface roughness.

Ndaruhadi, P.Y.M.W et al. [4] helps in assessing surface roughness value t was found that feed did not significantly influencesurface roughness. Among the influencing factor, the rank is tool type, cutting speed, and cutting direction.

Dhabale, R et al. [6] presents a new idea to generate process plan from feature-based modeling, based on an inclusive ofgeometric modeling method that proposes both feature-based modeling and feature information storage.

Experimental studies and datasets

Table 1. Dataset for input parameters

Run Order	*Speed (RPM)*	*Feed Rate (mm/min)*	*Depth of Cut (mm)*	*MRR (mm^3/min)*	*Ra (μs)*
1	180	0.2	0.2	113.927	1.04
2	180	0.2	0.4	212.018	0.98
3	180	0.2	0.6	261.698	2.2
4	180	0.315	0.2	672.129	2.44
5	180	0.315	0.4	333.569	3.84
6	180	0.315	0.6	897.738	2.4
7	180	0.4	0.2	22.443	2.06
8	180	0.4	0.4	953.491	2.3
9	450	0.4	0.6	901.732	3.66
10	450	0.2	0.2	780.859	0.9
11	450	0.2	0.4	528.915	0.94
12	450	0.2	0.6	145.761	2.9
13	450	0.315	0.2	176.76	1.42
14	450	0.315	0.4	303.637	3.38
15	450	0.315	0.6	2263.05	1.34
16	450	0.4	0.2	40.271	1.74
17	450	0.4	0.4	890.513	1.94
18	710	0.4	0.6	4822.2	2.88
19	710	0.2	0.2	130.586	0.86
20	710	0.2	0.4	744.814	0.92
21	710	0.2	0.6	2862.91	1.98
22	710	0.315	0.2	592.809	1.14
23	710	0.315	0.4	3098.48	1.22
24	710	0.315	0.6	9365.24	1.16
25	710	0.4	0.2	948.858	1.2
26	710	0.4	0.4	5658.57	1.38
27	710	0.4	0.6	3305.82	2.68

The above table of datasets depicts input parameters considered for turning operation, the billet of Al-6061 was considered with dimension of 4*6*8 (mm) the feed rate, depth of cut, cutting speeds and corresponding Material Removal Rate obtained. The machining parameters considered was kept in accordance withindustrial requirements of turning operations on AL 6061. AL 6061 being considered industrially as high strength heat treatable alloy. It is also known for withstanding corrosion and very good weldability. The chemicalcomposition consideration for 6061 aluminium includes 97.9% Al, 0.6% Si, 1.0% Mg, 0.2% Cr, and 0.28% Cu. The density of 6061 aluminium alloy is 2.7 g/cm^3 with adequate formability and workpiece can be machined using turning operation to meet industrial demands.

The objective of carrying our research on given dataset is to model conventional turning operation to asses optimal value of Output parameters material removal rate and surface roughness for ensuring precision and accuracy of machining.

Methodology

The experimental results were assessed on design and modeling level by taking considerations of Taguchi Method and MRR –surface roughness were assessed based on response of predicted data statistically without remotely performing set experiments. The experimental results derived in original experimental research are in synchronization to the ANN predicted results.

The MATLAB nn- toolbox is integrated for training and testing of neural network model. The results inferred using Artificial Neural Network (ANN) indicate fair closeness between the predicted output values and that of experimental values. Thereafter , Genetic Algorithm (GA) is made inclusive with neural network model to determine the optimal machining elements considerations feed rate, depth of cut and cutting speed to get desired industrial demand in accordance to needs of optimality in process parameters Material removal rate and surface roughness inturning operation.

The due considerations of exploration in data analysis were looked into for establishing relationship between input and output variables, The mentioned integration assessed the non-linearity between parameters. Due to unavailability of solutions for non-linearity, ANN was integrated into our project for its ability to learn and model complex solutions.

Development Artificial Neural Networks

Artificial Neural networks are the framework that are intended to reproduce the working of a human mind. With the assistance of involvement and information Artificial Neural Network works on itself utilizing artificial neurons. Artificial Neural Network comprise of rudimentary units called as neurons which take at least one sources of info and produces a result.

Computations that are carried out on each neuron if ANN are as follows:

$$Z[i] = W[i]*A[i-1] + b[i]$$

$$A[i] = f(Z[i])$$

Here the notations are as follows:

W[i] represents the weight of the neuron

A[i-1] represents the output derived form last layer

b[i] represents the bias of the connection

f(x) represents the non linear activation function

A neural network consists of several layers which are grouped as neural network mimics as input layer, hidden layer and output layer. Here layer depicts the set of parallel neurons without having connections between them.

Neurons from input layer are keyed to hidden layer which in turn is connected to the output layer in the whole Artificial Neural Networks System.

In our model we have used Gradient Descent back propagation method for the best tuning of the neurons present in each layer

For our model we have used MATLAB nntool for training and obtaining of Artificial Neural Network. and results associated withthe Neural networks. For ANN in MATLAB we first imported and classified our dataset into input set which include input parameters viz. that includes Cutting Speed, Depth of Cut, Feed Rate and after classification of Input data we had made another classification which was target set that includesdata of output parameters viz. Material Removal Rate and Surface Roughness.

A neural network comprises of various configurations such as type of network used, Training function, Learning function, Transfer function, number of neurons in input, hidden and output layers and number of epochs. To get the best result it is veryimportant to have best value for these configurations. The table below has listed down the functions and specifications that weused for our neural network.

Levenberg- Marquardt algorithm is taken as the training function due to its wide applications in solving non-linear problems by curve fitting and Mean Square error function is chosen as the performance function for accurate model.

To get the accurate neural network model by tuning weights and bias efficiently we have used Gradient descent back propagation technique

Table 2 Neural Network Parameters.

Network Type	Feed Forward Back Propagation
Training function	TRAINLM
Adaptive Learning Function	LEARNGDM
Performance Function	MSE
Number of Layers	5
Number of Neurons in hidden layers	[5, 3, 4]
Transfer Function	TANSIG
Number of Epochs	1000

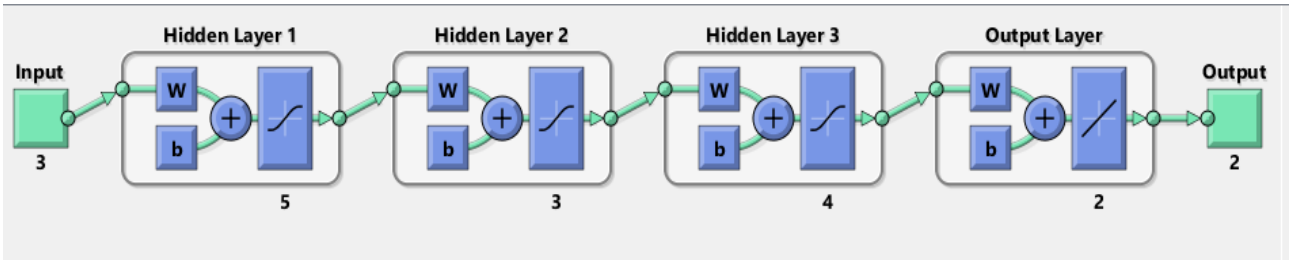

Figure 1 Neural Network Model in Matlab.

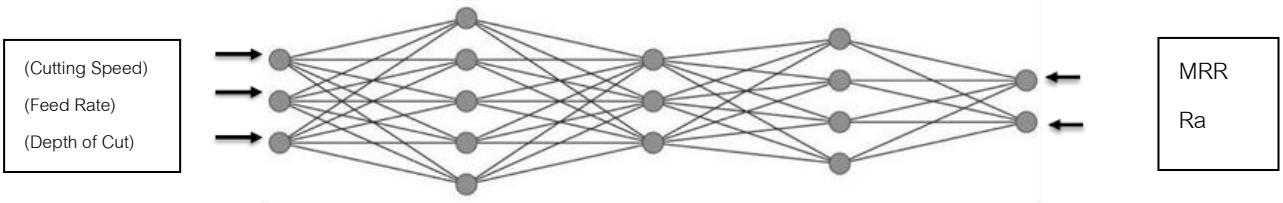

Figure 2 Neural Network Model Architecture.

Stochastic Gradient Descent is the optimization algorithm used for adaptive learning as it minimizes the gradient and adjustsweights accordingly. Weights and biases are tuned in an iterative manner to obtain optimum values for least error.

Results of Artificial Neural Networks

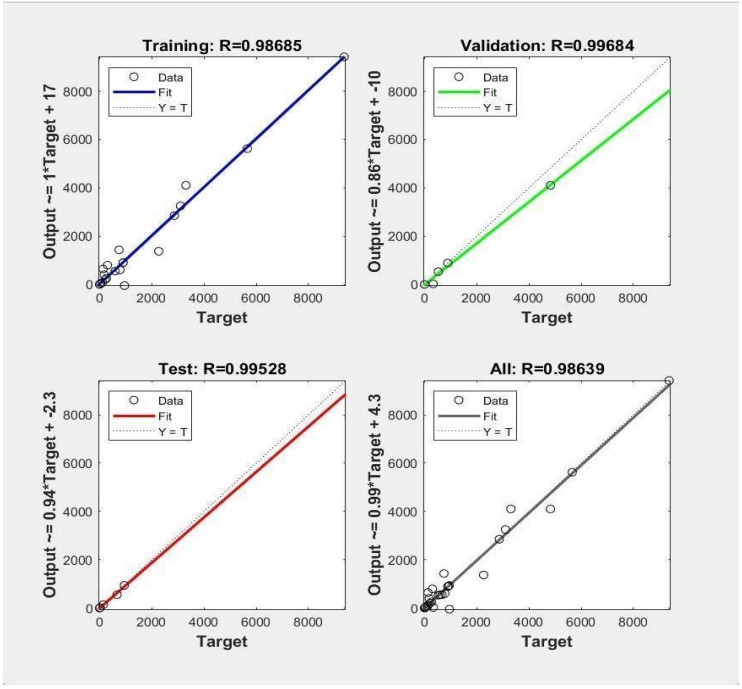

Figure 3 Regression Plots.

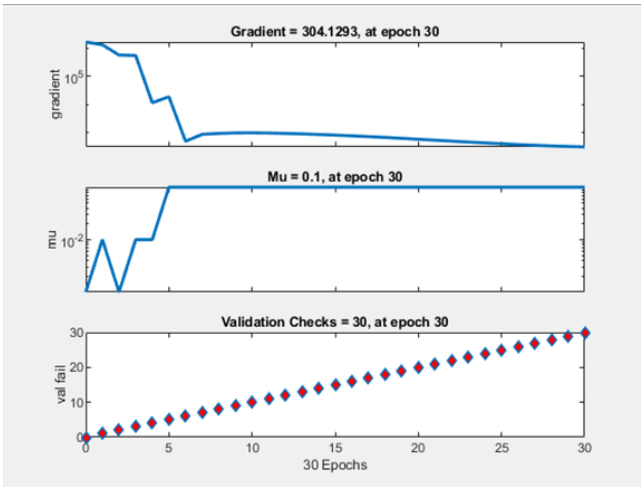

Figure 4 Validation Performance.

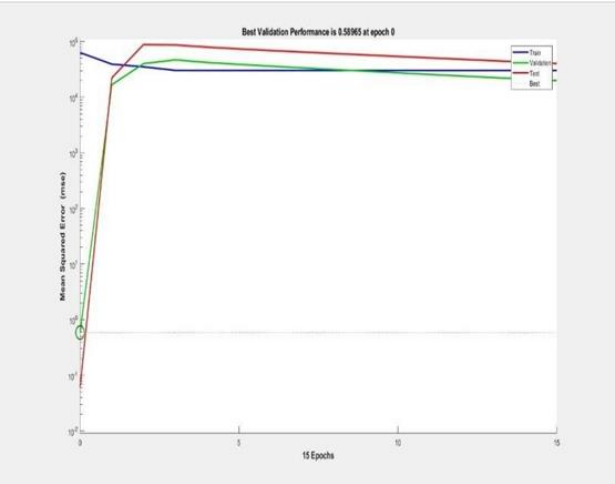

Figure 5 Gradient Descent Plots.

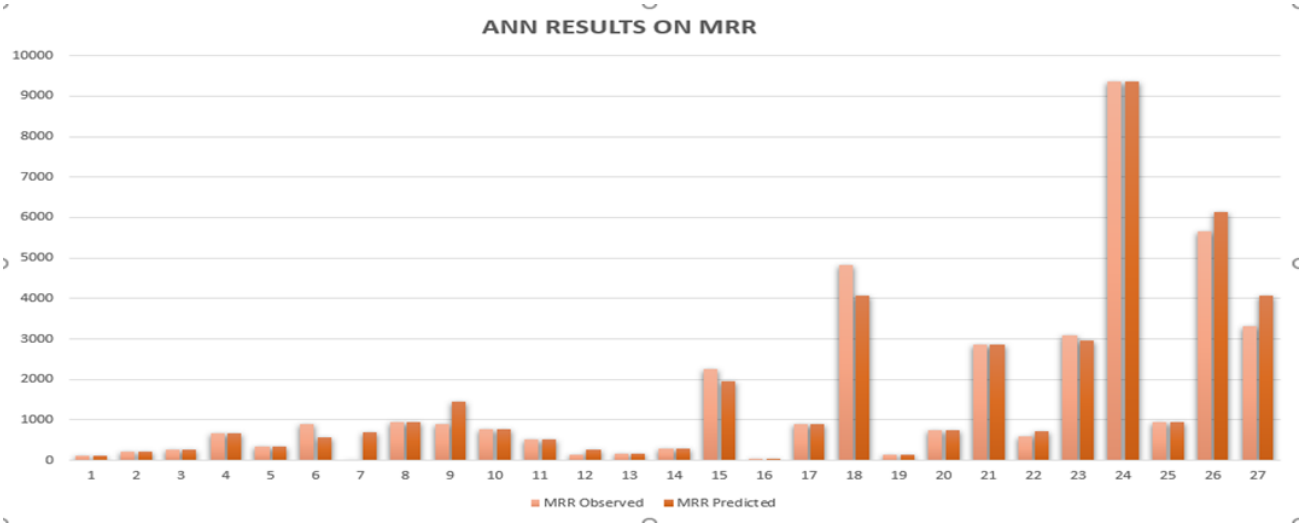

Figure 6 Observed Vs Predicted MRR.

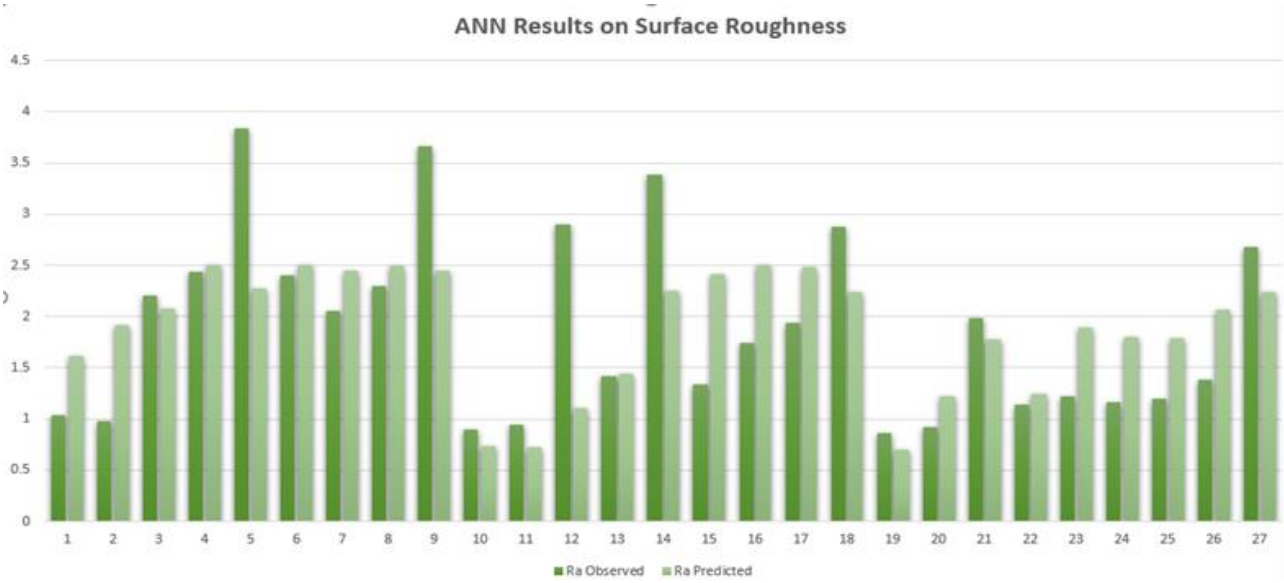

Figure 7 Observed vs predicted.

Table 3 ANN Results.

	Experimental		Predicted	
S.No.	MRR (mm^3/min)	Ra (μs)	MRR (mm^3/min)	Ra (μs)
1	113.927	1.04	114.165	1.61
2	212.018	0.98	212.155	1.91
3	261.698	2.20	261.80	2.08
4	672.129	2.44	672.159	2.51
5	333.569	3.84	333.641	2.27
6	897.738	2.40	572.567	2.50
7	22.443	2.06	691.35	2.44
8	953.491	2.30	953.427	2.49
9	901.732	3.66	1461.130	2.44
10	780.859	0.9	781.045	0.73
11	528.915	0.94	529.102	0.72
12	145.761	2.9	260.810	1.11
13	176.76	1.42	177.068	1.44
14	303.637	3.38	303.654	2.24
15	2263.05	1.34	1942.553	2.41
16	40.271	1.74	40.401	2.50
17	890.513	1.94	890.598	2.48
18	4822.2	2.88	4064.131	2.24
19	130.586	0.86	130.751	0.70
20	744.814	0.92	744.989	1.21
21	2862.91	1.98	2863.012	1.78
22	592.809	1.14	720.44	1.24
23	3098.48	1.22	2958.771	1.89
24	9365.24	1.16	9365.190	1.79
25	948.858	1.20	948.953	1.78
26	5658.57	1.38	6147.365	2.07
27	3305.82	2.68	4064.131	2.24

Table 3 above shows the experimental values and predicted values of Material Removal Rate (MRR) and Surface Roughness (Ra) achieved from Artificial Neural Networks. Regression results are also plotted in Fig.4 for training, testing and validation set whereour model achieved the accuracy of 98.68% for training and 99.52% for testing set. The plots

represents the fitting of model whereR represents the square of observed and predicted relations. More the value close to 1 better are the results.

Apart from that Gradient descent visualization in Fig.5 and Validation performance in Fig.6 are also plotted. A comparison between the observed and predicted values of Material Removal Rate and Surface Roughness are also plotted in Fig. 7 and Fig.8which shows how much predicted values are deviated from observed response.

Optimization using Genetic Algorithm

Genetic algorithm considerations include evolutionary revolution optimization which centers around natural selection, inheritance, mutations and crossovers.

The genetic algorithm considered to be trial and tested classical evolutionary algorithm. With inclusion of random comprehends that in order to find a concrete solution using the GA, random changes are to be considered. Note that GA may be called Simple GA due to its ease inputcompared to other EAs.

GA is based on law governing principle of Darwin's theory of evolution. It is a delayed continuous process that marches by making slight and interval changes. Also, GA makes slight changes towards its results slowly until ending up the best solution.

In a genetic algorithm, efficacy ensured population of candidate results (called individuals, creatures, or phenotypes) to an optimization problem is continually evolved towards better solutions. The choice of opting Genetic Algorithm in optimising turning operations points out to its easy compatibility and integrability compared to other parallel optimisation algorithms like Ant Colony optimisation, swarm optimisation and others.

The GA is known to immute the natural selection as proposed by Darwin and decodes algorithm best suited to give best possible predictions, optimality is configured for both MRR and surface roughness. The major flow practice includes following :

1. Selection (Reproduction)

It is brought down initiated first operator and is based on selection criteria. It selects the unit of chromosomes from the population of parents, cross overand produce offspring. It is inspired from evolution theory of "Survival of the fittest" given by Darwin.

There are numerous methods involved for the genome operators for reproduction or selection such as :

I. Tournament selection

II.Ranked position selection

III. Steady state selection

2. Cross Over

Population is enhanced with improved individuals after primary reproduction phase. Then crossover operator is comprised to the mating pool anddevelop better strings. Crossover operator improves upon clones of good strings but does not develop entirely new ones. By recombining characteristics of good individuals, the method is likely to create even more apt fit individuals.

3. Mutation

Mutation is considered as an operator at background. Mutation for instance drives flipping the mentioned by changing 0 to 1 and vice- versa. After crossover, the mutation operator subjects to the strings to mutation. It promotes an unexpected change in a gene within a chromosome.

Thus, it facilitates the algorithm to look for the results far away from the present ones. It ensures that the search algorithm is not limited to a local optimum. The main consideration of this background operator is to apprehend early convergence and maintain diversity within the population. The added advantage of performing modal state with behavioral integration is appreciable.

1. Response Surface Methodology

Response surface methodology is an integral mathematical tool which resonates with modelling and response of problems in which a response of interest is affected by innumerable variables, and the objective is to reduce for the optimal value. The inclusion of RSM, Relationship between the preferred response and independent input variables could be produced as:

$$Y = f\left(x_1, x_2, x_3, \ldots\ldots\ldots\ldots x_n\right) \pm e_r$$

Where,

y -preferred response, f - response function (or response surface),

x1, x2, x3, …, xn - independent input variables,

er - fitting error

The predicted surface response in accordance to response function as obtained from graph plotting of function f, the closness of fwill help in reaching to true results. The second order polynomial regression model was framed which results out to be:

$$Y = c_{o} + \sum_{i=1}^{n} c^{i} X_i + \sum_{i=1}^{n} b^{ii} X_i^2 + \sum c_{ij} X_i X_j \pm e_r$$

The following considerations of assumptions of surface roughness is often shown with linear, crossed and squared product terms of Xi's design finds the second-order response surface very precisely.

The second-order response surface highlights the surface roughness (Ra, lm) can be expressed as a function of cutting speed , depth of cut and feed rate.

$$MRR = a_o + a_1(A) + a_2(B) + a_3(C) + a_4(A^2) + a_5(B^2) + a_6(C^2) + a_7(AB) + a_8(BC) + a_9(CA)$$

$$Ra = a_o + a_1(A) + a_2(B) + a_3(C) + a_4(A^2) + a_5(B^2) + a_6(C^2) + a_7(AB) + a_8(BC) + a_9(CA$$

The following phase of documentation and experimentation saw the inclusion of machining parameters like depth of cut, feed rateand cutting speed on surface roughness and trials on included data sets were carried and machining on turning operation in dry condition was studied .

Here :

A = Cutting Speed

B = Feed Rate

C = Depth of Cut

2. Regression Analysis

The efficacy of desired optimality condition is obtained with the integration of regression analysis. The regression analysis uses the experimental data to compute the coefficients for equations which shows the study assessment system at any traversed point in the experimentally range. The inclusion of regression analysis in output oriented machining parameters like feed rate, depth of cut and cutting speed were taken into consideration.

By taking reference from Table 1 we have found out the coefficients for Material Removal Rate and Surface Roughness and hence find the regression equation for the above given parameters and if we put the input parameters viz. Cutting Velocity, Feed Rate, Depth of cut into the equation we will get the desired experimental Material Removal Rate and Surface Roughness and then compareit with the predicted values.

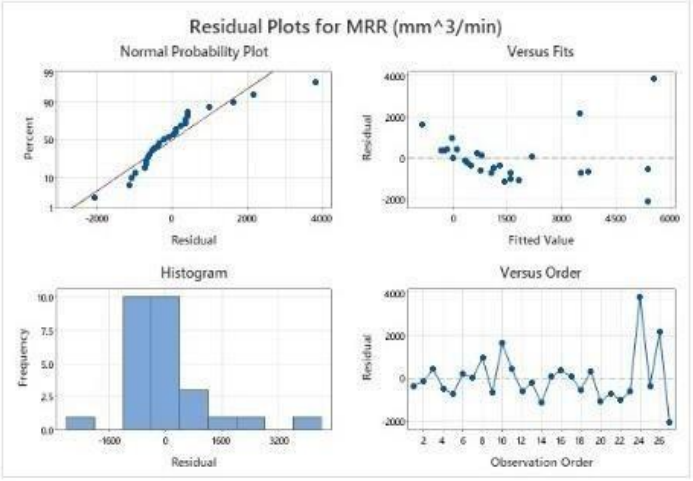

Figure 8 Residual Plots for MRR.

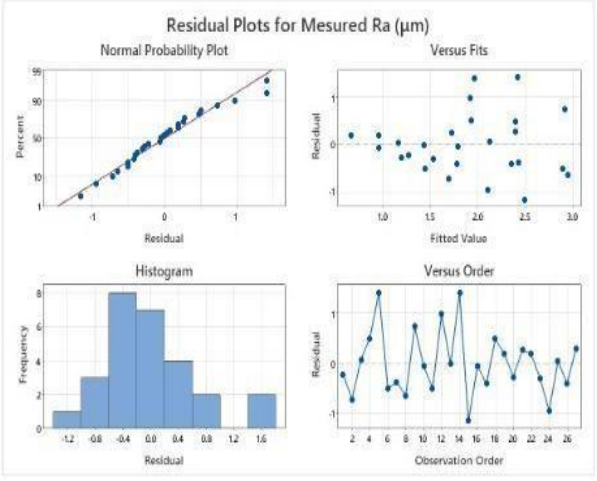

Figure 9 Residual Plots or Ra.

Regression Equation for Material Removal Rate (MRR):

MRR(mm^3/min) =-3250-21.72*A+ 50978 *B -2958 *C +0.01396 *A^2-96052* B^2-3983* C^2+ 19.0* A*B + 3847* B*C + 20.84*A*C

Regression Equation for Measured Surface roughness (Ra):

Measured Ra(μm)= -1.16 +0.00175*A +12.8 feed rate*B +0.17 *C -0.000002 *A^2-10.8* B^2 +1.67* C^2- 0.00578*A*B +1.67*B*C - 0.00578* A*B +1.9 *B*C + 0.00120 A*C

The computation and variance analysis was performed using ANOVA analysis where sums of squares and separated and thenvariance among these are checked due to different parameters and accordingly best fitted regression equation is formed. The ANOVA analysis terms were computed in accordance to MINITAB 21 calculation process flow. The design tree interface ofANOVA helped in data integration and regressive predicted values closure to statistically proven data sets.

In Fig. 8 and Fig. 9 residuals plot are shown for Material Removal Rate and Surface Roughness respectively. Normal Probability plot shows the fit of the distribution to the data and shows how the data is fitted along the distribution line. Versus Fits helps in verifying the random distribution and constant variance. Versus order plot helps in verifying that the residuals are independent fromone another and showing no particular pattern among the residuals.

3. Fitness Function

After finding coefficients for the regression equation from the Regression Analysis we got our fitness function for Material Removal Rate (MRR) and Surface Roughness (Ra). Fitness Function is very important in applying Genetic Algorithm Optimization. Fitness Function is the equation which is dependent on the inputs given for the desired outputs for e.g. Here are inputs are CuttingSpeed, Feed Rate, Depth of Cut and are output are Material Removal Rate and Surface Roughness. Fitness Function tells how goodor fit the data is according to the aims set for the outputs. Our output will be optimized on the basis of fitness function equation

Fitness Function for Material Removal Rate (MRR):

y(1) = -3250 - 21.72*x(1) + 50978*x(2) - 2958*x(3) + 0.01396*(x(1)^2) - 96052*(x(2)^2) - 3983*(x(3)^2) + 19.0*(x(1)*x(2)) + 3847*(x(2)*x(3)) + 20.84*(x(1)*x(3))

Fitness Function for Surface Roughness:

y(2) = -1.16 + 0.00175*x(1) + 12.8*x(2) + 0.17*x(3) - 0.000002*(x(1)^2) - 10.8*(x(2)^2) + 1.67*(x(3)^2) - 0.00578*(x(1)*x(2))+ 1.9*(x(2)*x(3)) + 0.00120*(x(1)*x(3))

Results of Optimization using GA

After developing fitness function we have defined the bounds for the inputs and population size were determined which was takenas 50. Tournament Selection was used and for the reproduction the crossover function was set to 0.6. Adaptive feasible function was used as the crossover function and Single point mutation function was used.
The upper and lower boundary for the input parameters are given below:

$180 \leq$ Cutting Speed ≤ 710

$0.2 \leq$ Feed Rate ≤ 0.4

$0.2 \leq$ Depth of Cut ≤ 0.6

Result for Material Removal rate and Surface Roughness obtained from genetic Algorithm is:

Table 3 Optimized Results from GA.

S.No	Material Removal Rate (mm^3/min)	Surface Roughness (μm)
1.	698.66	0.91

The results obtained from genetic algorithm for Material Removal rate and Surface Roughness are summarized in the Table 4. We obtained total of 18 optimized results out of which are criteria for selection was that Material Removal Rate should be maximum and for Surface Roughness was chosen to be less than equal to 1μm. The surface Roughness was chosen as per the industry requirements. The real-world manufacturing processes can be mechanized towards optimality using response methodology and reducing parametrization within optimality.

Conclusion

In our study the optimization of conventional turning operation was performed with considerations of machining performance parameters like feed rate, cutting speed and depth of cut and optimal MRR was predicted, industrially viable using ANN and GA. For studying relationship between linearity of plots between actual and predicted, ANN model was developed and accuracy up to – were achievedon training and datasets. The model showed the closeness to input values and values pertaining to optimality was selected. The accounted error fall well within industrial limits were achieved. The integration of GA optimization led to calibrate targeted machining parameter suited index and achieve minimal loss of material finish compromise.

Future Scope

We are hopeful with successful integration of ANN- GA tools in being proactive prediction methodology, industrial machining parameters like nose radius, rake angle can be included for enhancement of current working process. The added advantage of computational contingent ability of process flowing complex machining ability and reduced machining time while taking into account of technological and material limitations. The promising solutions to existing gap in behavioral prediction in intelligent machining and right solution practices for automatic selection of themachining parameters may open new avenues to real time-based manufacturing process optimization.

The design mode failure incorporation can be minimized up to greater extent and accuracy in desired manufactured product can be achieved leading to overall increase in productivity. The cycle time of failure and material enhancement can be viewed in real perspective.

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Computer Science and Information Technology (CI)

Development of Instructional Material in Motion Graphics on Fundamental Concepts of Object-Oriented Programming

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Abstract

The purposes of this research were: 1) to develop motion graphics instructional material on fundamental concepts of object-oriented programming; 2) to compare the learning achievement both before and after learning with the instructional material in motion graphics; 3) to study the satisfaction of students towards motion graphics instructional material. The sample group used in this research was 35 3rd year undergraduate students in the field of information systems in Rajamangala University of Technology Suvarnabhumi at Phra Nakhon Si Ayutthaya Wasukri Center who enrolled in object-oriented programming in semester 1/2021. Students were taught by motion graphics instructional material consisting of 2 lessons: lesson 1 object-oriented concepts and lesson 2 principles of object-oriented programming. The research instruments consisted of 1) motion graphics instructional material on fundamental concepts of object-oriented programming; 2) the student achievement test had a confidence value of 0.89; 3) the student satisfaction assessment had a confidence value of 0.91. The statistics used in the data analysis were mean, standard deviation, and paired t-test.

The results of the research revealed that: 1) instructional material in motion graphics on fundamental concepts of object-oriented programming had an efficiency value of 75.14/77.43; 2) the students had higher learning achievement with motion graphics instructional material than before learning and 3) the motion graphics instructional material had a high level of student satisfaction.

Keywords: Instructional Material, Motion Graphics, Object-oriented Programming

Introduction

There are many factors that affect education trends in Thailand. It is not only the teaching process but also the external factors that are important and affect the ability to succeed and develop education in the country. That factor is the technology factor, which is the factor that affects the current and future trends in education in Thailand. Due to the continuous advancement of information technology, which is beneficial to increase the competitiveness of the country. Therefore, education that requires additional knowledge about new technologies in teaching and learning should be organized [1]. The important turning points that affect the development of higher education in Thailand are learning skills in the 21st century (21st Century Skills) and the concept of Thailand Education 4.0 (Education 4.0) that give importance to the knowledge transfer of teachers at the higher education level. Know and manage teaching and learning in accordance with the objectives of the curriculum. Instructors must have modern teaching techniques that rely on technology to develop learners' learning. The learners must be developed to have knowledge and understanding of academic content and be able to think critically and communicate effectively.

Department of Information Systems and Business Computing, Faculty of Business Administration and Information Technology, Rajamangala University of Technology Suvarnabhumi, Phra Nakhon Si Ayutthaya Wasukri Center aims to produce graduates in the field of information systems in the sector. Instruction is provided to ensure

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that students achieve learning outcomes in accordance with the framework of a higher education standard. Therefore, the department encouraged teachers to use technology to develop graduates to have desirable attributes. The new teaching materials are used for learning various subjects, such as materials in the form of computer-aided lessons, infographics, and motion graphics. These all attract more attention from learners because they include 2D images, 3D images, sounds, animations, and motion graphics. Students can study through teaching materials at any time and use them in conjunction with normal teaching and learning arrangements.

Over the past few years, it was found that the majority of students enrolled in subject 306-32-05, object-oriented programming, had moderate academic performance. It was found that the content was quite difficult to remember or understand. Students need to study fundamental concepts of object-oriented programming first, and then they will be able to practice object-oriented programming. Therefore, the researcher has developed motion graphics instructional material to stimulate learners' learning so that learners can learn by themselves effectively. This study is in line with the research results of Kumar & Jamil [2], which used motion graphics to teach in higher education. It was found that learners had a better sense of media and understood the content with better learning outcomes than lectures. In addition, the research results of Wiana, Barliana, & Riyanto [3] studied the effectiveness of using interactive multimedia based on motion graphics in concept mastering enhancement and fashion designing skills in digital format. From the calculation result after using Normalize Gain, there is an increase of higher learning results in students with interactive learning based on motion graphics, compared with student achievement in conventional learning. In this research, interactive multimedia learning based on motion graphics is effective toward the improvement of student learning in concept mastering indicators and on the aspect of making fashion design in digital format.

Based on the above problems, the researcher developed instructional material in motion graphics on fundamental concepts of object-oriented programming to help promote students' self-learning alongside classroom lecture methods. Students can review the content as needed. As a result, students remember and understand the content of the course, which will be useful for further teaching and learning.

Objectives

1. to develop instructional material in motion graphics on fundamental concepts of object-oriented programming to be effective according to the standard 75/75.
2. compare the learning achievement both before and after learning with instructional material in motion graphics on fundamental concepts of object-oriented programming.
3. study the satisfaction of students towards instructional material in motion graphics on fundamental concepts of object-oriented programming.

Research Framework

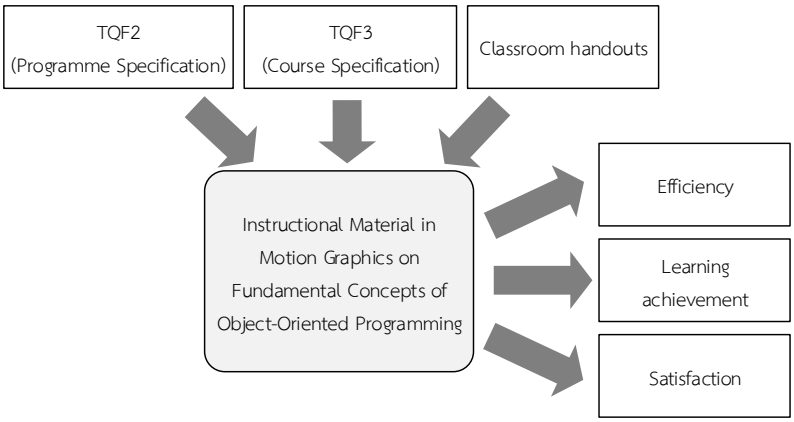

Figure 1 Research framework of motion graphics instructional material.

Instructional material in motion graphics on fundamental concepts of object-oriented programming created by the researcher. It was based on a detailed study of the Bachelor of Business Administration Program in Information Systems, programme specification (TQF2), course specification (TQF3), and classroom handouts. The result of the instructional material is the efficiency of motion graphics instructional material, learning achievement, and learners' satisfaction.

Methodology

This research is research and development (R & D) to present the sample group, research instruments, evaluating research instruments quality, which are detailed as follows:

Sample Group

The sample group used in this research was 35 3rd year undergraduate students in the field of information systems in Rajamangala University of Technology Suvarnabhumi at Phra Nakhon Si Ayutthaya Wasukri Center who enrolled in object-oriented programming in semester 1/2021.

Research Instruments

1) Instructional material in motion graphics on fundamental concepts of object-oriented programming.
2) Student achievement test. It is a multiple choice test of 30 questions.
3) student satisfaction assessment form consisted of content, design, and interaction with learners.

Evaluating Research Instruments Quality

Instructional material in motion graphics on fundamental concepts of object-oriented programming created by the researcher. It was based on a detailed study of the Bachelor of Business Administration Program in Information Systems, programme specification (TQF2), course specification (TQF3), and classroom handouts. There are two lessons: 1) object-oriented concepts and 2) principles of object-oriented programming. The quality of the motion graphics instructional material was tested by 5 experts. It was scored the quality of the motion graphics instructional material at a good level ($\bar{x}$ = 4.18, SD = 0.64) when it was separated in descending order: the content side ($\bar{x}$ = 4.27, SD = 0.64), interaction with the learners ($\bar{x}$ = 4.16, SD = 0.69), and the design side ($\bar{x}$ = 4.10, SD = 0.61). The

researcher took experts' recommendations to improve instructional material and used them in teaching experiments to determine the effectiveness of motion graphics instructional material. The researcher used one-to-one testing, three non-sample students, taking a test during class with motion graphics instructional material, and taking a post-test that was the same set as the during class test. Scores from the quiz were calculated to determine the efficiency of motion graphics instructional material based on criteria, 75/75 value (E1/E2) is 67.78/68.89. The researcher then improved the motion graphics instructional material in the content section to make it easier to understand. The researcher experimented with small group testing with 10 non-sample students using the same experimental methods as one-to-one trial, achieving an efficacy value (E1/E2) of 71.67/74.00. The third field testing experiment was conducted on 30 non-sample students using the same experimental methods as experiments with small groups, achieving an efficacy value (E1/E2) of 75.22/76.00.

Student achievement test is a multiple choice question. According to the content and learning objectives, there were 60 questions, but only 30 were used. They were reviewed by 5 experts to examine the correctness of the test, and the relationship between the content and the objective by using IOC and the result was 1.00. The test was revised, according to experts' recommendations and it was trialed with 30 non-sample students. The tests used were of difficulty between 0.2-0.8 and discrimination (r) from 0.2 or higher. 30 questions were selected for the exam and used to find the confidence value using the formula of Kuder-Richardson (KR-20), which has a confidence value of 0.89.

Students' satisfaction assessment learned through the motion graphics instructional material are divided into three areas: content, design, and interaction with learners. There are the 5-level, 17 questions to assess satisfaction, according to Likert scale [4]. A range of 4.51-5.00 means very high, 3.51-4.50 means high, 2.51-3.50 means average, 1.51-2.50 means low, and 1.00-1.50 means very low. 5 experts reviewed the satisfaction assessment form using the IOC value of 1.00. And then, it was experimented with 30 non-sample students and the confidence was determined using Cronbach's alpha coefficient method. It obtained a confidence value of 0.91, and then it would be applied to the sample group.

Results

The development of instructional material in motion graphics on fundamental concepts of object-oriented programming consisted of the content below:

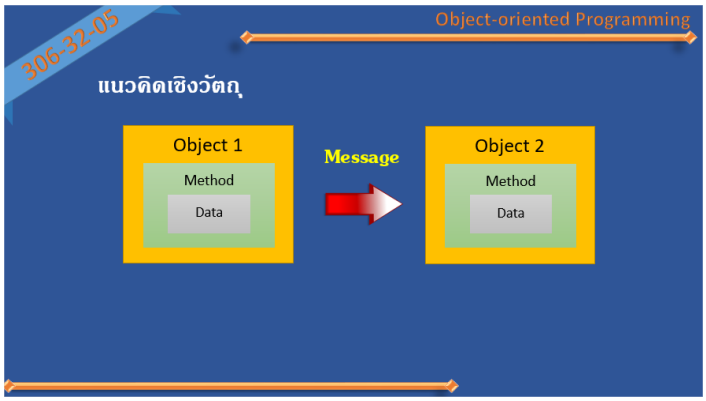

Figure 2 Object-oriented concepts.

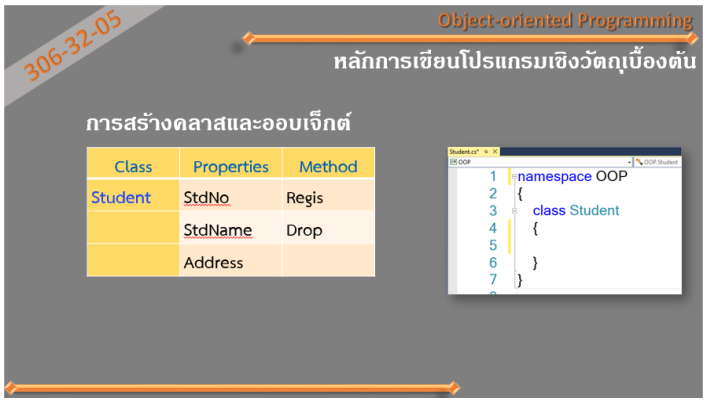

Figure 3 Principles of object-oriented programming.

The results of finding the efficiency of instructional material in motion graphics based on criteria 75/75.

Table 1 The efficiency of instructional material in motion graphics based on criteria 75/75. (n=35)

Score	Maximum score	Average $\bar{x}$	Standard deviation (SD)	Efficiency (E)
During class (E1)	30	22.54	1.95	75.14
Post-test (E2)	30	23.23	2.25	77.43

Student achievement with instructional material in motion graphics on fundamental concepts of object-oriented programming.

Table 2 Student achievement with instructional material in motion graphics with paired t-test. (n=35)

Score	Maximum score	Average $\bar{x}$	Standard deviation (SD)	t	p
Pre-test	30	16.89	2.49	11.23	.000*
Post-test	30	23.23	2.25		

*Statistically significant at .05 (p<.05).

Assessment of satisfaction with instructional material in motion graphics on fundamental concepts of object-oriented programming.

Table 3 Students' satisfaction with instructional material in motion graphics. (n=35)

Satisfaction	Average $\bar{x}$	Standard deviation (SD)	Satisfaction level
Content	4.13	0.81	high
Design	4.08	0.76	high
Interaction with learners	4.23	0.76	high
	4.14	0.78	high

Discussion

1. Development of instructional material in motion graphics on fundamental concepts of object-oriented programming for 35 3rd year undergraduate students in the field of information systems in Rajamangala University of Technology Suvarnabhumi at Phra Nakhon Si Ayutthaya Wasukri Center who enrolled in object-oriented programming in semester 1/2021 had an efficiency of 75.14/77.43. Instructional material is designed in accordance with course descriptions and learning objectives in the course specification (TQF3) and researcher manages learning by applying technology to produce graduates with desirable characteristics as defined in the program specification (TQF2). It is related to the research "Factors Related the Ideal Characteristics of Thai Graduates According to Thailand Qualification Framework for Higher Education (TQF: HEd) the Nursing Student of Boromarajonani College of Nursing, Surat Thani" [5]. The results showed that the factors learning style correlated with the ideal characteristics of Thai graduates according to TQF. For the most part, learners are good at learning things that match their preferences, and learn well from a format that reduces lectures from the classroom teacher with a variety of learning arrangements. Therefore, diversified learning styles should be developed as it affects the desirable graduate characteristics according to the Thai Qualifications Framework for Higher Education.

2. The student's learning achievement after learning was significantly higher than before learning at 0.5, the average score of pre-test is 16.89 ($\bar{x}$ = 16.89, SD = 2.49), and the average score of post-test is 23.23 ($\bar{x}$ = 23.23, SD = 2.25). This may be due to the graphic motions instructional material. It has content that meets learning purposes. Moreover, the media consists of visuals and sounds are beautiful and attractive. This enabled students to achieve higher post-test scores than pre-test scores. It is related with Kim's research [6] who studied effects of animated graphics of plate tectonics on students' performance and attitudes in multimedia computer instruction. The results indicate that students using animated visuals did significantly better than students using static visuals with respect to knowledge of plate tectonic. In addition, Hanif's research [7] searched the development and effectiveness of motion graphics animation videos to improve the science learning outcomes of fifth graders. Students were divided into two experimental groups: a control group using a still picture and 2D image media learning method, and an experimental group learned with animated motion graphics video. The t-test results showed significant differences in cognitive learning outcomes between the control group and the experimental group. The results were scored after study between the control group and the experimental group. Scores were 65.67 and 71.72 respectively. Thus, developed motion graphics animation videos are better at promoting the scientific achievement of 5th graders than 2D image media.

3. The motion graphics instructional material had a high level of student satisfaction. ($\bar{x}$ = 4.14, SD = 0.78). It was because the instructional material had interesting presentation patterns using animated graphical characteristics. Therefore, students are more motivated to study. This leads students to pay attention in studying lessons through motion graphics media. It is related with Moon's research [8] who studied the effects of 3D interactive animated graphic on student learning and attitudes in computer-based instruction. It found that students in the 3D animated graphic condition exhibited more positive attitudes toward instruction than 2D static, 2D animated, and 3D static conditions.

Conclusion

Motion graphics instructional material on fundamental concepts of object-oriented programming has been developed to be used as a tool for teaching and learning in parallel with the teaching style of lectures in the classroom. Motion graphics instructional material is developed in accordance with the course specification (TQF3). The teachers used the instructional material to provide teaching and learning to make students have better learning results. From the research results, students had higher learning achievement with motion graphics instructional material than before learning. This shows that students have a good understanding of the content when learning with motion graphics instructional material. In addition, motion graphic instructional material is also used as a tool to attract learners so that students feel good and want to learn by themselves. From the results of the research, the students were satisfied with the motion graphics teaching material at a high level. This may be because the teaching materials are easy to understand. It has a beautiful and interactive format that is easy for learners to learn. From the results of the research, the students were satisfied with the motion graphics teaching material at a high level. This may be because the teaching materials are easy to understand. It has a beautiful and interactive format that is easy for learners to learn. Therefore, teachers should provide teaching methods by using modern teaching materials such as motion graphics, and multimedia, which will result in better learning efficiency for students.

Recommendations for the next study:

1. Motion graphics instructional material should be developed to contain content for all lessons of object-oriented programming.
2. Motion graphics instruction material should be developed along with other teaching-learning methods.

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Classification of Spotted Leaves Plants by Physical Characteristics using Image Processing Technology

Nattakan Thonhual[1*], Chutima Klanpaitoon[1] and Chanvate Ingkavet[2]

Abstract

This research proposes methods for the classification of physical characteristics of spotted leaves plants using image processing technology. Objectives with the following: 1) Classify physically characterization of the spotted leaves plants by defining their margins by color tones, 2) Group the color tones according to the color values detected from the motifs of the spotted leaves plants, and 3) Assess the accuracy of the physical characterization of spotted leaves plants from an expert. This study used a variegated rubber tree, a popular spotted leave plant used for indoor air purification. Image filtering was employed to prepare image information. Moreover, the region growing method was used for edge detection. Furthermore, the Advanced Comprehensive Color Feature (ACCF) method was performed for color tones detection. In addition, k-means clustering was applied to classify the color tones. Finally, the accuracy validation of the research process was determined using statistical values.

The results showed that 1) the region growing used in this study was able to classify physically characterization of the spotted leaves. They were able to detect the boundaries of the tone color of the edges of the pattern, 2) the color tones could be grouped according to the values of color they appeared correctly, and 3) the results of the assessment of the rims of the color tones. Color tones detection by Advanced Comprehensive Color Feature method and color tones group classification by k-mean clustering gave 100% accuracy.

Keywords: Image filtering, Region growing, Advanced Comprehensive Color Feature, K-means clustering

Introduction

Currently, the popularity of planting trees has continued and this tends to be increasing, which is due to the trend of online and social media, where there is a lot of tree photography. Including the epidemic situation of the coronavirus COVID-19 that makes people who have to stay at home need to plant trees to help relax. Trees are planted both inside and outside the building. They create beautiful, shady areas and help purify the air. In particular, beautiful foliage plants or spotted plants are popular with buyers because of their unique color tones, which are rare, in some cases grown for commercial purposes. Many of them turned their careers into farmers in order to grow the high-priced spotted leaves. They generate a substantial income by setting the price between the seller and the buyer. There are no clear rules based on their satisfaction and negotiation. The motifs and tones of the plant's mottled leaves are important components of a buyer's purchasing decision. For example, Aureo-striata, Yellow-striped Heliconia, and Monstera adansonii aurea variegated, Variegated rubber tree. The indication of the tone of the spotted leaves for the seller to present to the buyer will use the principle of consideration from sales experience. The characterization from the human eyes may take quite a long time to classify and also cannot tell the value of the color tones that appear clearly.

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The above problems, therefore, are the origin of the principle of image analysis and processing, which uses computers to process, such as image enhancement and noise filtering. Image segmentation and object images are analyzed with quantitative data such as the size, shape, and direction of motion of the object in the image.

The research on the classification of the physical characterization of the spotted leaves plants uses image processing technology to present methods in the physical characterization of spotted leaves plants. This study used a variegated rubber tree, a popular houseplant choice due to its ease of care, attractive foliage, and tree-like presence. Image filtering (Rana Al-Taie, 2021) was employed to prepare image information. Moreover, the region growing method was used for edge detection. Furthermore, the Advanced Comprehensive Color Feature (ACCF) (Jothiaruna, Joseph Abraham Sundar & Ifjaz Ahmed, 2021), method was performed for color tones detection. In addition, k-means clustering (Na, Xumin & Yong, 2010), was applied to classify the color tones. Finally, the accuracy validation of the research process was determined using statistical values. Objectives with the following: 1) Classify physically characterization of the spotted leaves plants by defining their margins by color tones, 2) Group the color tones according to the color values detected from the motifs of the spotted leaves plants, and 3) Assess the accuracy of the physical characterization of spotted leaves plants from an expert.

Figure 1 Variegated rubber tree.

Methodology

This Research Methodologies in Physical Characterization of Spotted Leaf Plants using Image Processing Technology comprised a sequence of processes according to the following objectives:

1) Physically characterization of the spotted leaves plants by defining their margins by color tones

Data Pre-processing

Image data was obtained by photographing the leaves of a multicolored rubber tree planted by a home researcher using a Samsung Galaxy Android smartphone and selecting 15 leaves used in the experiment with smooth leaf margins. And the beautiful pattern was clear. After that, the background of the spotted leaves was erased and the image enhancement using add noise and mean filtering. This is shown in Figure 2.

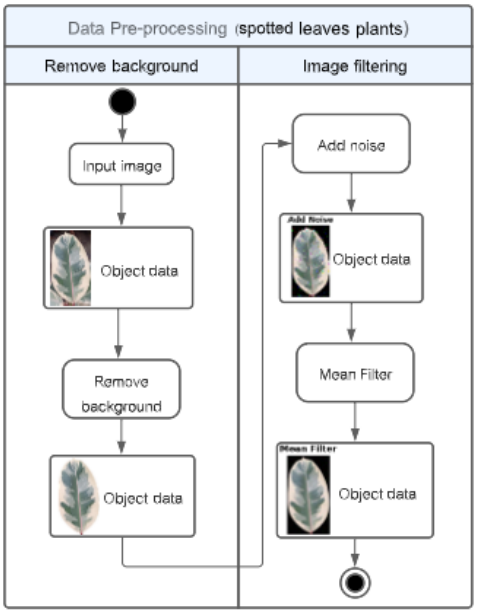

Figure 2 Data Pre – processing.

Region growing method

The Region Growing method takes neighboring pixels into account, grouping them together by considering the intensity of pixels of similar value.

This research lets the user define seed points (x,y). The process of the region growing this can be done by scanning the image from left to right and top to bottom. When an image spot at the edge of the seed region is found, it considers neighboring image spots by placing a mask over that image spot. If any adjacent image points have a color scale within the region of the magnification, it will combine or expand the area image to that side point, but if not, then the next side point will be considered. In this region, the growing process will take place. Every seed region iterates over and over until the region cannot be expanded. This is shown in Figure 3.

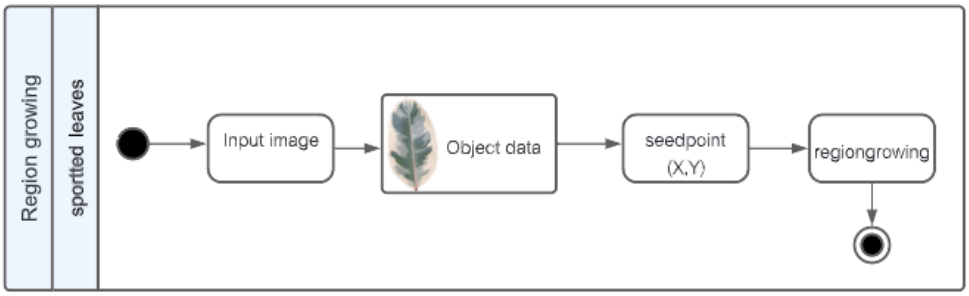

Figure 3 Region growing.

Advanced methods Comprehensive Color Feature (ACCF)

This research uses the Advanced Comprehensive Color method concept for the detection of color gaps in the pattern of spotted leaf plants with different color values according to physical characteristics, use RGB color model are the red, green, blue channel and Determine the number of color groups (number of classes=4) in the spotted leaves.

The tone value detection of the plant's mottled leaves is an important component of a buyer's purchasing decision and the intensity of the color with a value between 0 and 255.

This is shown in Figure 4.

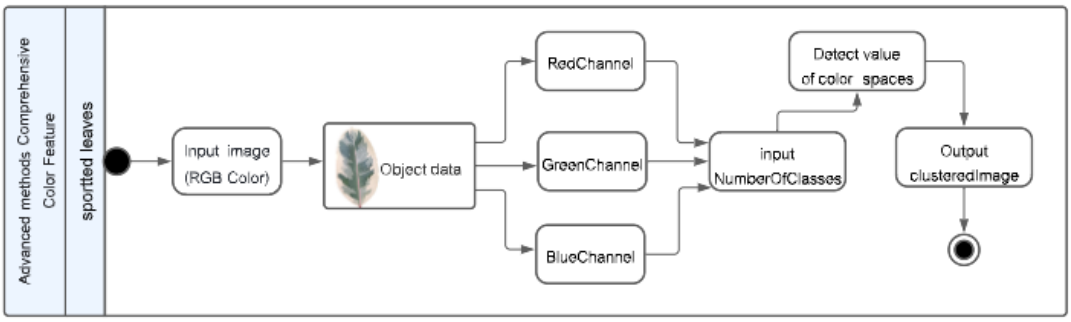

Figure 4 Using Concept of Advanced methods Comprehensive Color Feature.

2) Grouping the color tones according to the color values detected from the motifs of the spotted leaves plant

K-means clustering

This research uses the K-means clustering algorithm for grouping the color tones according to the color values detected from the motifs of the spotted leaves plant.

K-means clustering 5 step

Step 1 and 2: Choose the number of clusters (k=4) and select a random centroid for each cluster.

Step 3: Assign all the points to the closest cluster centroid.

Step 4: Recomputed centroids of newly formed clusters.

Step 5: Repeat steps 3 and 4 once.

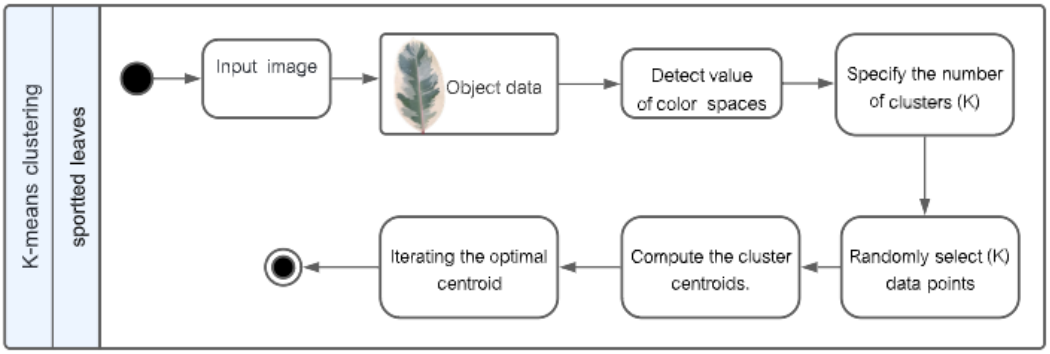

Figure 5 K-means clustering.

3) Assess the accuracy of the physical characterization of spotted leaves plants from an expert

An expert who assisted in introducing the color tones division of spotted leaves plant was a lecturer at the Faculty of Agriculture, Rajamangala University of Technology Suvarnabhumi.

Results and discussion

1) Physically characterization of the spotted leaves plants by defining their margins by color tones

Result of Region Growing method

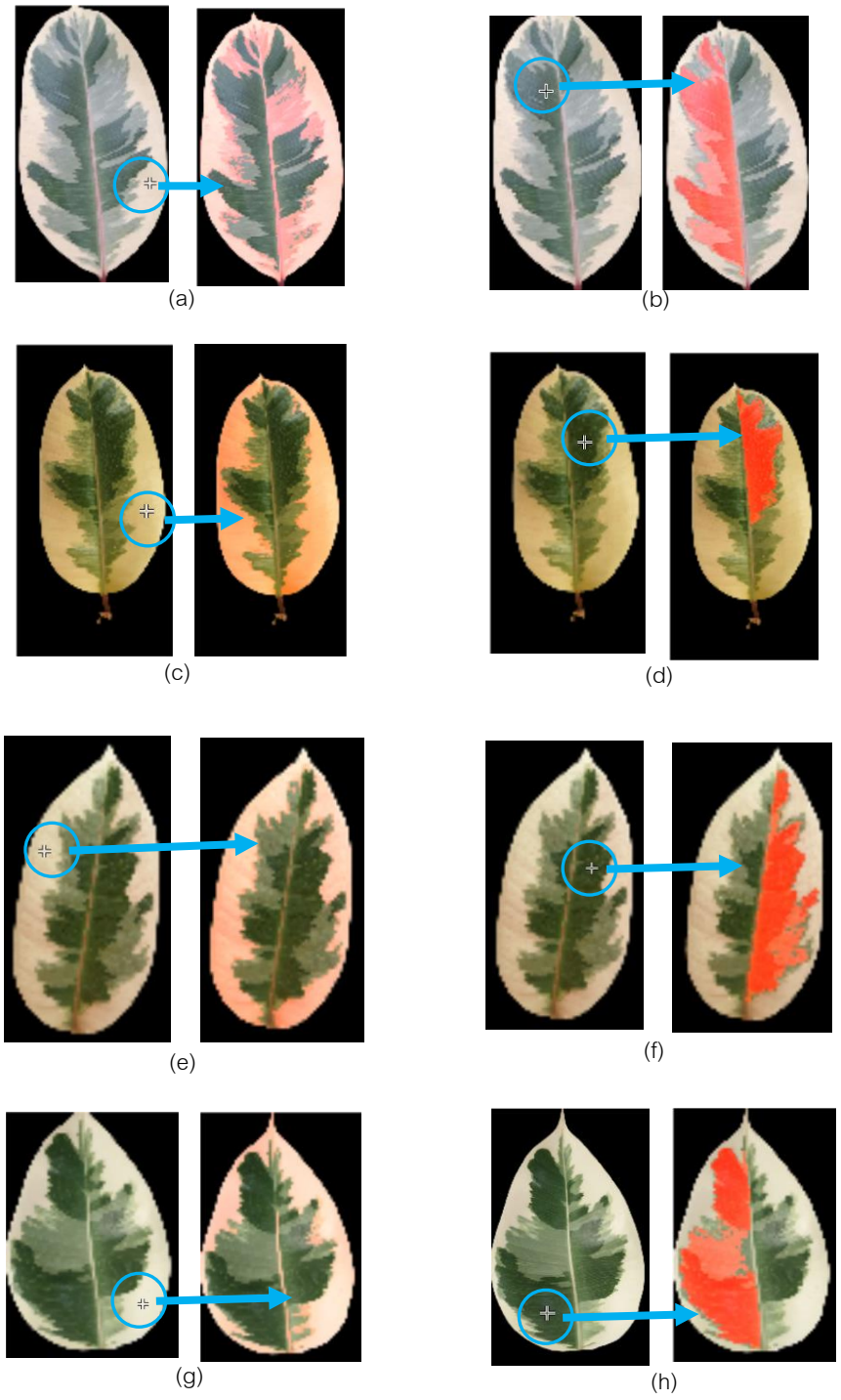

Figure 6 (a) – (h) Example for Region Growing method of variegated rubber plant.

Result of Advanced methods Comprehensive Color Feature (ACCF)

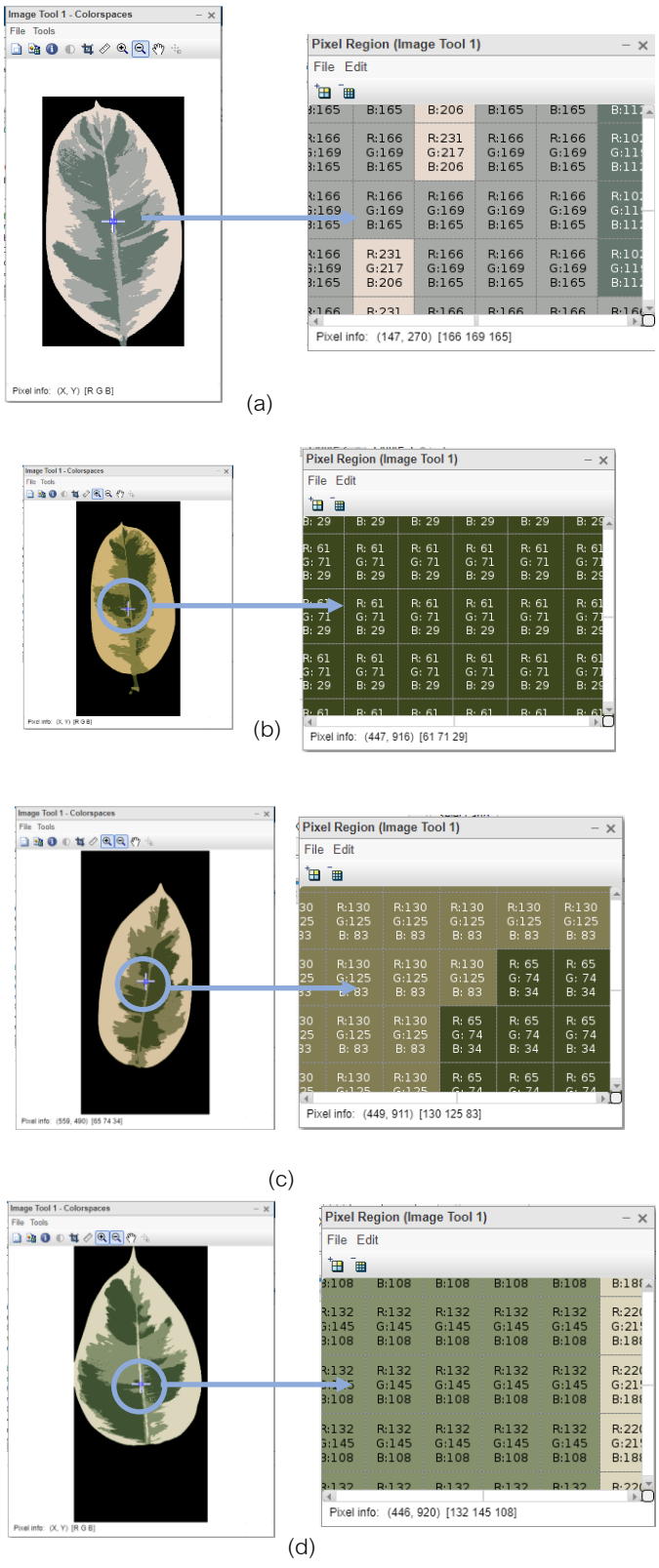

Figure 7 (a) – (d) Example for detected color tones method of variegated rubber plant.

2) Grouping the color tones according to the color values detected from the motifs of the spotted leaves plants

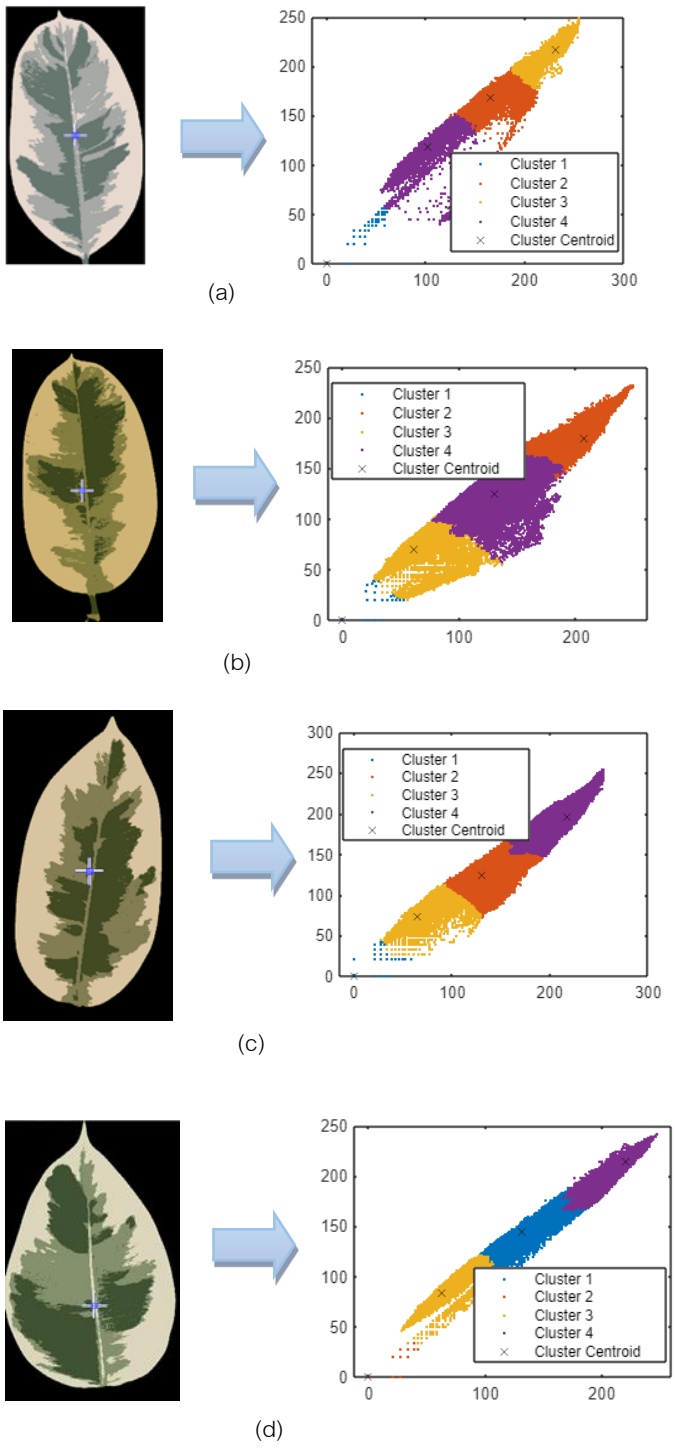

Figure 8 (a) – (d) Example for k-means clustering method of variegated rubber plant.

3) Assessing the accuracy of the physical characterization of spotted leaf plant from an expert.

Table 1 Comparison of color tones division of spotted leaves.

Data set (spotted leaves)	Expert (number of groups)	k-means clustering (number of groups)
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4
6	4	4
7	4	4
8	4	4
9	4	4
10	4	4
11	4	4
12	4	4
13	4	4
14	4	4
15	4	4
Percentage of accuracy (%)	100	100

Based on the comparison of color tones division of spotted leaves in Table 1, the ACCF concept for tonal clustering of spotted leaves using k-means clustering is 100% correct. This equates to the classification of tone groups by the expert.

The region growing used in this study was able to classify the spotted leaves through physical characterization. They were able to detect the boundaries of the tone color of the edges of the pattern, but by grouping the color tones of spotted plants with common edge detection algorithms such as Sobel, Canny, Prewitt, Roberts, and fuzzy logic methods. It gives inaccurate results because the motifs of potted plants are smooth and the edges of the pattern are not, making use of the edge detection algorithm, resulting in incorrect results.

Conclusion

The results showed that 1) the region growing used in this study was able to classify physically characterization of the spotted leaves. They were able to detect the boundaries of the tone color of the edges of the pattern, 2) the color tones could be grouped according to the values of color they appeared correctly, and 3) the results of the assessment of the rims of the color tones. Color tones detection by Advanced Comprehensive Color Feature method and color tone group classification by k-mean clustering gave 100% accuracy.

Therefore, this research helped to clearly identify the color tones of the spotted leaves, and it's quick to fix time-consuming classification problems with the human eye.

Acknowledgement

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Science and Technology (ST)

Molecular Dynamics Study of the Binding and Molecular Interactions Between Paraquat and Pyranine

Jitnapa Sirirak[1], Poomipat Tamdee[1], Nantanit Wanichacheva[1], and Krit Setthakarn[1*]

Abstract

The use of agricultural chemicals including pesticides becomes the main choice for controlling the pest and weed problems in agricultural fields. However, the leftover pesticides cause various problems to human and the ecosystem, leading to a large investigation of pesticide sensors. Herein, molecular dynamics (MD) is employed to explore the molecular interactions between paraquat, which is one of the recently banned herbicides, and a paraquat sensor called pyranine. The systems of MD containing different molecular ratios of paraquat and pyranine in water were designed. The energy minimization, heating up to 310 K and MD simulations at 298 K with constant pressure were then performed for 100 ns at 298 K using Amber20 to observe the physical movements and molecular interactions in each system. The results showed that sulfonate groups of pyranine had an important role in binding with paraquat via charge-charge interactions. Pi-stacking between paraquat and pyranine molecules was also observed during molecular simulations. Additionally, in the case of the excess of the sensor over paraquat, sensor bound with paraquat with the ratio of the sensor to paraquat of 2:1 and 3:2. On the other hand, the ratio of sensor to paraquat could change to 1:2 and 2:3 when number of paraquat molecule was higher than pyranine. Our results could provide useful information at molecular levels for the design of the paraquat sensor.

Keywords: Paraquat, Pyranine, Fluorescent sensor, Molecular Dynamics

Introduction

According to the rapid enhancement of human populations in the world, the need of agricultural products has been also increased. Thus, the agricultural chemicals have been used widely such as herbicides, insecticides, fungicides, rodenticides, and bactericides in order to solve the problem of the crop destruction. However, the excessive use of agricultural chemicals such as paraquat causes many negative effects in food chains and ecosystems. Paraquat was first synthesized in 1882 and commercially used in 1955 as an herbicide. Due to the great efficiency of paraquat, it has been used widely more than 100 countries around the world [Rashidipour et al, 2019]. Later on, many studies revealed that paraquat is highly toxic to humans, mammals, and aquatic animals. Paraquat is rapidly absorbed into the human body causing toxic chemical reactions in the cells which distribute the damage to all areas of the body such as liver, kidneys, and especially lungs. The cells in lungs selectively accumulate with paraquat. Thus, paraquat has been banned in many countries to date. The United State Environmental Protection Agency (US EPA) has specified the maximum concentration of paraquat in drink water to be 0.03 µg/L and the acceptable daily intake (ADI) from food to be 0.0045 mg/kg/day. In Thailand, the pollution control department has specified the maximum concentration of paraquat in natural water sources to be 0.5 mg/L and food and drug administration (FDA) has specified the maximum concentration of paraquat in food and crops to be 0.005 – 2 mg/L. Paraquat can be naturally decomposed by microbiological process and photochemical process. However, the half-life of the decomposing process of paraquat in soil is quite long from 1.3 to 13 years [Rashidipour et al, 2019]. Thus, the detection of the residue of paraquat becomes important to keep humans and living things safe. There are various methods for determining paraquat reported to date

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such as spectrophotometry [Sha et al, 2017; Dominguez et al, 2019], high performance liquid chromatography (HPLC) [Ou et al, 2018; Wen et al, 2018], flow injection analysis (FIA) [Chuntib & Jakmunee, 2015], and electrochemistry [de Figueiredo-Filho et al, 2017; Nasir et al, 2018; Pacheco et al, 2019; Zhang et al, 2019]. Moreover, one of those techniques which provides highly sensitive and selective detection of paraquat is to use fluorescence sensors [Sun et al, 2014; Chen et al, 2014; Wang et al, 2014; Song et al, 2015; Zhao et al, 2018; Dominguez et al, 2019]. Some of fluorogenic methods found that a pyranine group can act as a fluorescence sensor for selective binding to paraquat in host-guest chemistry [Chen et al, 2014; Zhao et al, 2018]. However, the actual mechanism and the binding ratio for detecting paraquat using pyranine are unclearly reported. Thus, we herein have investigated the detection paraquat by pyranine sensor using molecular dynamics simulations for better understanding and developing a new pyranine-based fluorescence sensor in the future.

Methodology

The initial atom coordinates of the paraquat and pyranine were obtained from Cambridge Crystallographic Data Centre (accession code PAR: 1142592) and Chemspider (accession code of PYR:55317), respectively (Figure 1). The topology files for paraquat and pyranine were constructed using the antechamber program in the AMBER20 software package [Case et al, 2020] and their frcmod were generated using parmchk2. To represent the system that paraquat was in the excess of pyranine and the system that pyranine was in the excess of paraquat, respectively, two simulation models consisted of paraquat and pyranine with molecular ratio of 1:3 and 3:1 were designed and solvated with 2 Å thick TIP3P water using Leap module. Using sander module, each model was minimized and heat up to 310 K. After that the production run of MD simulation at 310 K with constant pressure (1 atm) was conducted using pmemd module for 100 ns. To explore the binding and the interaction between paraquat and pyranine during MD simulation progresses, the important distances and between paraquat and pyranine were investigated using cpptraj module [Case et al, 2005]. The dihedral angles between two aromatic rings of paraquat were also observed using cpptraj module. All simulations were imaged by VMD - Visual Molecular Dynamics [Humphrey et al, 1996].

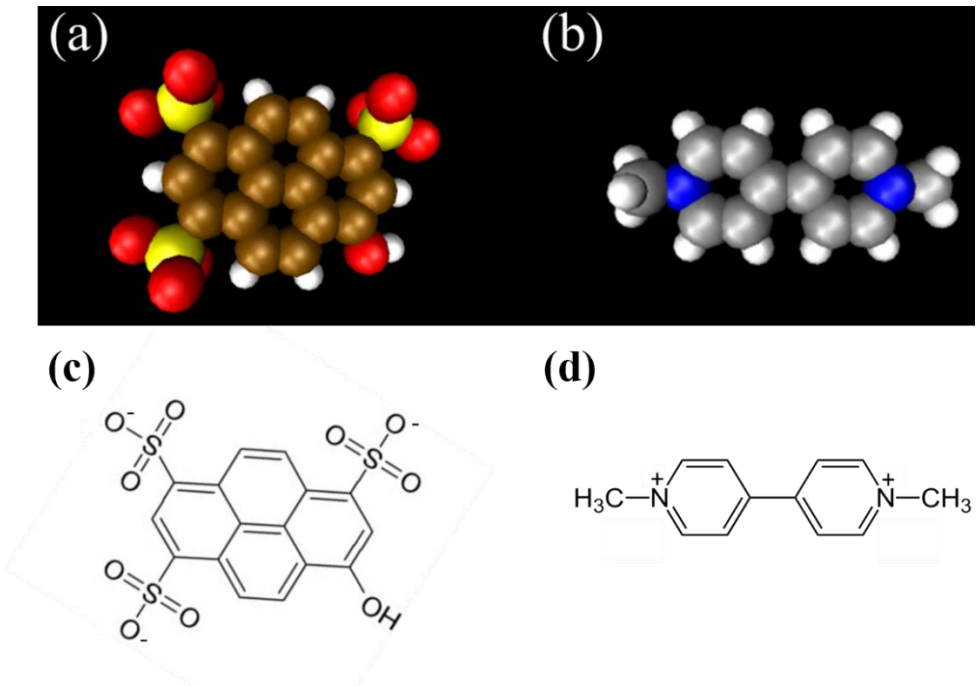

Figure 1 The initial and 2D structures of Pyranine (a, c) and Paraquat (b, d).

Results and discussion

Model 1: Pyranine-Paraquat 3:1

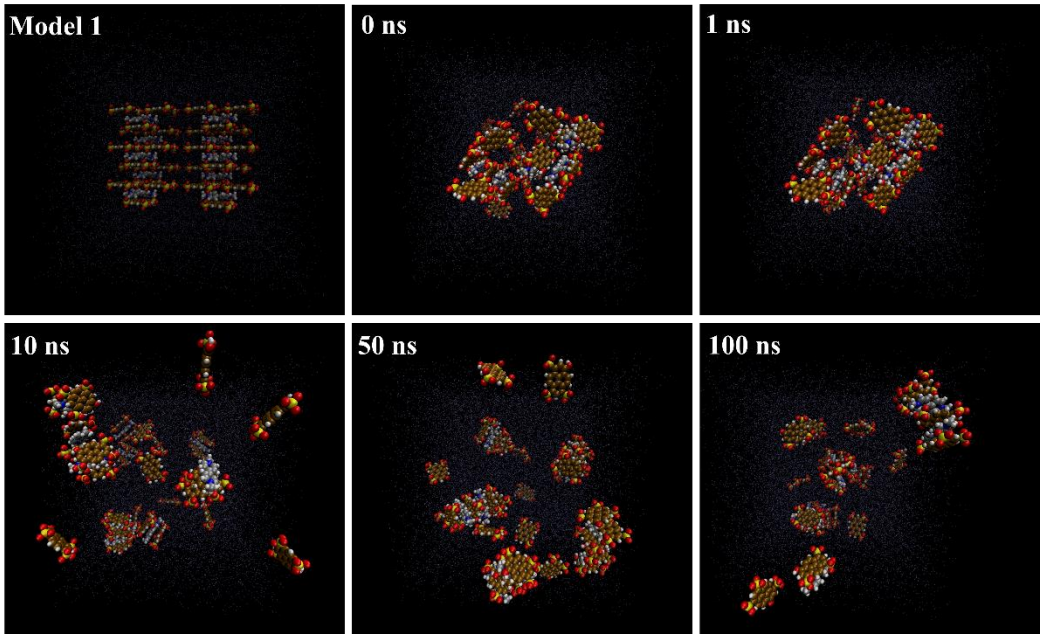

Figure 2 Snapshot structure of Model 1: Pyranine-Paraquat 3:1 at 0, 1, 10, 50 and 100 ns of MD simulation.

Model 1 represented the system that paraquat is in the excess of pyranine. As can be seen in Figure 2, paraquat and pyranine rearranged and binding patterns developed during the MD simulation. It can be noticed that pyranine started binding with paraquat since the beginning of simulation. Moreover, it was found that pyranine bound with paraquat with the ratio between pyranine and paraquat of 2:1 and 3:2 as displayed in Figure 3., and there was no free paraquat observed. The distances between molecules in a group of pyranine (PY1) – paraquat (PA) – pyranine (PY2) (Figure 3a) were also investigated.

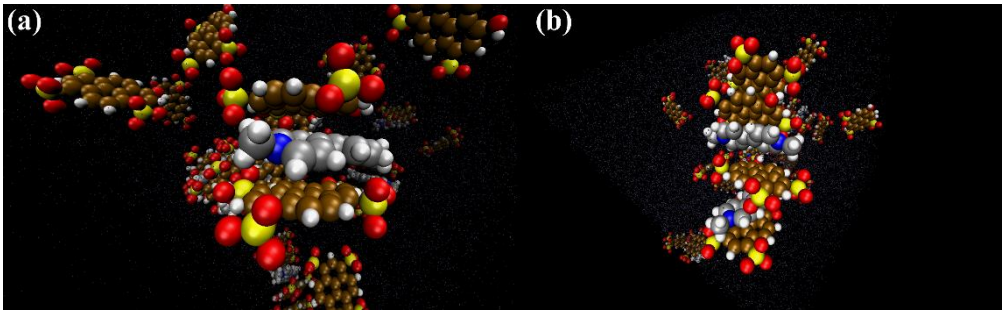

Figure 3 Snapshot structure of Model 1 represented the binding ratio of pyranine and paraquat of 2:1 (a) and 3:2 (b).

Figure 4 showed that, during 100 ns of simulation time, the distances between PY1 and PA were approximately 3.5 Å, while the PY2-PA distance and PY1-PY2 distance were fluctuated at the beginning of the simulation and become approximately 3.5 Å and 7.0 Å, respectively, after 5 ns. This indicated that one paraquat molecule was strongly bound

with two pyranine molecules. Additionally, the dihedral angles between two aromatic rings of paraquat bound with pyranine were mainly in the range of -20 to 20 degree (Figure 5), indicating that the interaction between paraquat and pyranine was not only pi-pi interaction but also charge-charge interactions.

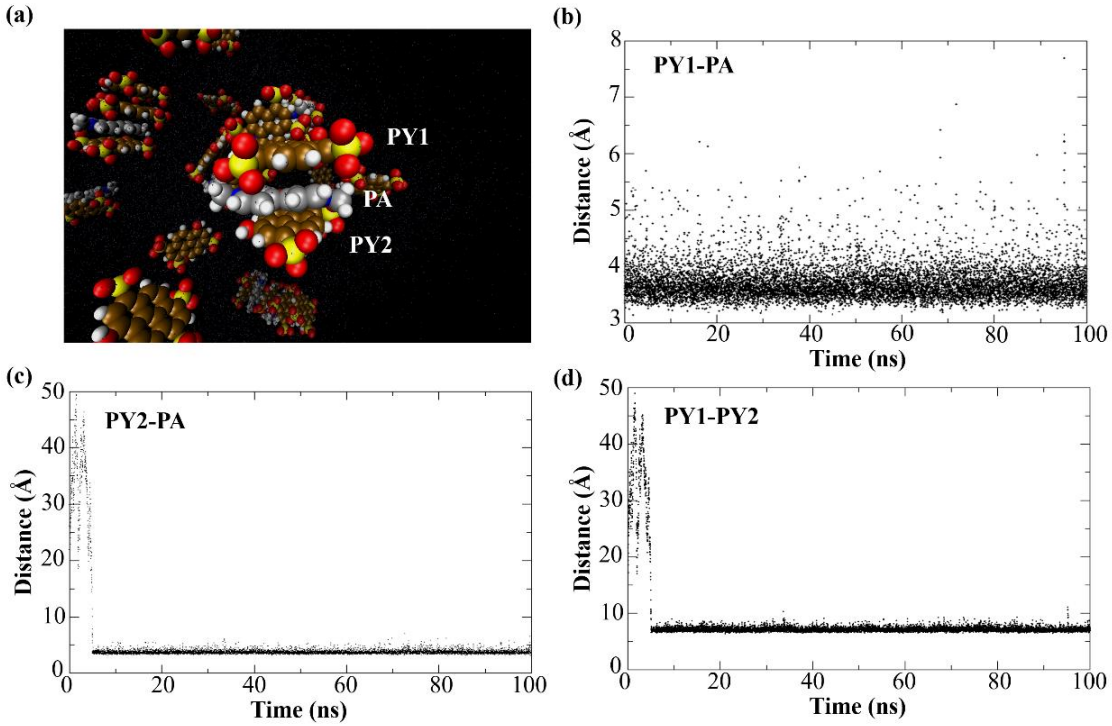

Figure 4 Variation in the distance between molecules in a group of pyranine (PY1) – paraquat (PA) – pyranine (PY2) namely (a) PY1-PA, (b) PY2 -PA and (c) PY1-PY2 as MD simulation progresses.

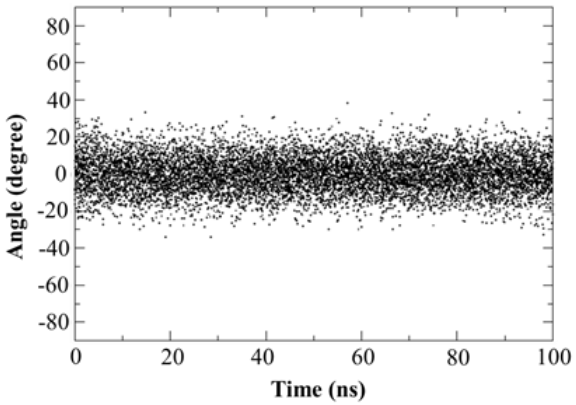

Figure 5 The dihedral angles between two aromatic rings of paraquat bound with two pyranine as MD simulation progresses.

Model 2: Pyranine-paraquat 1:3 system

Model 2 was designed to investigate the possible binding between pynanine and paraquat in the system containing more paraquat than pyranine. Figure 6 demonstrated that paraquat bound with pyranine since the beginning of simulation and there was no free paraquat detected during the 100 ns of simulation time. In contrast to what

observed in model 1, pyranine bound with paraquat with the ratio between pyranine and paraquat of 1:2 and 2:3 as can be seen in Figure 7a and Figure 7b, respectively. Moreover, the distances between molecules in a group of paraquat (PA1) – pyranine (PY) – paraquat (PA2) (Figure 7a) were observed and shown in Figure 8.

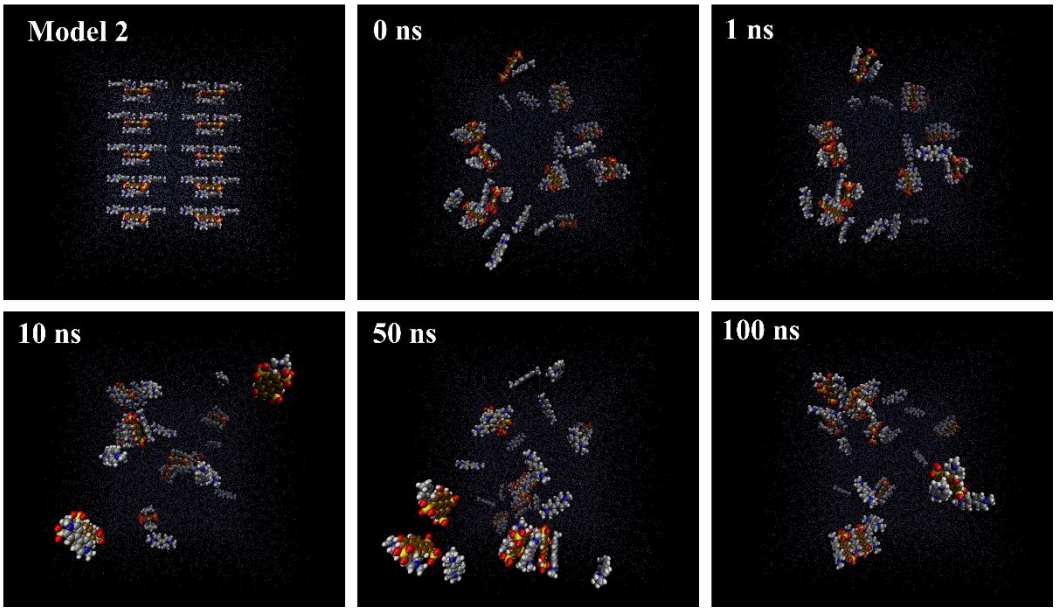

Figure 6 Snapshot structure of Model 2: Pyranine-Paraquat 1:3 at 0, 1, 10, 50 and 100 ns of MD simulation.

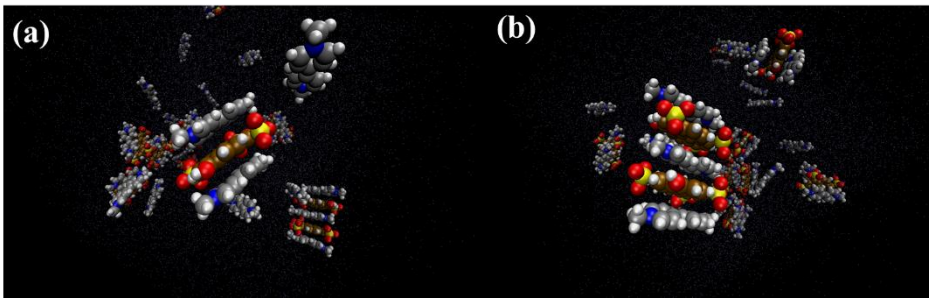

Figure 7 Snapshot structure of Model 2 represented the binding ratio of pyranine and paraquat of 1:2 (a) and 2:3 (b).

As displayed in Figure 8, the distances between PA1-PY and PA2-PY of approximately 3.5 Å were observed during simulations progresses, whereas the PA1-PA2 distance was approximately 7.0 Å, indicating that one pyranine molecule was strongly bound with two paraquat molecules. Moreover, the dihedral angles between two aromatic rings of paraquat bound with pyranine were investigated and shown in Figure 9. It can be seen that these dihedral angles were mainly in the range of -20 to 20 degree which was similar to that observed in Model 1. This elucidated that the interaction between paraquat and pyranine was not only pi-pi interaction but also charge-charge interactions.

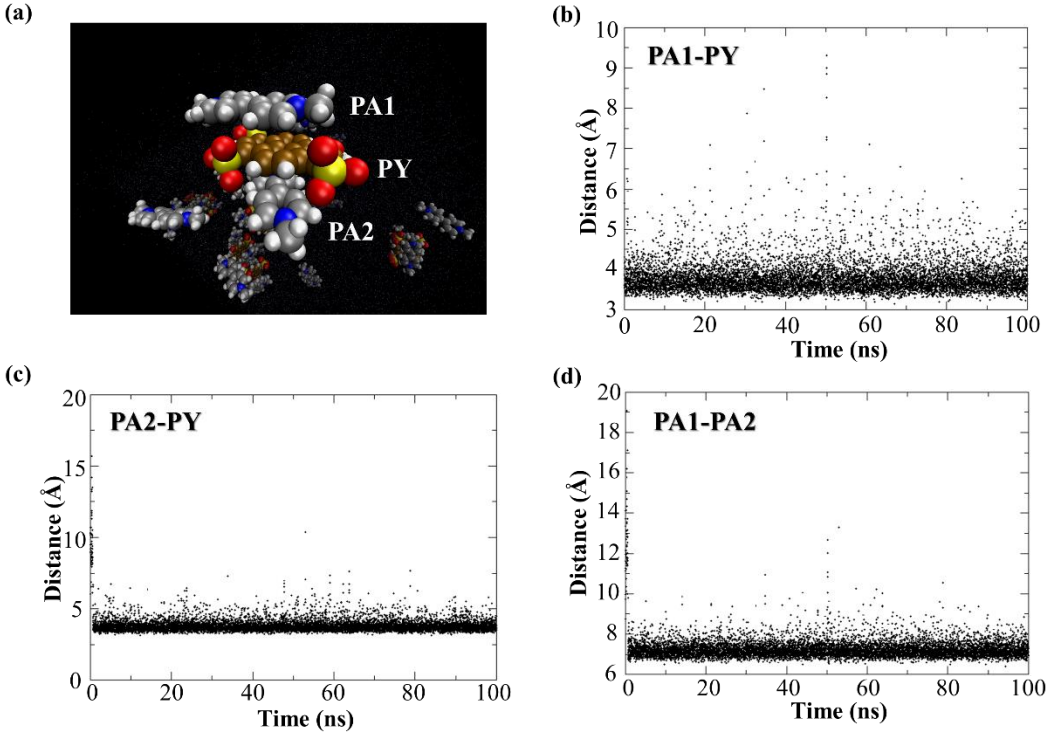

Figure 8 Variation in the distance between molecules in a group of paraquat (PA1) – pyranine (PY) – paraquat (PA2) namely (a) PA1-PY, (b) PA2 -PY and (c) PA1-PA2 as MD simulation progresses.

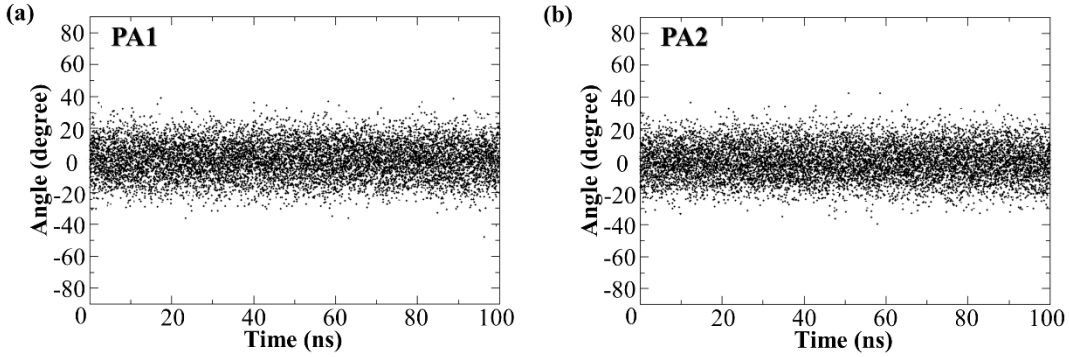

Figure 9 The dihedral angles between two aromatic rings of paraquat (PA1) and paraquat (PA2) bound with one pyranine (PY) as MD simulation progresses.

Paraquat is a strong positively charged molecule while pyranine containing three sulfonate groups is a strong negatively charged molecule. Therefore, the binding interactions between paraquat and pyranine should be strong electrostatic interaction (charge-charge interaction) and weak pi-pi interaction. Moreover, according to the results of Model 1 and Model 2, the possible binding ratio between paraquat and pyranine were 1:2, 2:1, 2:3 and 3:2, and depended on which compound was excess. This maybe because both paraquat and pyranine had two binding sides: above and below their aromatic rings. As a result, they preferred to bind in the sandwich or stacking form. Previous study was also found that the binding ratio between paraquat and pyranine was not 1:1 [Zhao et al, 2018]. Our

simulation results could give the direct information at molecular level, and hence would be useful for the design and development of a new pesticide sensor.

Conclusion

In order to investigate the detection paraquat by pyranine sensor at molecular level, molecular dynamics simulations of two models with molecular ratios of paraquat and pyranine of 1:3 and 3:1 were conducted using AMBER2020 for 100 ns. It was found that, due to both paraquat and pyranine containing two possible binding sides, their binding was in the sandwich or stacking form, occurred via strong electrostatic interaction (charge-charge interaction) and weak pi-pi interaction. The possible binding ratio between paraquat and pyranine were 1:2, 2:1, 2:3 and 3:2, and depended on which compound was excess. These results would benefit the design and development of a new pyranine-based fluorescence sensor for monitoring the contamination of paraquat on plant and crop.

Acknowledgement

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Civil, Environmental and Architectural Engineering (CEA)

The study of compressive strength of aerated concrete containing waste materials from natural and waste synthetic materials instead of fine aggregate

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Abstract

This paper describes the development of aerated concrete containing waste natural materials (coffee chaff ash) and waste synthetic materials (shredded plastics) thus replacing the usual fine aggregates. This is achieved through a weight and water-to-cement ratio (W/C) of 0.40, and a sand-to-cement ratio (S/C) of 1:2. The compressive strength of aerated concrete using natural waste materials (coffee chaff ash) and synthetic waste materials (shredded plastics) use a replacement ratio of 3%, 5%,10%,15% for the fine aggregates. This approach results in a mixture, which has lower compressive strength than concrete aerated with normal fine aggregate. In other words, standard aerated concrete sample bars show more compression. The compressive strength of aerated concrete using natural waste materials (coffee chaff ash) is best used in a concentration of 3% to replace the usual fine aggregate; however, compressive strength is 25% lower than that of aerated concrete with standard fine aggregate. The compressive strength of aerated concrete using synthetic waste materials (shredded plastics) is best used in a concentration of 3% to replace the usual fine aggregate; however, in this case, the compressive strength is 11% lower than that of standard aerated concrete. The sample bar of standard aerated concrete has a thermal conductivity of 0.80 watts/meter-Kelvin. On the other hand, the aerated concrete using natural waste materials (coffee chaff ash) in a mixture of 5% has the highest thermal conductivity of 0.99 W/m-Kelvin and the lowest thermal conductivity in a mixture of 15% of 0.66 W/m-Kelvin. The resulting sample bar shows the thermal conductivity using synthetic waste material (shredded plastics) in a mixture of 10%, which has the highest thermal conductivity at 0.35 watts / meter-Kelvin and the lowest thermal conductivity in synthetic waste material (shredded plastics) in a mixture of 3% of 0.20 watts/m-Kelvin.

Keywords: aerated concrete, ash from coffee chaff, shredded plastics

Introduction

Aerated concrete or lightweight concrete is an innovative building material for the Thai construction industry, which has been very popular as a new alternative to the construction industry. Because aerated concrete has special properties that are different from other types of concrete, it can be used to build houses quickly, resulting in savings in labour and in construction; it can, as well, help save energy. It has good heat protection, resistance to sound, durability and strength with a service life of more than 50 years. Aerated concrete is *square concrete* that comes in many sizes. It looks like a concrete block, but it is light in colour, almost white. It is porous throughout the block and lightweight. Because of its unique properties, aerated concrete is used in the construction of walls and floors. Furthermore, it exhibits good resistance against high temperature fire, and, last but not least, it is energy efficient. The fire resistance of aerated concrete can be two to four times higher than the typical brick wall and the concrete block. Aerated concrete brick properties are tested using different raw materials such as cement, sand, foam, fly ash from rice husk, and fly ash from coal. Compared to normal bricks in regards to weight, this concrete efficiently saves cost and energy. In fact, fly ash, a waste from the combustion process, can be substituted for sand and cement as an ingredient in bricks, thus reducing production costs, and making the best use of available resources. This process is usually implemented

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with good results. In this context, the researcher brought forward the idea that it might be possible to integrate in the manufacturing process other efficient and cheap materials such as ash from coffee chaff and synthetic materials such as shredded plastics. Such added ingredients in the making of aerated concrete were tested as a way to reduce the amount of fine aggregate (sand) in a comparative study of compressive strength. Also, the weight of such aerated concrete integrating recycled elements was compared to standard aerated concrete using normal ingredients. This study also determines the effect of aerated concrete as the main material in the construction of houses replacing brick and Mon brick, the latter formed from a combination of clay and rice husk that has been burnt until cooked. Because lightweight bricks have outstanding properties, they use less cement mix, shorten construction periods, and prevent heat buildup. This makes aerated concrete a very popular alternative in construction. This approach also reduces construction costs and the required amount of sand. Finally, by using less sand, the erosion of the river banks is reduced.

Methodology

Operational Method

1.1 Equipment used in the project

1.1.1 One cubic metre concrete mixer

1.1.2 Concrete formwork size 15 × 15 × 15 centimetres

1.1.3 Scaling glider

1.1.4 Scales with weighing accuracy of 0.01 g.

1.1.5 Precision measuring instruments with an accuracy of 0.01 mm.

1.1.6 200 tons compression-testing machine

1.1.7 Foam-injection machine

1.1.8 Air compressor

1.2 Materials used in the project

1.2.1 Portland cement type I

1.2.2 Coffee chaff ash

1.2.3 Shredded plastics

1.2.3 Water, clean tap water

1.2.4 River sand sifted through standard sieve no. 16 and 30

1.2.5 Foaming solution

1.3 Aggregate Sample Preparation

Sift the river sand through a standard sieve. By sifting through sieve No. 16 and sieve No. 30, take the sifted sand to weigh the fine aggregate. Take the coffee chaff ash and the shredded plastic to weight the fine aggregate using the specified ratio.

1.4 Test procedure

1.4.1 Measure the prepared concrete mix.

1.4.2 Add the aggregate (cement + sand) first, then follow with the coffee chaff ash or shredded plastics. Pour about 4/5 of the water that will be needed. Run the mixer and immediately add the remaining water.

1.4.3 Mixing time should not be shorter than three minutes for good mixing of the materials.

1.4.4 Pour concrete from the machine into a container that does not absorb water and has no leaks. The container should be large enough to allow the hand to mix the concrete back and forth, to prevent separation of concrete.

Table 1 Shows the mixing ratio of coffee chaff ash and shredded plastics from discarded water bottles as a mixture expected to reduce sand content.

NO.	percentage	Cement (kg)	Sand (kg)	coffee chaff ash / shredded plastics (kg)	Water (g)	Foam (l)
1	0	17.5	41.4	0	200	18
2	3	17.5	40.01	1.24	200	18
3	5	17.5	39.18	2.06	200	18
4	10	17.5	37.12	4.13	200	18
5	15	17.5	35.06	6.19	200	18

1.4.6 Pour concrete into the prepared formwork, and smooth the surface in the final step.

1.4.7 Concrete make-up.

1.4.8 Concrete curing procedure: The test curing time of concrete is 1, 3, 7, 14, 21, 28 days.

1.5 Procedure for testing the physical characteristics of concrete containing coffee chaff ash composites and shredded plastics by using a concrete compressive strength tester (Automatic Uniaxial and Triaxial test system).

1.5.1 Measure the cross-sectional size of the test sample.

1.5.2 Weigh the test sample cube.

1.5.3 Tests for compressive strength in each curing period of 1, 3, 7, 14, 21, 28 days.

1.5.4 Record test results.

Figure 1 Characteristics of samples tested for compression resistance.

1.5.5 Test the thermal conductivity with ASTM standard 5334 tools.

1.6 Place of testing

Concrete Testing Laboratory Civil Engineering Rajamangala University of Technology Suvarnabhumi, Nonthaburi Centre (North District), Thailand.

Results and discussion

Performance

2.1 The test results of the properties of concrete containing shredded plastics and coffee chaff ash. The ratio used to replace sand was 0, 3, 5, 10 and 15 percent at an age of concrete of 1, 3, 7, 14, 21 and 28 days. According to engineering qualifications, the mixture can be divided into two, in part for the testing of the weight unit of concrete, and in part for the determination of its compressive strength.

Table 2 Concrete compressive strength test results. Mixture ratio of natural materials (coffee chaff ash) replacing fine aggregates 0% (at an average room temperature of 28 °C).

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15.07	15	15	226.05	3390.75	4.05	1194.43	8400	37.16		0.524	
1	2	15	15.04	15.01	225.6	3386.26	4.12	1216.68	8500	37.68	37.03	0.55	0.527
	3	15.08	15	15	226.2	3393	4.02	1184.79	8200	36.25		0.506	
	1	15.04	15	15.02	225.6	3388.51	3.99	1177.51	9200	40.78		0.611	
3	2	15.02	15	15	225.3	3379.5	4.08	1207.28	9000	39.95	40.35	0.506	0.546
	3	15.05	15	14.97	225.75	3379.48	4.1	1213.21	9100	40.31		0.52	
	1	15	15.01	15.13	225.15	3406.52	4.09	1200.64	10000	44.41		0.554	
7	2	15.01	15	15	225.15	3377.25	4.05	1199.2	10000	44.41	44.4	0.747	0.786
	3	15.02	15	15	225.3	3379.5	4.01	1186.57	10000	44.39		1.058	
	1	15	15	15	225	3375	4.11	1217.78	13600	60.44		0.783	
14	2	15	15	15	225	3375	4.08	1208.89	14100	62.67	61.43	0.783	0.775
	3	15	15.04	15	225.6	3384	4.08	1205.67	13800	61.17		0.76	
	1	15.02	15	15.17	225.3	3417.8	4.1	1199.6	18200	80.78		0.716	
21	2	15.04	15.06	15.13	226.5	3426.98	3.99	1164.29	18200	80.35	80.82	0.863	0.802
	3	15	15	15.1	225	3397.5	4.06	1195	18300	81.33		0.828	
	1	15	15.04	15	225.6	3384	4	1182.03	22400	99.29		0.79	
28	2	15.03	15	15.02	225.45	3386.26	4.05	1196.01	22100	98.03	99.21	0.77	0.777
	3	15	15.02	15	225.3	3379.5	4.03	1192.48	22600	100.31		0.77	

Table 3 Concrete compressive strength test results. Mixture ratio of natural materials (coffee chaff ash) replacing fine aggregates 3% (at an average room temperature of 28 °C).

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15	14.96	14.83	224.4	3327.85	3.61	1084.78	7200	32.09		0.567	
1	2	15.01	14.99	14.84	225	3339	3.59	1075.17	7250	32.22	32.45	0.524	0.553
	3	14.75	15.02	15.05	221.55	3334.25	3.57	1070.7	7320	33.04		0.567	
	1	14.95	14.96	14.97	223.65	3348.07	3.63	1084.21	8300	37.11		0.567	
3	2	15	15	15.05	225	3386.25	3.62	1069.03	8370	37.2	37.09	0.546	0.558
	3	14.95	15	14.99	224.25	3361.51	3.68	1094.75	8290	36.97		0.56	
	1	15	15	15	225	3375	3.57	1057.78	8600	38.22		0.892	
7	2	15	14.98	14.99	224.7	3368.25	3.68	1092.55	8600	38.27	38.1	0.819	0.819
	3	15	14.99	15	224.85	3372.75	3.69	1094.06	8500	37.8		0.747	
	1	15.21	15.09	14.95	229.52	3431.31	3.49	1017.1	12400	54.03		0.749	
14	2	15.25	14.63	15.17	223.11	3384.54	3.48	1028.2	12350	55.35	54.72	0.672	0.71
	3	15.34	14.83	15.25	227.49	3469.26	3.67	1057.86	12460	54.77		0.709	
	1	15.17	15.04	15.22	228.16	3472.55	3.42	984.87	12500	54.79		0.726	
21	2	15.01	14.84	15.26	222.75	3399.14	3.54	1041.44	12400	55.67	55.86	0.551	0.669
	3	15.2	14.97	15.14	227.54	3445.02	3.52	1021.77	13000	57.13		0.729	
	1	15.13	15.12	15.03	228.77	3438.35	3.66	1064.46	16600	72.56		0.609	
28	2	15.27	15.18	14.97	231.8	3470.03	3.7	1066.27	16350	70.54	72.16	0.698	0.645
	3	15.2	15.15	15.05	230.28	3465.71	3.64	1050.29	16900	73.39		0.629	

Table 3 Concrete compressive strength test results. Mixture ratio of natural materials (coffee chaff ash) replacing fine aggregates 5% (at an average room temperature of 28 °C).

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15	14.99	15	224.85	3372.75	3.29	975.47	6500	28.91		0.567	
1	2	14.92	14.88	14.9	222.01	3307.94	3.11	940.16	6800	30.63	29.86	0.556	0.556
	3	14.99	14.99	14.98	224.7	3366.01	3.11	923.94	6750	30.04		0.546	
	1	14.96	14.98	14.99	224.1	3359.27	3.1	922.82	6900	30.79		0.567	
3	2	15	15	14.99	225	3372.75	3.32	984.36	7100	31.56	30.87	0.56	0.589
	3	15	14.98	15.1	224.7	3392.97	3.24	954.92	6800	30.26		0.64	
	1	14.99	15.1	15	226.35	3395.24	3.05	898.32	7560	33.4		0.892	
7	2	15	14.99	15	224.85	3372.75	3.32	984.36	7450	33.13	33.3	0.747	0.899
	3	15	14.95	14.89	224.25	3339.08	3.49	1045.2	7480	33.36		1.058	
	1	15.05	15.01	15.22	225.9	3438.21	3.29	956.89	9200	40.73		0.958	
14	2	15	15	14.69	225	3305.25	3.12	943.95	9100	40.44	40.12	0.849	0.894
	3	15.03	15.11	14.88	227.1	3379.3	3.24	958.78	8900	39.19		0.874	
	1	15	14.39	15.05	215.85	3248.54	3.27	1006.61	12000	55.59		0.853	
21	2	15.23	15.12	14.5	230.28	3339.03	3.26	976.33	12300	53.41	54.31	0.837	0.855
	3	15.02	15.06	14.7	226.2	3325.16	3.3	992.43	12200	53.93		0.876	
	1	15	15.03	14.27	225.45	3217.17	3.6	1119	15760	69.9		0.838	
28	2	15.09	15.23	14.76	229.82	3392.15	4.17	1229.31	15680	68.23	69.08	1.304	0.986
	3	15.01	15.07	14.33	226.2	3241.46	3.89	1200.08	15630	69.1		0.817	

Table 4 Concrete compressive strength test results. Mixture ratio of natural materials (coffee chaff ash) replacing fine aggregates 10% (at an average room temperature of 28 °C).

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15.13	15.1	14.87	228.46	3397.24	3	883.07	4500	19.7		0.432	
1	2	15.02	15.02	14.97	225.6	3377.24	3.01	891.26	4500	19.95	20.39	0.442	0.475
	3	15.56	14.92	14.76	232.16	3426.61	3.02	881.34	5000	21.54		0.55	
	1	15.3	14.91	15.07	228.12	3437.81	3.11	904.64	5200	22.79		0.475	
3	2	14.96	15.23	15.05	227.84	3429	2.29	667.83	5150	22.6	22.83	0.523	0.494
	3	14.98	15.03	14.97	225.15	3370.49	3.08	913.81	5200	23.1		0.484	
	1	14.97	14.9	15.03	223.05	3352.49	3.17	945.57	5700	25.55		0.518	
7	2	15.07	15.09	15.1	227.41	3433.84	3.14	914.43	5650	24.85	25.17	0.354	0.433
	3	15.07	15.07	15.01	227.1	3408.84	2.94	862.46	5700	25.1		0.427	
	1	15.09	14.92	15.29	225.14	3442.43	3.29	955.72	7450	33.09		0.588	
14	2	15.16	15.12	15.01	229.22	3440.58	3.37	979.49	7500	32.72	32.88	0.517	0.565
	3	15.16	15.07	15.1	228.46	3449.76	3.22	933.4	7500	32.83		0.589	
	1	15.26	15.22	15.06	232.26	3497.79	3.37	963.46	11300	48.65		0.519	
21	2	15.15	15.19	15.13	230.13	3481.84	3.43	985.11	11300	49.1	49.21	0.654	0.565
	3	15.11	15.13	15.11	228.61	3454.362	3.32	961.1	11400	49.87		0.521	
	1	15	15.11	15.12	226.65	3426.95	3.49	1018.4	13100	57.8		0.662	
28	2	15.01	15.02	15.09	225.45	3402.04	3.44	1011.16	13090	58.06	57.82	0.549	0.608
	3	15.1	15.06	15.1	227.41	3433.83	3.24	943.55	13100	57.61		0.612	

Table 5 Concrete compressive strength test results. Mixture ratio of natural materials (coffee chaff ash) replacing fine aggregates 15% (at an average room temperature of 28 °C).

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15.08	15.33	15.45	231.18	3571.68	3.33	932.34	3300	14.27		0.524	
1	2	15.12	15.18	14.9	229.52	3419.87	3.29	962.02	3200	13.94	14.03	0.55	0.509
	3	15.25	15.11	15.1	230.43	3479.46	3.44	988.66	3200	13.89		0.454	
	1	15.24	15.27	15.21	232.71	3539.59	3.46	977.51	3450	14.83		0.506	
3	2	15.36	15.29	15.22	234.85	3574.48	3.54	990.35	3400	14.48	14.84	0.611	0.546
	3	15.11	15.21	14.92	229.82	3428.96	3.42	997.39	3500	15.23		0.52	
	1	15.13	15.26	15.24	230.88	3518.67	3.56	1011.75	3900	16.89		0.554	
7	2	15.22	15.09	15.32	229.67	3518.54	3.39	963.47	3850	16.76	16.97	0.458	0.509
	3	15.08	15.36	15.18	231.63	3516.13	3.41	969.82	4000	17.27		0.514	
	1	15.37	15.32	15.08	235.47	3550.86	3.6	1013.84	5250	22.3		0.604	
14	2	15.3	15.09	15.27	230.88	3525.49	3.73	1058.01	5200	22.52	22.52	0.627	0.625
	3	15.27	15.26	15.1	233.02	3518.61	3.57	1014.61	5300	22.74		0.645	
	1	15.2	15.23	15.19	231.5	3516.42	3.39	964.05	9100	39.31		0.588	
21	2	15.39	14.92	15.1	229.62	3467.24	3.25	937.34	9300	40.5	39.96	0.614	0.595
	3	15.2	15.19	15.12	230.89	3491.03	3.34	956.74	9250	40.06		0.583	
	1	15.05	15.01	15.11	225.9	3413.36	3.52	1031.24	11200	49.58		0.664	
28	2	15.01	15.11	15.11	226.8	3426.96	3.78	1103.02	11250	49.6	49.39	0.643	0.667
	3	15.06	15.05	15	226.65	3399.8	3.55	1044.18	11100	48.97		0.693	

Table 6 Results of concrete compressive strength test. Synthetic material mix ratio (shredded plastics) replacing 0 % fine aggregate.

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15.07	15	15	226.05	3390.75	4.05	1194.43	8400	37.16		0.524	
1	2	15	15.04	15.01	225.6	3386.26	4.12	1216.68	8500	37.68	37.03	0.55	0.527
	3	15.08	15	15	226.2	3393	4.02	1184.79	8200	36.25		0.506	
	1	15.04	15	15.02	225.6	3388.51	3.99	1177.51	9200	40.78		0.611	
3	2	15.02	15	15	225.3	3379.5	4.08	1207.28	9000	39.95	40.35	0.506	0.546
	3	15.05	15	14.97	225.75	3379.48	4.1	1213.21	9100	40.31		0.52	
	1	15	15.01	15.13	225.15	3406.52	4.09	1200.64	10000	44.41		0.554	
7	2	15.01	15	15	225.15	3377.25	4.05	1199.2	10000	44.41	44.4	0.747	0.786
	3	15.02	15	15	225.3	3379.5	4.01	1186.57	10000	44.39		1.058	
	1	15	15	15	225	3375	4.11	1217.78	13600	60.44		0.783	
14	2	15	15	15	225	3375	4.08	1208.89	14100	62.67	61.43	0.783	0.775
	3	15	15.04	15	225.6	3384	4.08	1205.67	13800	61.17		0.76	
	1	15.02	15	15.17	225.3	3417.8	4.1	1199.6	18200	80.78		0.716	
21	2	15.04	15.06	15.13	226.5	3426.98	3.99	1164.29	18200	80.35	80.82	0.863	0.802
	3	15	15	15.1	225	3397.5	4.06	1195	18300	81.33		0.828	
	1	15	15.04	15	225.6	3384	4	1182.03	22400	99.29		0.79	
28	2	15.03	15	15.02	225.45	3386.26	4.05	1196.01	22100	98.03	99.21	0.77	0.777
	3	15	15.02	15	225.3	3379.5	4.03	1192.48	22600	100.31		0.77	

Table 7 Results of concrete compressive strength test. Synthetic material mix ratio (shredded plastics) replacing 3 % fine aggregate.

curing	Spac	Width	Length	Hight	Area	Volume	Weight	Unit	Ult.	Compressive	Average	thermal	Average
(Day)	No.	(cm)	(cm)	(cm)	(sq cm)	(cu cm)	(kg)	Weight	(kg)	(kg/sq cm)	Comp.Str	conductivity	
								(kg/cu cm)			(ksc)	(W/m*K)	
	1	15.1	15.02	15	226.8	3402.03	4.14	1216.92	7400	32.63		0.167	
1	2	15.05	15.03	15	226.2	3393.02	3.89	1146.47	7800	34.48	33.55	0.135	0.152
	3	15.07	15.03	15.05	226.5	3408.86	4.2	1232.08	7600	33.55		0.154	
	1	15.12	15.2	15	229.82	3447.36	4.21	1221.22	8400	36.55		0.167	
3	2	15	15.1	15.05	226.5	3408.83	4.17	1223.3	8200	36.2	36.16	0.132	0.148
	3	15.07	15.05	15	226.8	3402.05	4.05	1190.46	8100	35.71		0.145	
	1	15.05	15.17	15	228.31	3424.63	3.87	1130.05	9000	39.42		0.234	
7	2	15.01	15	15	225.15	3377.25	4.22	1249.54	8600	38.2	38.32	0.176	0.208
	3	14.99	15.18	15	227.55	3413.22	3.97	1163.12	8500	37.35		0.213	
	1	15.08	15.16	15.01	228.61	3431.48	4.21	1226.88	12500	54.68		0.243	
14	2	15.03	15.06	15.17	226.35	3433.76	4.05	1179.47	11900	52.57	53.51	0.241	0.232
	3	15	15.14	15.25	227.1	3463.28	4.18	1206.95	12100	53.28		0.213	
	1	14.97	15.13	15.22	226.5	3447.27	4.03	1169.04	13800	60.93		0.134	
21	2	15.17	15.05	15.26	228.31	3483.99	4.15	1191.16	14000	61.32	60.76	0.156	0.211
	3	15.19	15.13	15.14	229.82	3479.55	4.04	1161.07	13800	60.05		0.342	
	1	15.1	15.04	15.03	227.1	3413.37	3.96	1160.14	19500	85.86		0.326	
28	2	15.03	15.05	15	226.2	3393.02	4.17	1228.99	19800	87.53	86.29	0.213	0.243
	3	15.18	15.03	15.05	228.16	3433.74	4.19	1220.24	19500	85.47		0.189	

Table 8 Results of concrete compressive strength test. Synthetic material mix ratio (shredded plastics) replacing 5 % fine aggregate.

curing (Day)	Spac No.	Width (cm)	Length (cm)	Hight (cm)	Area (sq cm)	Volume (cu cm)	Weight (kg)	Unit Weight (kg/cu cm)	Ult. (kg)	Compressive (kg/sq cm)	Average Comp.Str (ksc)	thermal conductivity (W/m*K)	Average
	1	15.04	15	15	225.6	3384	3.98	1176.12	6700	29.7		0.186	
1	2	15.13	15.04	15.01	227.56	3415.6	4.01	1174.02	6900	30.32	30.03	0.176	0.159
	3	15.02	15.06	15	226.2	3393.02	3.89	1146.47	6800	30.06		0.116	
	1	15.13	15.03	15.01	227.4	3413.33	3.95	1157.23	7100	31.22		0.124	
3	2	15.08	15.2	15	229.22	3438.24	3.99	1160.48	7400	32.28	32.18	0.135	0.161
	3	15.24	15.1	15.1	230.12	3474.87	4.02	1156.88	7600	33.03		0.225	
	1	15.05	15.21	15	228.91	3433.66	3.99	1162.03	7600	33.2		0.346	
7	2	15.05	15	15	225.75	3386.25	4.02	1187.15	7800	34.55	34.23	0.189	0.245
	3	15.21	15.06	15.01	229.06	3438.23	4	1163.39	8000	34.92		0.2	
	1	15	15.03	15.22	225.45	3431.35	3.97	1156.98	9300	41.25		0.245	
14	2	15.03	15.1	15	226.95	3404.3	3.95	1160.3	9600	42.3	41.98	0.256	0.245
	3	15.04	15.06	15	226.5	3397.54	4.01	1180.27	9600	42.38		0.234	
	1	15.11	15.06	15.05	227.56	3424.73	3.9	1138.78	13400	58.89		0.345	
21	2	15.06	15.02	15	226.2	3393.02	4	1178.89	13200	58.36	58.6	0.234	0.241
	3	15.03	15	15.01	225.45	3384	3.97	1173.17	13200	58.55		0.145	
	1	15.32	15.21	15	233.02	3495.26	4.01	1147.27	17300	74.24		0.186	
28	2	15.1	14.99	15	226.35	3395.24	4.1	1207.57	16600	73.34	73.75	0.187	0.176
	3	15.04	15.25	15	229.36	3440.4	4.02	1168.47	16900	73.68		0.156	

Table 9 Results of concrete compressive strength test. Synthetic material mix ratio (shredded plastics) replacing 10 % fine aggregate.

curing (Day)	Spac No.	Width (cm)	Length (cm)	Hight (cm)	Area (sq cm)	Volume (cu cm)	Weight (kg)	Unit Weight (kg/cu cm)	Ult. (kg)	Compressive (kg/sq cm)	Average Comp.Str (ksc)	thermal conductivity (W/m*K)	Average
	1	15.04	15.25	15.02	229.36	3444.99	4.02	1166.91	5000	21.8		0.318	
1	2	15.1	14.99	15	226.35	3395.24	4.1	1207.57	4800	21.21	21.63	0.24	0.299
	3	15.32	15.21	15.21	233.02	3544.19	4.01	1131.43	5100	21.89		0.339	
	1	15.03	15	15.07	225.45	3397.53	3.97	1168.5	5200	23.06		0.245	
3	2	15.06	15.02	15.05	226.2	3404.33	4	1174.97	5300	23.43	23.12	0.334	0.272
	3	15.11	15.06	15.05	227.56	3424.73	3.9	1138.78	5200	22.85		0.236	
	1	15.04	15.06	15.03	226.5	3404.33	4.01	1177.91	5800	25.61		0.228	
7	2	15.03	15.1	15.1	226.95	3426.99	3.95	1152.61	5800	25.56	25.33	0.228	0.227
	3	15	15.03	15.01	225.45	3384	3.97	1173.17	5600	24.84		0.226	
	1	15.21	15.06	15.29	229.06	3502.37	4	1142.08	7500	32.74		0.243	
14	2	15.05	15	15.01	225.75	3388.51	4.02	1186.36	7500	33.22	32.62	0.243	0.247
	3	15.05	15.21	15.1	228.91	3456.55	3.95	1142.76	7300	31.89		0.254	
	1	15.24	15.1	15.06	230.12	3465.67	3.99	1151.29	11500	49.97		0.337	
21	2	15.08	15.2	15.13	229.22	3468.04	3.98	1147.62	11300	49.3	49.95	0.353	0.352
	3	15.13	15.03	15.11	227.4	3436.073	4.01	1167.03	11500	50.57		0.365	
	1	15.02	15.06	15.12	226.2	3420.16	4.03	1178.31	15100	66.75		0.365	
28	2	15.13	15.04	15.09	227.56	3433.81	3.92	1141.59	15000	65.92	66.98	0.343	0.343
	3	15.04	15	15.1	225.6	3406.56	4	1174.21	15400	68.26		0.321	

Table 10 Results of concrete compressive strength test. Synthetic material mix ratio (shredded plastics) replacing 15 % fine aggregate.

curing (Day)	Spac No.	Width (cm)	Length (cm)	Hight (cm)	Area (sq cm)	Volume (cu cm)	Weight (kg)	Unit Weight (kg/cu cm)	Ult. (kg)	Compressive (kg/sq cm)	Average Comp.Str (ksc)	thermal conductivity (W/m*K)	Average
	1	15	15.25	15	228.75	3431.25	3.97	1157.01	3300	14.43		0.244	
1	2	15.01	15.1	15	226.65	3399.77	3.95	1161.85	3400	15	14.48	0.245	0.243
	3	15.21	15	15.1	228.15	3445.07	4.01	1163.98	3200	14.03		0.239	
	1	15.03	15	15	225.45	3381.75	3.96	1170.99	3500	15.52		0.24	
3	2	15.04	15.04	15.22	226.2	3442.79	3.89	1129.9	3700	16.36	15.74	0.235	0.227
	3	15.21	15	15	228.15	3422.25	3.9	1139.6	3500	15.34		0.205	
	1	15.08	15	15.24	226.2	3447.29	3.94	1142.93	4000	17.68		0.143	
7	2	15.1	15.02	15	226.8	3402.03	4.01	1178.71	4100	18.08	17.55	0.254	0.181
	3	15	14.99	15.18	224.85	3413.22	4.05	1186.56	3800	16.9		0.145	
	1	15.14	15.03	15	227.55	3413.31	3.97	1163.09	5600	24.61		0.243	
14	2	15.25	15.02	15.2	229.06	3481.64	3.89	1117.29	5900	25.76	24.88	0.243	0.251
	3	15.04	15.06	15.1	226.5	3420.19	4.03	1178.3	5500	24.28		0.267	
	1	15.04	15.1	15.1	227.1	3429.27	3.92	1143.1	9800	43.15		0.228	
21	2	15.12	15.03	15.1	227.25	3431.53	3.95	1151.09	9500	41.8	42.39	0.224	0.259
	3	15	15	15	225	3375	3.97	1176.3	9500	42.22		0.325	
	1	15.05	15.21	15.11	228.91	3458.84	4	1156.46	13700	59.85		0.226	
28	2	15.13	15.03	15.01	227.4	3413.33	3.93	1151.37	13600	59.81	59.83	0.221	0.233
	3	15.04	15	15	225.6	3384	4.02	1187.94	13500	59.84		0.253	

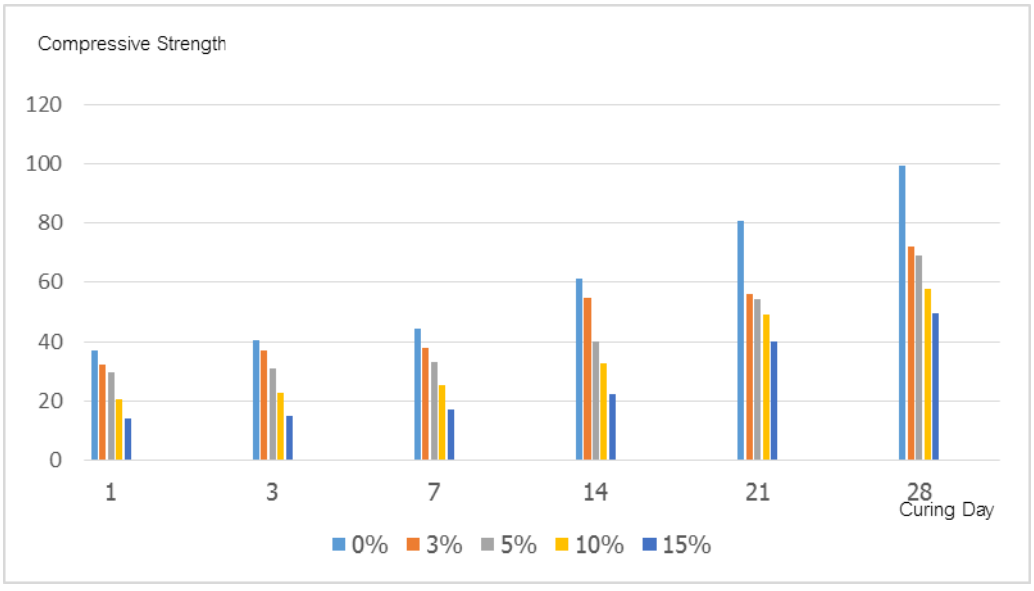

Figure 1 Graph showing the compressive strength of concrete with the ratio of synthetic materials (shredded plastics) replacing fine aggregates.

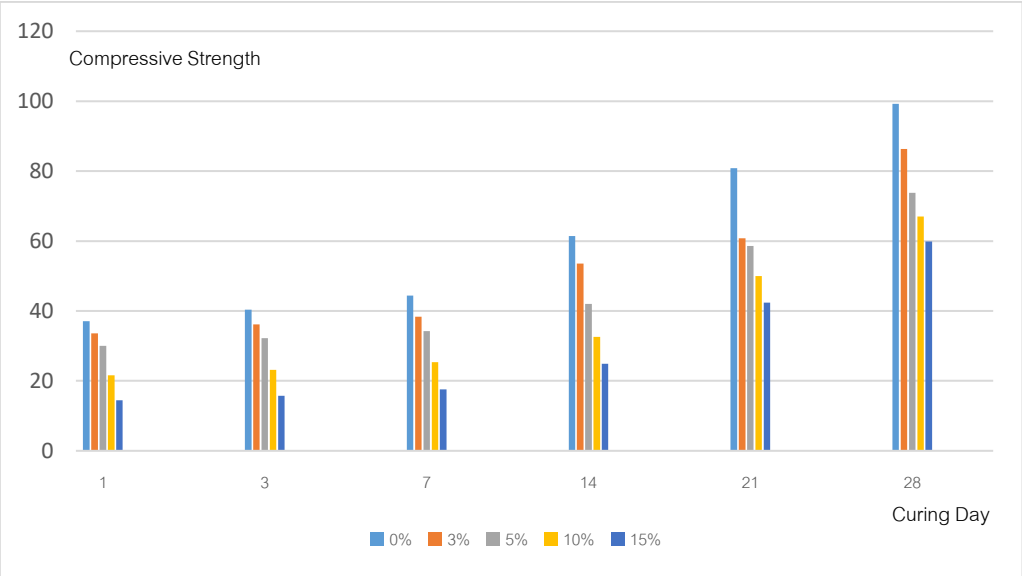

Figure 2 Graph showing the compressive strength of concrete with the ratio of natural waste materials (coffee chaff ash) replacing the fine aggregates.

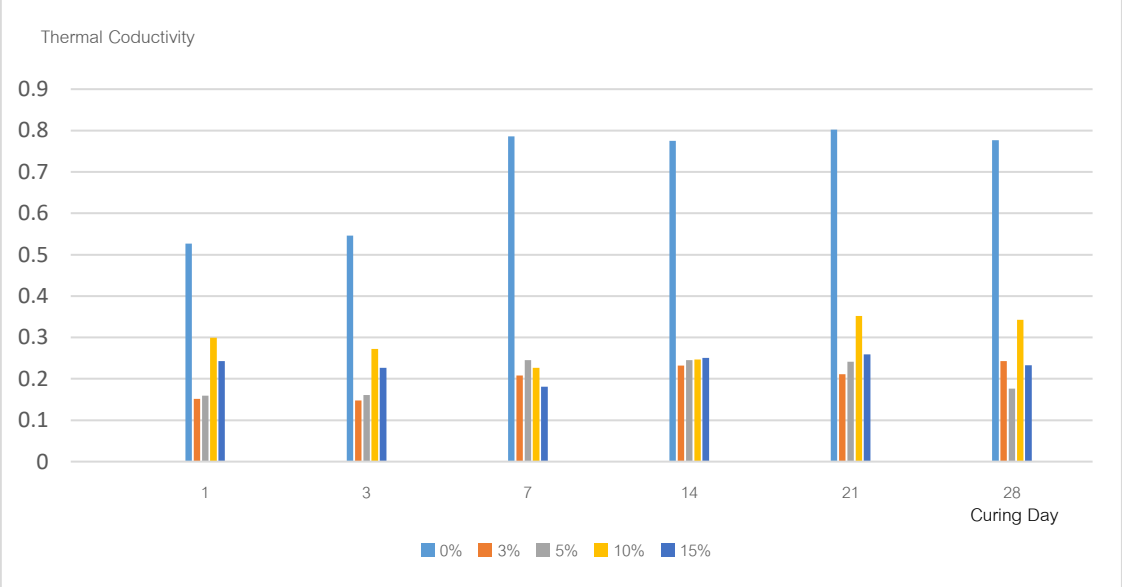

Figure 3 Graph showing the Thermal Conductivity of concrete with the ratio of synthetic materials (shredded plastics) replacing fine aggregates.

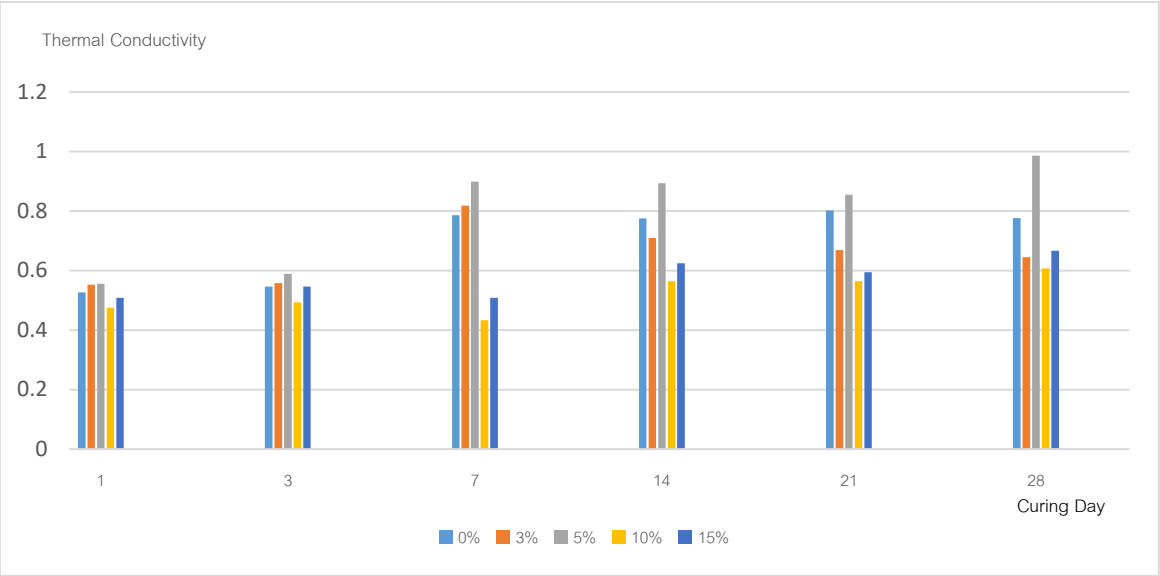

Figure 4 Graph showing the Thermal Conductivity of concrete with the ratio of natural waste materials (coffee chaff ash) replacing the fine aggregates.

Conclusion

Summary and recommendations

From the results of this research on the compressive behaviour of aerated concrete using natural waste materials (coffee chaff ash) and synthetic waste (shredded plastics) to replace fine aggregates, we can arrive at the following observations:

1. The development of the blaster strength of aerated concrete using materials both from natural waste materials (coffee chaff ash) and synthetic waste materials (shredded plastics) can replace fine aggregates. It has lower compressive strength than standard aerated concrete with fine aggregate.

2. The compressive strength of aerated concrete using natural waste materials (coffee chaff ash) is best at a concentration of 3% to replace fine aggregate; however, compressive strength is 25% lower than that of aerated concrete with normal fine aggregate.

3. The compressive strength of aerated concrete using synthetic waste material (shredded plastics) is best at a concentration of 3% replacing fine aggregate; however, its compressive strength is 11% lower than that of aerated concrete with normal fine aggregate.

4. The result of the sample bar shows the thermal conductivity of standard aerated concrete of 0.80 watts/meter-Kelvin. The aerated concrete using natural waste materials in a mixture (coffee chaff ash) in a mixture of 5% has the highest thermal conductivity at 0.99 W/m-Kelvin, and has the lowest thermal conductivity in a mixture of 15% at 0.66 W/m-Kelvin.

5. The result of the sample bar shows the thermal conductivity by aerated concrete using synthetic waste material (shredded plastics) in a mixture of 10%, which has the highest thermal conductivity at 0.35 watts / meter-

Kelvin, and has the lowest thermal conductivity in synthetic waste material (shredded plastics) in a mixture of 3% of 0.20 watts/m-Kelvin.

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Cement block from plastic bottle lids

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Abstract

This research aims to use the waste from plastic bottles lids as cement blocks for pavement by grinding the high-density polyethylene (HDPE) plastic bottle lid thoroughly, sifting through the no.4 sieve to replace the coarse sand. Use a coarse cement-to-sand ratio of 1:3 by replacing it with the grinding plastic bottle lids. The ratio between coarse sand per lid and plastic bottles is increasingly ground from 0-5% by using a fixed water-to-cement ratio of 0.4 and the size of the cement block, width 20 cm, length 20 cm, thickness 6 cm, compacting and forming cement blocks with human force. According to the test results, the cement blocks paved, made by the composite lids of plastic bottles with a 1-5% ratio, have similar transverse bending resistance according to TIS 826-1988 cement floor tiles and according to TIS 378-1988 concrete floor tiles. The results also find that a ratio of 5% is more suitable than overall ratios; the Flexural strength is 34.13 ksc; higher than the standard set at 31 ksc. and the water absorption value is 2.04%. less than 10% according to the standard.

Keywords: Cement block, plastic bottle lid, pavement

Introduction

Nowadays, plastic bottles have a short service life; they are one-time use and ready to turn into the trash. It is a burden to manage. Degradation is difficult, time-consuming and requires a lot of landfill space. If disposal by incineration will produce toxic gases, which is harmful to the respiratory system, complete combustion will produce carbon dioxide, which causes greenhouse gas and make the world warmer. In order to solve environmental problems, reduce waste in plastic bottles and think of the importance of recycling, this research has the idea of removing waste from plastic bottles used to produce cement blocks for pavement. By grinding the high-density polyethylene (HDPE) plastic bottle lid thoroughly, sifting through the no.4 sieve to replace the coarse sand and a mixture of cement blocks.

Methodology

This research aims to use the waste from plastic bottles lids as cement blocks for pavement by grinding the high-density polyethylene (HDPE) plastic bottle lid thoroughly, sifting through the no.4 sieve to replace the coarse sand. Use a coarse cement-to-sand ratio of 1:3 by replacing it with the grinding plastic bottle lids. The ratio between coarse sand per lid and plastic bottles is increasingly ground from 0-5% by using a fixed water-to-cement ratio of 0.4 and the size of the cement block, width 20 cm, length 20 cm, thickness 6 cm, compacting and forming cement blocks with human force.

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1. Mix ratio

The mixture ratio of cement block pavement mixed with high-density polyethylene (HDPE) plastic bottle lids instead of coarse sand is as follows:

1.1 Sand through a sieve No. 4 according to Figure 1

1.2 Plastic bottle lids of high-density polyethylene (HDPE) ground and sifted through a sieve No. 4, as shown in Figure 2 and Portland Cement Type 1.

Figure 1 Sand used for testing.

Figure 2 Plastic bottle lids used for testing.

2. Sample preparation

Brought the ground and sifted through a sieve No. 4 plastic bottle lids, and the material measured the weight according to the cement to aggregate ratio instead of the plastic bottle lids. The ratio of cement blocks that are commercially produced generally uses cement and the sand ratio of 1:3, Use sand by replacing it with ground plastic bottle lids with the ratio between sand: ground plastic bottle lids increase by 1% of the weight of sand, starting from 0-5, as shown in Table 1. Water to cement ratio constant 0.4, The size of the cement block pavement, width 20 cm., length 20 cm., thickness 6 cm., ground by human force.

Test for bending strength at 28 days of age according to TIS 826-1988 for floor cement tiles and TIS 378-1988 for concrete floor tiles.

Table 1 Ingredients for the test (by weight).

formula	ratio (Cement : sand : plastic bottle cap)
0 HDPE	1: 3: 0
1 HDPE	1: 2.97: 0.03
2 HDPE	1: 2.94: 0.06
3 HDPE	1: 2.91: 0.09
4 HDPE	1: 2.88: 0.12
5 HDPE	1: 2.85: 0.15

Remarks

0 HDPE means replacing sand with plastic bottle lids, the ratio of 0%

1 HDPE means replacing sand with plastic bottle lids, the ratio of 1%

2 HDPE means replacing sand with plastic bottle lids, the ratio of 2%

3 HDPE means replacing sand with plastic bottle lids, the ratio of 3%

4 HDPE means replacing sand with plastic bottle lids, the ratio of 4%

5 HDPE means replacing sand with plastic bottle lids, the ratio of 5%

Results and discussion

1. Flexural strength test

Test results for flexural strength of cement blocks pavement mixed with plastic bottle lids (HDPE) to replace sand at 28 days of age according to TIS 826-1988, floor cement tiles and TIS 378-1988, concrete floor tiles according to Table 2, Figure 3 and Figure 4.

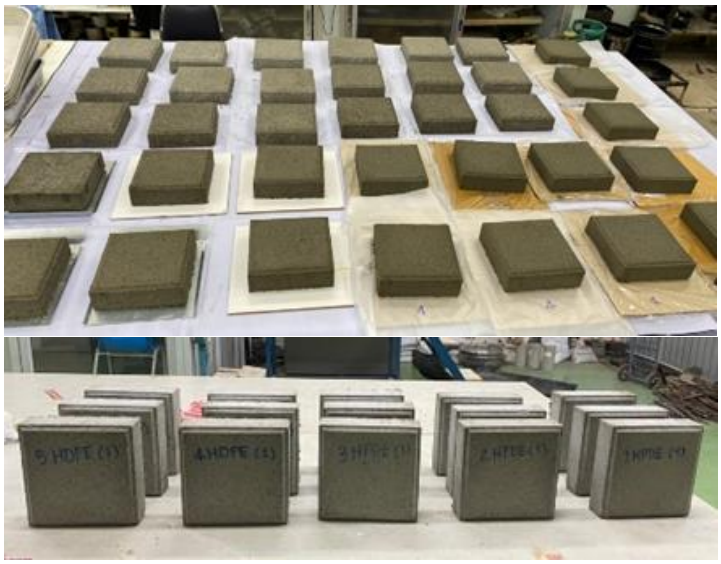

Figure 3 Cement block from plastic bottle lids.

Table 2 Flexural test results of cement blocks from sand mixture and plastic bottle lids at 28 days.

Ratio	Percentage of plastic bottle lids	Flexural strength (ksc.)
0 HDPE	0	37.65
1 HDPE	1	37.24
2 HDPE	2	36.43
3 HDPE	3	35.61
4 HDPE	4	35.21
5 HDPE	5	34.13

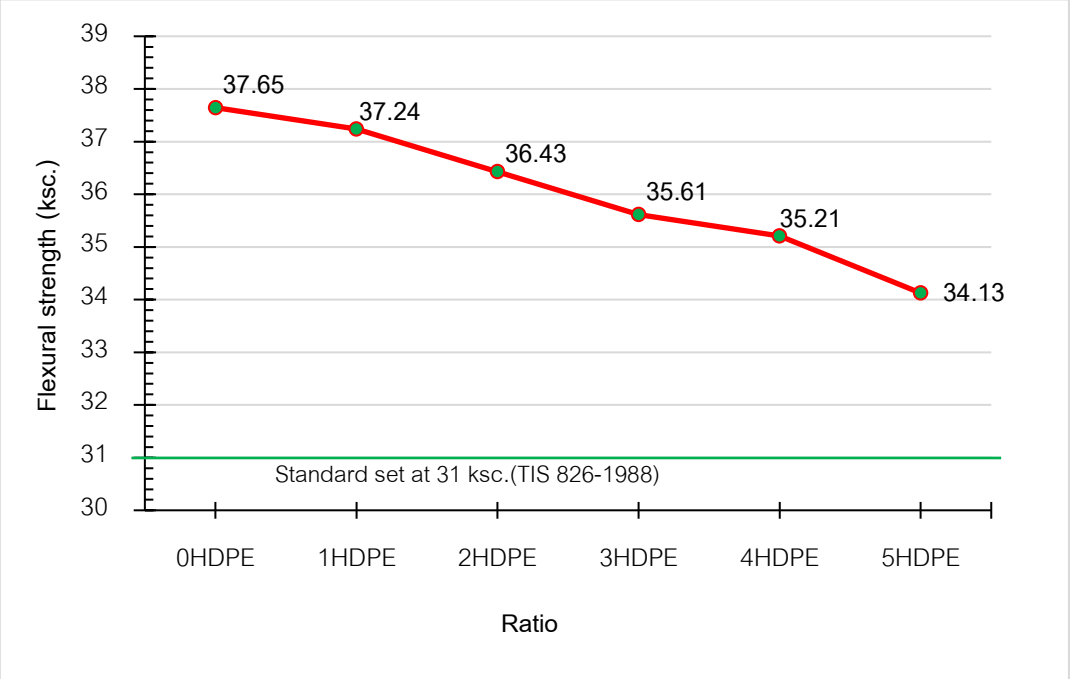

Figure 4 Flexural test results of cement blocks from sand mixture and plastic bottle lids at 28 days.

From Figure 4, the flexural strength test of the cement block pavement of the sand mixture and the plastic bottle lids at 28 days showed that the flexural strength tended to decrease. The more plastic bottle lids are mixed, the cement block pavement without plastic bottle lids at the ratio of 0 HDPE has the highest average flexural strength of 37.65 ksc. Followed by the cement block pavement mixed with plastic bottle lids instead of sand at the ratio of 1% of HDPE equals 37.24 ksc.; at the ratio of 2 HDPE equals 36.43 ksc.; at the ratio of 3 HDPE equals 35.61 ksc.; at the ratio 4 HDPE equals 35.21 ksc.; and the ratio of 5 HDPE has the lowest average flexural strength 34.13 ksc. respectively. The result of plastic bottle lids replacing sand is a more flexible material. When subjected to bending, it becomes flexible and unbearably flexural strength. As a result, the value is reduced compared to TIS 826-1988, cement floor tiles and TIS 378-1988, concrete floor tiles. It finds that the cement blocks pavement from the sand mixture and plastic bottle lids at the age of 28 days showed good flexural strength at all mix ratios, according to the specified standard of not less than 31 ksc.

2. Water absorption test

Water absorption test results of pavement cement blocks mixed with plastic bottle lids (HDPE) to replace sand at 28 days according to TIS 826-1988 for floor cement tiles and TIS 378-1988 for concrete floor tiles. According to Table 3 and Figure 5.

Table 3 Water absorption of cement blocks from sand mixture and plastic bottle lids at 28 days.

Ratio	Percentage of plastic bottle lids	Water absorption (percent)
0 HDPE	0	3.11
1 HDPE	1	2.94
2 HDPE	2	2.51
3 HDPE	3	2.33
4 HDPE	4	2.25
5 HDPE	5	2.04

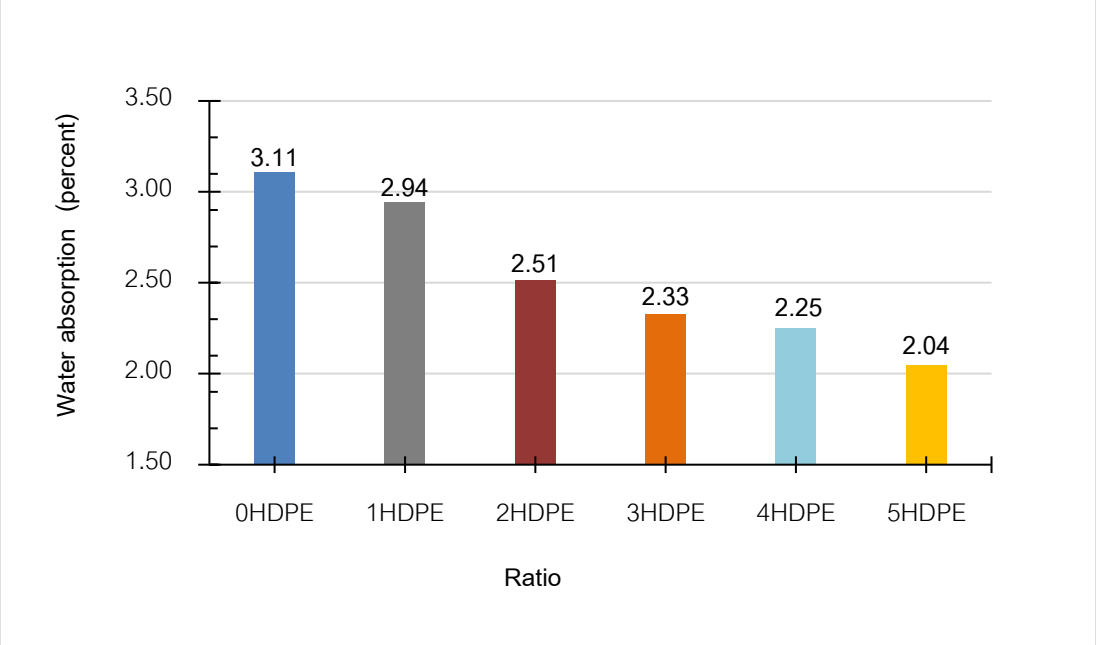

Figure 5 Water absorption of cement blocks from sand mixture and plastic bottle lids at 28 days.

From Figure 5, the water absorption values of the cement block pavement from the sand mixture and the plastic bottle lids at the age of 28 days showed that the cement block pavement with more plastic bottle lids has a lower water absorption value than a cement block with less plastic bottle lids. It shows that the cement blocks pavement without plastic bottle lids, the ratio of 0 HDPE has the highest water absorption, followed by the ratio of 1 HDPE, 2 HDPE, 3 HDPE, 4 HDPE and 5 HDPE, which is the lowest water absorption respectively. As a result, the plastic bottle lids are opaque compared to the coarse sand in the mixture; therefore, the water absorption value can be reduced., according to the standard, less than 10 percent.

Conclusion

This research aims to use the waste from plastic bottles lids as cement blocks for pavement by grinding the high-density polyethylene (HDPE) plastic bottle lid thoroughly, sifting through the no.4 sieve to replace the coarse sand. Use a coarse cement-to-sand ratio of 1:3 by replacing it with the grinding plastic bottle lids. The ratio between coarse sand per lid and plastic bottles is increasingly ground from 0-5% by using a fixed water-to-cement ratio of 0.4, with the ratio of 1% to 5% having similar flexural strength accordingly to the standard. By replacing sand with plastic bottle lids (HDPE), the ratio of 5% is more suitable for all ratios. the Flexural strength is 34.13 ksc; higher than the standard set at 31 ksc. and the water absorption value is 2.04%. less than 10% according to the standard.

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Management (MM)

Factors influencing Generation Y's purchasing decisions *via* online applications

Laddawan Someran[1*], and Soraya Supaphol[1]

Abstract

The two aims of this study were: 1) To compare the level of generation Y's opinions on their purchasing decisions *via* online consumer applications, as classified by their demographics; and 2) To investigate the marketing factors influencing the decision to purchase products *via* the online application of generation Y consumers. A total of 400 Generation Y consumers, aged from 21 to 37 years old, were chosen using a convenience sampling technique. A questionnaire was used to collect the relevant information on their purchasing decisions. Data analysis was conducted using the statistics of frequency, percentage, mean, standard deviation, one-way ANOVA and multiple regression analysis. The research findings revealed that the respondents generally had a high level of opinion about the Marketing Mix factor and purchasing decisions of Generation Y consumers *via* online applications. The hypothesis testing revealed that the two major demographic factors of Generation Y consumers were their different education levels and occupations, which were related to different purchasing decisions *via* online applications. The significant Marketing Mix factors were the process aspect and the physical aspect effects on Generation Y purchasing decisions *via* online applications with a predictive power of about 37%.

Keywords: Marketing Mix, purchasing decisions, online applications, Generation Y consumers

Introduction

Generation Y consumers who have access to online media, the digital world and online websites, are strongly influenced by these factors. They have become increasingly influenced by online marketing and advertising because it is a consistent medium that can reach consumers of all ages, particularly generation Y. As a result of the technological advancements of the present day, companies and organizations have opted to rely more on online sales. In-house use is mainly limited to online, digital, and portable or mobile communication technology. It constantly evolves and influences consumers like generation Y, which plays a role in consumers' decisionmaking nowadays. (SCB Economic Intelligence Center, 2563)

Moreover, it has changed the way of life of many consumers. There is more straightforward communication and living has become more comfortable. These technologies will come to the rescue, solve problems, and allow consumers to live life more easily. That is why generation Y people increasingly choose to consume products and services online. Online businesses in the country have adapted by relying on these technologies to drive online business trading or the model of selling products through the e-commerce marketplace system. This is just another trendy business, and it has also evolved into websites for the sale of information to consumers, in the form of images, audio, and video clips, as well as transparent product prices, streamlining the ordering and payment process, so that it is as simple and convenient as buying products in a traditional store.

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From the above changes, it has become evident that we live in the age of the consumer. Generation Y has the highest Internet usage compared to other, older generations. Generation Y consumers favor social media platforms such as LINE, Facebook, and YouTube. People grow up with comfort, so the products and services for this group must be presented comfortably, fashionably, be good-looking, and tasteful. It also must be a unique product. Any product with an unusual design tends to have a photo taken on social media - It also helps promote products. People in generation Y are bored easily, so the product must have a short lifespan to change with the flow. Distribution channels and after-sales services must be facilitated, as well as to impress and to encourage repurchases, and it becomes a word-of-mouth product among people in the group. It will take a lot of research and data comparison to get the best option or try it until they are confident to buy. And, then, the decision will be made to purchase. Specialists and influencers significantly impact purchasing decisions with their preference for information to consider and compare these decisions. Product reviews and actual user experiences heavily influence product decisions. Therefore, using the marketing method of "Word of mouth" recommendation is likely to work due to the group's popularity on social media. It is an opportunity for brands to use technological tools to help them to their fullest potential, such as applications that can be used in conjunction with loyalty cards, coupons, and promotions. This marketing package will impress the people in this generation Y.

Soosakulsing and Rurkwararuk (2020) studied the online marketing mix factors affecting the decision to buy fashion clothes through e-commerce websites in Mueang, Phitsanulok Province, finding that demographic characteristics and marketing mix factors in the e-commerce website affected the purchasing decision of fashion clothing. The researchers used Booms and Bitner's 7Ps combination theory (1981), consisting of product, price, place, promotion, people, process, and physical evidence applications that can be applied to consumer goods, covering more factors in the purchasing decision than McCarthy's 4Ps marketing mix theory.

Therefore, the researchers in this study were very interested to investigate the decision to shop online through the application among the consumer of generation Y, a large and high-powered demographic, by using 7 Ps Marketing Mix factors to conduct research on generation Y consumers who are influenced in their decision to shop through online applications. This research aims to increase academic knowledge as a research guide that benefits academics in advertising, communications, and marketing. Its objective is to study generation Y's consumption and consider the strategies to effectively plan the proper communications for the consumers.

Research Objectives

The two objectives were:

1. To compare the level of generation Y's opinion of purchasing products via online consumer applications classified by Demographic factors; and

2. To investigate the marketing mix factors influencing the decision to purchase products ***via*** the online application of generation Y consumers.

Research hypothesis

The two research hypotheses were:

1. Demographic factors include gender, education level, income, occupation, and online ordering applications that affect purchasing through online consumer applications among generation Y.

2. At least one marketing factor affects the decision to purchase products through the consumer's online application of generation Y.

Methodology

1. Population and samples

The population in this research was generation Y consumers, the group of 21 to 37 years old. The exact number of people and the sample was calculated based on the Cochran (1977) formula by determining the confidence level of 95% at 5% error, resulting in a sample of 400 cases using convenience random sampling.

2. Research tools

A questionnaire was the data collection instrument. It consisted of four sections: Part 1. a demographic data questionnaire (Checklist), Part 2. marketing mix factors, and Part 3. purchasing making through online consumer applications among generation Y. A rating scale characterizes parts 2-3; Part 4 is an open-ended question requesting comments and suggestions.

The scoring criteria for questions in parts 2 and 3, each part has five different levels of answering questions, defining the scoring criteria for each level: highest (5), high (4), medium (3), less (2), and least (1). The criteria for interpreting the average comment score on each side, as follows: 4.21 – 5.00 (highest), 3.41 – 4.20 (high), 2.61 – 3.40 (medium), 1.81 – 2.60 (less) and 1.00 – 1.80 (least). Three experts established the content validity of the questionnaire using IOC techniques. The researcher pilot tested for reliability with a sample of 30 cases and obtained an Alpha coefficient value. According to Cronbach's method, it was determined that all questions exceeded 0.50 and that the questionnaire was reliable and had face validity. The alpha coefficient was between 0.804 and 0.924, greater than 0.70. (Vanichbuncha, 2006).

3. Data Collection

The researchers collected data using a questionnaire generated by a Google form and sent the link to easily-reachable Generation Y consumers until 400 cases were collected.

4. Data Analysis

The data analysis employed two types of statistics:

4.1 Descriptive statistics, including frequency, percentage, mean ($\overline{X}$), and standard deviation (S.D.).

4.2. Inferential statistics, including one-way ANOVAs and Multiple Regression Analysis.

Results

1. General data analysis of respondent data

Table 1 Frequency and percentage of demographic factors.

demographic factors		frequency	percentage
1. gender	male	121	30.30
	female	239	59.80
	lgbtq+	40	10.00
total		400	100.00
2. education level	undergraduate	140	35.00
	bachelor's degree	247	61.80
	upper bachelor's degree	13	3.30
total		400	100.00
3. income (per month)	less than or equal to 10,000 baht	136	34.00
	10,001 - 20,000 baht	209	52.30
	20,001 - 30,000 baht	44	11.00
	30,001 baht or more	11	2.80
total		400	100.00
4. occupation	student	145	36.30
	civil servant	35	8.80
	farmer	38	9.50
	general hire	73	18.30
	other	109	27.30
total		400	100.00
5. applications for ordering online	shopee	252	63.00
	lazada	64	16.00
	line	19	4.80
	facebook	36	9.00
	instagram	9	2.30
	other	20	4.90
total		400	100.00

The majority of respondents—239 or 59.80 percent—were female, 247 or 61.80 percent were Bachelor's degrees, 209 or 52.30 percent made between 10,000 and 20,000 baht per month, 145 or 36.30 percent were students, and 252 or 63.00 percent utilized the Shopee application for online shopping.

2. Results of analysis of opinions on marketing mix factors

Table 2 Average and standard deviation of opinion levels on marketing mix factors.

marketing mix factors	$\overline{X}$	S.D.	opinion level
process	4.22	0.53	highest
price	4.20	0.53	high
place	4.18	0.54	high
promotion	4.14	0.54	high
people	4.10	0.57	high
physical evidence	4.08	0.59	high
product	4.05	0.56	high
total	**4.14**	**0.44**	**high**

Table 2 demonstrated that the respjndents generally had high opinions of the marketing mix factors, with the highest being process. Other factors that revealed high opinions were price, place, promotion, people, physical evidence, and product.

3. Results of generation Y's opinion on purchasing products via online consumer applications

Table 3 Average and standard deviation of generation Y's opinions of purchasing products via online consumer applications.

determination	$\overline{X}$	S.D.	opinion level
1. you decide to shop through the online application because it is convenient.	4.38	0.73	highest
2. you shop through the online application because of the speed.	4.29	0.69	highest
3. you search for information and compare prices before purchasing the online application.	4.25	0.74	highest
4. you purchase the online application, which is always publicized and updated.	4.19	0.75	hight
5. the packaging characteristics and appearance of beautiful goods affect purchasing products through online applications.	4.19	0.78	hight
total	**4.26**	**0.44**	**highest**

From Table 3 it was demonstrated that an analysis of Gen Y's overall opinion of purchasing decisions made through online consumer applications showed the highest level of opinion ($\overline{X}$ = 4.26, S.D. = 0.44), based on the opinions of: 1) You decide to shop through the online application because it is convenient; 2) You decide to shop through the online application because of the speed; and 3) You search for information and compare prices before purchasing the online application.

4. Comparative analysis of generation Y's purchasing decisions through online consumer applications, categorized by demographic factors.

Table 4 Results compared the level of generation Y's opinion on purchasing decisions *via* online consumer applications, classified by five demographic variables.

demographic factors	purchasing decisions via online consumer applications	
	F	p (sig)
gender	0.411	0.663
education level	3.510	0.031*
income	0.075	0.973
occupation	4.016	0.003*
applications for ordering online	0.793	0.668

* p <.05

The results in Table 4 compared the level of generation Y's opinion on purchasing decisions *via* online consumer applications, classified by demographic. Different education levels and occupations were discovered, which led to different decision-making. It was made through the online application of the generation Y consumer significantly at 0.05. Furthermore, gender, income, and applications for ordering online produced no significant differences.

5. Analysis of Marketing Mix factors affecting the decision to purchase products through the consumer's online application of generation Y

Table 5 Results of analysis of marketing mix factors affecting purchasing decisions through online consumer applications of Generation Y.

marketing mix factors	purchasing decisions online consumer applications			t	p (sig)
	b	SE	β		
constant a	1.878	0.165		11.398	0.000
product	0.065	0.041	0.084	1.594	0.112
price	0.012	0.048	0.015	0.253	0.801
place	0.016	0.050	0.020	0.320	0.749
promotion	0.079	0.050	0.098	1.591	0.112
people	0.060	0.042	0.79	1.441	0.150
process	0.159	0.058	0.194	2.753	0.006**
physical evidence	0.184	0.047	0.248	3.919	0.000**
adjust r square =0.373 r square =0.384 r =0.620 durbin–watson = 1.852					

** p<.01, * p<.05

According to Table 5, two independent variables influenced the decision to purchase products through online consumer applications of generation Y: Process and Physical evidence. These two independent variables predicted generation Y's purchasing decisions *via* online consumer applications and had a predictive power of 37 percent (Adjusted R Square = 0.373).

Discussion

The first research hypothesis: Demographic factors, including gender, education level, income, occupation, and online ordering applications were tested for their effects on purchasing through online consumer applications among generation Y. The results showed that the difference in education level and occupation affected purchasing through online consumer applications among generation Y. And the demographic factors, such as gender, income, and online ordering applications did not affect their purchasing decision.

Different levels of education affect purchasing decisions through online consumer applications of Generation Y. This result is consistent with that of Bovornkiratikajorn (2017), who studied the fashion group trading on social media. He found that demographic factors, including gender, age, education, and income, affect the buyers' decision-making in buying fashion products through Social Commerce differently. Moreover, the results of the Pairwise Comparisons are as follows: Using the LSD Method, it was discovered that consumers with undergraduate studies were more likely to purchase online than those with Bachelor's Degrees. This may be due to generation Y consumers having a lower education degree than those with a Bachelor's Degree and less reason to shop than those with a Bachelor's Degree. As a result, it is easier to make purchases through online applications. Thus, there are more purchasing decisions. This result is consistent with Wiwantniti and Ayasanond (2022), who studied the online marketing that influenced product purchase decisions through the internet of consumers in Nakhon Pathom. They discovered that different levels of education affected Internet purchasing decision. They found that different levels of education influenced their purchasing decisions over the Internet differently.

Different occupations affect purchasing decisions through online consumer applications of Generation Y. The Pairwise Comparisons using the LSD Method also found that respondents who work as civil servants make purchase decisions through online consumer applications are less than a group of students. It may be because the student group is more capable of using technology and has more confidence in technology than the civil servants. A student has the value of using a smartphone, making it convenient to make purchases through online applications, similar to the results of the study by Sumananusorn (2018). A study of baby boomers' shopping decision-making habits found that different professions have significantly different social networking decision-making behaviors. Furthermore, Soosakulsing and Rurkwararuk (2020) studied the online marketing mix factors affecting the decision to buy fashion clothes through e-commerce website in Mueang, Phitsanulok Province. Significantly, they discovered a difference in purchasing behavior between occupations.

The second research hypothesis: Two marketing mixed factors affected the purchasing decisions through online consumer applications of Generation Y: The result of this study demonstrated that the process and physical evidence aspect affected purchasing decisions through online consumer applications of Generation Y. Therefore, this hypothesis

was accepted and may be interpreted as follows: The process aspect affects purchasing decisions through the online consumer applications of Generation Y. Because the online applications that generation Y consumers choose are often considered easy to use; there are easy ways to pay, which are convenient and reliable. The system should be accurate and easy to understand or user friendly. Therefore, the process side affects the decision to purchase through consumers' online applications. It corresponds to Teuksuban and Inmor's (2021) study which investigated service marketing factors that affect consumers' shopping habits through the Shopee app In Bangkok. The services market segment factors in the service process were found to correlate with the shopping habits through the Shopee application of consumers in Bangkok. Moreover, Chomraka and others (2022) studied the service marketing mix factors affecting decisions to buy clothes and fashion apparel through online marketing channels of people in Uttaradit province. They discovered that the process component of the marketing mix influenced the decision of people in Uttaradit province to purchase clothing and fashion apparel through online channels. Furthermore, Lhuangtep and Pasunon (2014) studied the factors affecting goods and services purchasing decisions through e-commerce of Silpakorn University Petchburi IT Campus students. They discovered that the process factor significantly influenced the decision to purchase goods and services through e-commerce businesses.

The physical evidence affected the purchasing decisions through online consumer applications of Generation Y. This finding was interpreted as the consumers valuing their being able to view products through online applications with precise details of each type of product to make a purchasing decision before making an online application. Moreover, consumers consider the modern features of online applications. The design of the application should be colorful and beautiful. The application displays product images that match the actual product, consistent with the results of Tueksuban and Inmore (2021), who found that the service marketing mix factors (7Ps) affected consumers' shopping habits through the Shopee app. In Bangkok, services marketing mix factors (7Ps) were found in the physical evidence. It is related to shopping habits through the Shopee application of consumers in Bangkok. It is also related to Klaysung (2021), who identified the factors affecting consumer buying decisions of goods on social media in Bangkok. The services market compound factor (7Ps) in terms of physical characteristics was found to affect shopping decisions *via* social media online in Bangkok. Our finding was also consistent with Chomraka and others (2022), who studied the service marketing mix factors affecting decision to buy clothes and fashion apparel through online marketing channels of people in Uttaradit Province. They discovered that physical factors influenced the decision to buy clothes and fashion apparel through online marketing channels.

Results and discussion

The following three recommendations were drawn fro the results of this study:

1. A marketing strategy should be developed for civil servants and undergraduate students to make more online shopping decisions, such as finding suitable products for this group through online shopping, discounts, and free delivery.

2. Based on the process aspect of marketing mix factors, there should be a focus on developing applications that are user friendly, offer easy payments, and are reliable, precise, and easy to understand.

3. The physical evidence aspect of marketing mix factors should provide enough visual information and product details. Thus, customers may access the product through the online application in order to make a purchasing decision.

Conclusion

According to the results of this study, research on factors affecting purchasing decisions through online consumer applications of Generation Y consumers, the important demographic variables included their education level and their occupation. There are different shopping decisions on various online applications. Furthermore, the important marketing mix factors included process and physical evidence. These two factors significantly influenced the purchasing decisions towards products on the consumer's online application. Process and physical evidence together had a predictive power of about 37 percent. This research was useful to the academic community by increasing the knowledge for scholars and researchers in this important field of consumer spending in the post-industrial age, especially for Generation Y consumers. It also benefits business organizations as a guideline for adjusting marketing strategies suitable for Generation Y customers.

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Others (OT)

Innovative Online Marketing Technology to Promote Community Tourism in the 21st Century

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Abstract

This academic article has purposes to study knowledge on innovative technology to promote community tourism and study online marketing platforms to develop community tourism in the 21st century. The communities with received tourism standards can increase their market value and increase sales of tourism products of community by utilizing innovative digital technology to expand trade , investment within the country and connect to the world market with online market innovative technology such as Network Slicing, eSIM, Mobile Application, Green gets mean, Machine learning,Streaming TV, Virtual Reality (VR), (B2B), Facebook,Tiktok, Reel, Google Business, Metaverse Tourism and all kinds of booking platforms, including the “5G” system, another important turning point in the world, that will transform everything to be "Smart" from the individual level to a daily lifestyle of "Smart Life", transforming the community level into "Smart Villages" to the city level (Smart City) and the country level (Smart Country) .Therefore, in order to upgrade the development of community tourism in Thailand to be a center of tourism, it is necessary to develop the strength of the community by utilizing technology to develop and promote community tourism in accordance with the 20-year national strategy and in accordance with the Thailand Development Policy Plan of Sustainable Thai Economy through tourism as the key to the country's further development.

Keywords: Innovative Technology of the 21st century, Community tourism, Online marketing, Market Value, 5G, Smart, Metaverse Tourism

Introduction

In 2017-2021, Thailand had a plan of working guidelines and adjusting the mechanism to drive the integration of tourism policies to generate income in the country with travel and tourism standards as well as adjusting the infrastructure and environment of the business sector by unlocking the potential of the community as a strategy to promote community rights and potential with sustainable quality tourism in the 21st century as an important factor in building a foundation economy on a stable and strong basis by applying technology to develop the changes (National Tourism Development Plan since 2012–2016).

According to UNWTO, it is possible to estimates that by 2030, the number of global tourists will increase to 1.8 billion. There are also emerging markets in developing countries that trend to be a higher rate of tourist growth than developed countries that the Asia and Pacific region will have the highest growth rate. The tourism model will be managed by the communities and will raise the capacity of the communities to a higher level. It is an advantage to support the growth of the cultural community, value of wisdom and various arts tourism industry by promoting the creation of new tourist attractions according to the adjustment of infrastructure and integration to be linked from the national level to the local and community level. These functions will promote and develop tourism personnel to have skills and knowledge to be competitive in the world market (Punchakhettikul, 2016)

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In addition, the year 2019 is considered as the beginning of 5G technology trials in technology superpower countries. and the world economy. It is expanding to general consumer applications by utilizing 5G with various digital online platforms(Industry Insightresearch, 2020) for the development of innovative online marketing technology to promote community tourism in the 21st century for communities that have received tourism standards to use and unlock the potential of the communities for maximum benefits in the development of infrastructure systems and income for grassroots communities to generate income and create sustainability in the country's grassroots economy by utilizing tourism-led tourism and utilizing innovation and developed technology to drive the community further.

In conclusion, online marketing technology innovations to promote community tourism in the 21st century require a system set up and use of technology that can unlock the potential of the tourism communities in the country to be able to promote community tourism and be accepted by the tourists with the use of 5G technology play in community tourism development together with online marketing strategies as a complement to develop communities to be strong angenerate sustainable income in the digital era.

Terms Definition

1. Technological innovation is the introduction of new ideas or the use of existing things in new way to cause economic and social benefit by focutilizing on creativity and develop science and technology that will lead to the acquisition technological innovation mainly for commercial benefits which is able to learn and put into practice to achieve real results.

2. Online marketing is marketing in online media such as Facebook ads, Google ads, Youtube ads, Instagram ads. The main objective is to make the product more known by utilizing various methods to advertise the website or sell products that will be published in the online media for people to be aware and interested until they decide to use the service or buy products.

3. Community tourism in the 21st century is tourism that must be in the pattern of participatory tourism focusing on conservation to strengthen communities in various dimensions. It is also the foundation of sustainable tourism and with the use of advances in technology and innovations that have been created as important elements in community development for sustainability.

4. FiveG technology (5G) is a new generation of wireless networking technology that will replace the present 4G system which is not limited to mobile phones only but include all kinds of devices that can connect to the Internet (Internet of Things or IoT).

5. Metaverse Tourism is a journey through the virtual world, viewing and testing products in a virtual world, trading assets in game including receiving various services and elevating the model of travel in the virtual world to cutting-edge innovations to create a unique experience.

6. The innovation platform is innovations that is developed for a healthy, safety, comfortable and environmental-friendly life including the innovation that connect lives together with new career and income and innovation for a happy life.

Evolution of online marketing technological innovations to promote tourism in the tourism community in Thailand

Evolution of online marketing technological innovations to promote tourism in tourism communities in Thailand has used various marketing technology innovations from the past to the present as follows:

1. Evolution of former marketing technological innovations

Starting from the early days, 1G was used to communicate and talk with voice over analog mobile phones. Later, users began to send MMS messages to each other in the 2G era until the important turning point was when entering the 3G era. At that time, it was possible to connect and surf the internet via mobile phones with higher speeds (between 220 Kbps to 42.2 Mbps). Until entering the 4G era, images and sounds or movies can be viewed online due to various speed levels. The users had options to choose whether i 4G LTE (100 Mbps) or LTE Advanced (1 Gbps) until stepping into innovative technology. The 5G era is a new generation of wireless network technology that will replace the current 4G system which is not limited to mobile phones only but also include all kinds of devices that can connect to the Internet (Internet of Things or IoT) and can be used to develop many people's lifestyles in this world.

2. The evolution of technological innovation (5G) in present era.

The beginning of trials of “5G” technology in technology powerhouses and the world economy especially expanding to use in general users as follows

"InternationalDataCorporation" (IDC) said that the 5G operative system will be develop from around the world for both Android and IOS by fully utilizing 5G technology through targeting revenue generation from the service and utilizing the content format “ContentPlatform” more because it is a key puzzle in building a strong Business Ecosystem.

"Telenor Group" stated that the emergence of 5G is a major turning point in the technology world as innovations related to AI and IoT are widespread that consumers can experience and actually use it. The 5G technology changes the lifestyle of consumers, whether AI, machine learning and IoT. Such innovative technologies include:

1. “Network Slicing” is considered as a transformation of the network architecture into a virtual system, resulting in the utilization of the IoT to its fullest potential. It can be applied in other industries such as public health, transportation and security.

2. “eSIM” Technology In 2022: “eSIM” technology will be the thing that users will experience in everyday life, along with IoT technology. The 5G technology will change users’ behavior, make it convenient and able to store actual usage data

3. Innovation for the Environment Environmental awareness trend will be more than raising awareness through technologies such as IoT, Big Data and AI or Artificial Intelligence to reduce the consumption of resources and use 100% of electricity to cover the business chain.

4. Developing technology with technology: It will be possible to see the development of a machine learning platform that can create AI on demand. This will allow businesses or individuals to develop AI for their own use, which can be called the introduction of technology to create another layer of technology.

5. The bodies will be connected to the Internet more than in the past: IoT technology in the logistics, manufacturing and agriculture industries, health and medicine will be appended to various devices. This makes it possible to store information about the body in real time.

6. The phenomenon of "Dirty Data", a new form of fake news.

7. “Reliability” has been elevated.

8. The battlefield of digital content distribution (Streaming TV) has radically changed the way consumers enjoy entertainment through “streaming”, enabling content creators and other platform owners like AppleTV+ and Disney+ comes in and asks for market share.

9. New govern criteria: Each digital business segments across platforms will be governed by new rules whether the issue of taxation, privacy, security, and prohibition on advertising for political purposes.

10. The prevention of the increasing number of phone scammers around the world which comes in a variety of forms. In order to reduce and prevent problems that arise, machine learning will play a role and be a tool to prevent phone scams from occurring.

11. The benefits of utilizing innovative 5G technology: The obvious main feature of 5G is probably the quality of video viewing or playing online games that allows users to experience the quality of clarity with the speed that is equivalent to utilizing a fiber optic network (Fiber Optic) or being able to work and access all information on the service system via the Internet, whether it's image or video format instantly as needed, including the development of technology to have faster download and upload speeds than 4G technology.

5G technology is also designed to support a large number of connections via internet which are also known as IoT, such as driverless cars, remote surgery and robot in factory. This represents a performance increase that is more than 10 times faster than 4G technology, as well as improving usability through a technology that brings 3D objects to be simulated into real world (AR). The adoption of technology that simulates places into a virtual world is largely related to vision. Users can interact with simulated locations or environments via (VR) devices in activities such as field surveys. telehealth, entertainment, and large-scale data pipelines to access applications through the use of hardware and software to deliver services over the network (Generally, the Internet (Cloud Computing). All of mentioned ideas are 5G technologies that has the effect of creating and helping to develop the potential of the retail system online shopping including various applications of Smart Office and leading to Smart Cities in the future

3. The use of Innovative information and communication technology and lifelong learning skills in the 21st century.

Stone（2006) said that competence in the use of information and communication technology refers to skills, knowledge, attitudes and the ability to apply information technology to communication, including the ability to use technology to access manage integrate, evaluate and create information as well as the ability to apply and transmit information effective. It's one of the skills learned throughout.

Partnership for 21stcentury skills (2009) stated that the definition of lifelong learning skills in the 21st century is a skill that is considered important in Living and working in social and economic systems, including

1. Learning and Innovation Skills

2. Information, media and technology skills

3. Life skills and career skills include leadership, ethics, responsibility for the ability to adapt, knowing how to increases one's productivity, self-responsibility, accessibility skills, self-guided ability and social responsibility

4. Community Tourism in Thailand and Online Marketing

Siriwan Pornlertwiwat (2021) said that community tourism in the country and online marketing has a requirement that the community must take into account the sustainability of the environment, society and culture of the community by setting the direction of the community. The management is conducted by the community for the community. The community has an ownership role in managing and caring to provide learning for visitors and create value as well as enhancing the income of the community by utilizing online marketing that is becoming widely popular to be able to know the community a wide range of community products through a variety of channels that are constantly evolving, such as Facebook ads, Google ads, Youtube ads, Instagram ads with the main objective of making the community and various products become more known utilizing various methods to advertise the website for selling the identity of a tourism community and products to create awareness and attract attention of the tourists until they decide to use the service or buy products of the community as much as possible through online marketing. In addition to the initial platforms, there are also additional platforms, namely search engine marketing on the Internet which is to get communities and products to rank in the first search. This will be easily discovered through the use of the platform and marketing which includes

4.1 SEO (how to make your community website and product rank on Google)

4.2 PPC is a tool for online advertising on Google network (Purchasing Ads on Google).Email Marketing is online marketing done through email to send news various promotions to target customers. It is the lowest cost marketing compared to other forms of marketing and also an online marketing that meets the group and can reach the recipient within a short time.

4.3. Social Marketing is an online marketing that is done through various social networks such as Facebook, Twitter, Instagram, Pinterest, Tiktok, Reel and Line official, etc. Social Marketing is becoming very popular because it has higher usage statistics than other online sources (NIPA, 2022) In summary, the evolution of online marketing technology innovations to promote tourism in the tourism community in Thailand has been continued since the period of former marketing technology innovation from the first 1G to 4G for use in both the public sector, government and private sectors.

In addition, innovations in the use of developed technology have also been increased as 5G in the present era to use information technology, communication and lifelong learning skills in the 21st century and to increase the capacity of utilizing information and communication technology to have skills in living and working in social and economic systems For the development of community tourism in Thailand to online marketing such as Facebook ads, Google ads, Youtube ads, Instagram ads, etc., with the main objective of making the community and the product is to be known more and let Pinterest, Tiktok, Reel and Line official the community use the platform and marketing by dividing into 1: SEO (website designed by a community and products to rank on Google) 2. PPC (Purchasing Ads on Google) Email Marketing is an online marketing through email. It is also an online marketing that meets the group and can reach the recipient within a short time and 3. Social Marketing is an online marketing that is done through various social networks such as Facebook, Twitter, Instagram, including other platforms are about applying marketing strategies in business or used for commercial purposes as a tool for campaigning aimed at solving social problems (Social Marketing) is

becoming very popular. These operations are to transform everything into a form of "Smart" from the individual level with a daily lifestyle of "Smart Life" to the community level as "Smart Village", city level as "Smart City" and up to the national level as "Smart Country"

Cooperation from government and private sectors in utilizing innovative technology to develop tourism in Thailand's tourism community in the 21st century

The use of online media is a communication strategy that demonstrates consistency with the organization's adaptation to technology and tourist behavior and becoming familiar with tourist attractions over time and including raising the awareness of the unique characteristics of tourist attractions in the memory of tourists (Aaker, 1996: 69). Developing the use of online media to promote tourism among community tourism provinces in Thailand with high efficiency and low budget in both form of advertising, public relations and promotional campaigns for communities and tourist attractions in order to be successful in the goal according to communication strategies such as the most efficient and effective use of online media, etc. (Eastern coastal provinces strategic management office, 2019) The strategies to enhance capacity and competitiveness are determined to be able to reach customers easily by utilizing online media and applying common media according to the format to promote marketing to increase tourism trends in the future (Tourism of Thailand, 2017: 8). The supporting of various technological innovations in order to develop tourism in the tourism community in Thailand in the 21st century are as follows:

1. Cooperation from government agencies in utilizing innovative technology to develop tourism in the tourism community in Thailand in the 21st century

1. The government sector attaches great importance to tourism. The Ministry of Tourism and Sports has a mission related to digital adoption, namely developing technology and information systems for management and service provision as well as knowledge and innovations that can increase the economic value of the community and the tourism and sports industry (Ministry of Tourism and Sports, 2017)

2. The government sector has promoted tourism policies by promoting tourism and tourist attractions of Thailand to be aware of globally and persuade foreign tourists to travel in Thailand, create incentives and facilities that support the tourism atmosphere and tourist attractions such as nature, history, art and culture, local wisdom and health will be linked to products developed from community lifestyles as well as develop tourist attractions in the country, both old and new attractions. by emphasizing on educating and increasing safety standards in life and property and providing quality services, fair prices, as well as facilitating various aspects for tourists

3. There is a driving policy for tourism as a national agenda to present a good image of Thai tourism and Thai identity along with supporting the use of digital technology for Thai tourism to enhance the competitiveness of Thai tourism. (Wattanawarangkun, 2017)

4. Operational policies related to tourism are:

4.1 Tourism is a tool to reduce income inequality as well as promoting sustainable tourism in terms of society, culture and environment, such as community tourism.

4.2 Communities must be “convenient, clean, safe, unique and sustainable” by utilizing indicators according to the standards set by the Global Sustainable Tourism Council (GSTC).

4.3. Establishment of a tourism clinic to provide advice and education to tourism related and help the owner of the attraction to maintain the quality of the tourist attraction

4.4. Digital Tourism Operations Center will prepare digital tourism information to be complete, accurate, up-to-date, qualified and disseminates it through websites and applications (Kowsurat, 2018).

5. Launching a new website and application to integrate cooperation from local sectors. The government sector will be the center for creating quality digital tourism information from the data subject in the local community area which the Ministry of Tourism and Sports will have an operating center mechanism of digital tourism in both central and provincial areas acting in the management of digital information to be complete, accurate and up-to-date before disseminating digital tourism information via www.thailandtourismdirectory.go.th and application. The website has set various logos to increase the credibility of the information in the system.

6. Digital tourism that has been verified, registered from the database of government agencies with direct responsibility under the law such as the “Verified” badge, the “Standard” badge. There are various certification standards in the field of tourism issued by a government agency to confirm the existence of various standards in the tourism industry today.

7. The Thailand Tourism Directory project has been made as part of the Digital Tourism Platform system under the management of the Digital Tourism project, which is the central platform for tourism in the country and responsible for managing digital data for surfing services (Central Digital Tourism Operation Center, 2018)

2. Cooperation from private sectors in utilizing innovative technology to develop tourism in the tourism community in Thailand in the 21st century

1. The private sector has supported the provision of internet services within the tourism community accommodation with a reservation system through Global Distribution Systems (GDS). GDS will act as an intermediary in distributing tourism products to the community by connecting the sellers and the users through the direct booking system.

2. The private sector has supported the provision of training on property management system (PMS) services to develop and practice management according to the model and systems of the hotel such as reception, sales, room availability checks. room reservations and cancellations, etc. (Chankit, 2018)

3. The private sector has supported the use of the internet system to communicate and book accommodation online between the community and users through the computer reservation systems (CRS) which is similar to the CRS system that is used in Thai Airways International Public Company Limited called Amadius. It is a system that covers many areas, such as booking air tickets, hotels, car rentals to issuing tickets and travel insurance. This system creates a comprehensive sales system in the tourism industry with the main objective of supporting and developing for the advancement of the Thai tourism industry to be equal and to keep pace with the country (Chankit, 2018).

In summary, technology presently has an influent in service management, hotel business operators and community tourism enterprises. Homestays business can also use this opportunity to generate more sales, requiring both the public and private sectors to play a role and increase channels by utilizing innovation and technology to promote activities and focus on social media marketing to make the business be popular with tourists, both Thais and

foreigners. Therefore, the tourism communities in Thailand have to adapt themselves to be ready in the digital era. (Digital tourism business/Benefits to all parties, 2015)

Issues on the development of community tourism routes utilizing innovative online marketing technology to promote community tourism in Thailand in the 21st century by analyzing in the form of SWOT analysis

From the study of the development of community tourism routes utilizing innovative online marketing technology to promote community tourism in Thailand in the 21st century, an analysis in the form of a SWOT analysis can be performed to analyze the environment, both internal and external factors that lead to the development of community paths by utilizing the following innovations in online marketing technology:

S: Strength, Strength is that Thailand is the abundance of resources and environment including community tourism routes in Thailand. There are h tourism and tourist attractions that can create awareness for both Thai and foreign tourists through the use of the Digital Tourism Platform system under the management of the Digital Tourism project, which is a central platform for tourism in the country that supports community tourism in Thailand to receive tourism standards and can use digital technology to develop the tourism community in Thailand.

W: Weak, The weak point is that the development of digital technology is happening so fast. Each community that has tourism is unable to adapt and lack of young leaders to manage the community in order to create a concrete community tourism.

O: Opportunity, Opportunity is the development of community tourism routes. Both government and private sectors have supported innovations in online marketing technology to promote tourism in the tourism community to learn, develop, recognize and present art, culture, identity, and way of life through digital online media systems and the introduction of modern technology 5G to enable the community to be in the Smart Village system.

T: Threat, The obstacle is the budget problem for the development of community tourism routes is limited. The leaders of each community are mostly elderly people. Therefore, the use of technology is an obstacle to the development of tourism routes to be known to tourists.

In summary, the SWOT analysis on the development of community tourism routes utilizing innovative online marketing technology to promote tourism in Thailand's tourism community in the 21st century is the use of innovative technology to develop community tourism routes in the country and tourist attractions that create awareness for both Thai and foreign tourists. This operation is conducted by utilizing the Digital Tourism Platform system that supports community tourism to receive tourism standards and develop the tourism community in Thailand to be concrete and sustainable, as well as create opportunities for the development of community tourism routes. The government and the private sector are allowed to support innovations in online marketing technology to promote tourism in tourism communities to live by utilizing modern 5G technology to enable the community to live in a Smart Village system.

Conclusion

Innovative online marketing technology to promote community tourism in the 21st century is the use of various marketing technology innovations from the evolution of former marketing technology innovations to modern 5G innovative technologies and learning by applying these innovative technologies in the information technology system used to communicate and enhance learning skills throughout life in the 21st century to achieve in access , manage,

integrate , evaluate and create information , as well as the ability to apply and transmit information efficiency and create value increase the income of the community by utilizing online marketing . These are to advertise the identity of the tourism community and products to spread awareness and attract attention until they come to use the service or buy products of the community through online marketing in the search of communities and products that have been ranked in the search engine rankings through the use of social media platforms and marketing such as SEO, PPC Email Marketing and Social Marketing, Facebook, Twitter, Instagram, Pinterest, Tiktok, Reel, Line official by cooperation from government and private agencies in utilizing innovative technology to develop tourism in the tourism community in Thailand in the 21st century.**Conceptual framework and new gained knowledge**

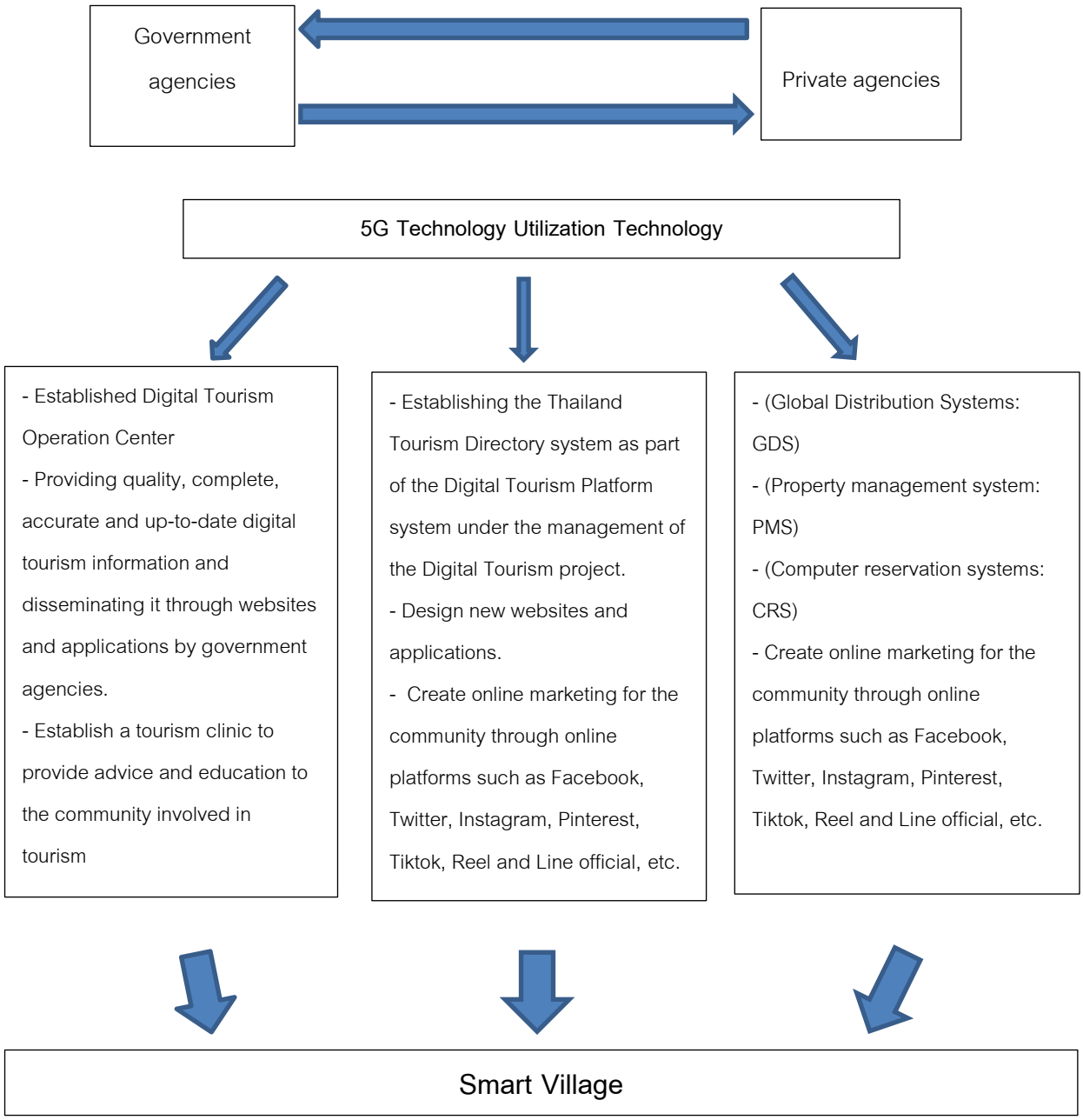

Figure 1 Shows the results of innovative online marketing technology to promote community tourism in the 21st century.

Figure 1 shows that cooperation between government and private sectors. It is the key to applying innovation and technology to assist in develop communities that meet the tourism standards of the Ministry of Tourism and Sports in Thailand to create a new tourism model in the community through the digital era network and technology innovation (5G) to be used along with the establishment of an operation center of digital tourism in the community including to prepare digital tourism information to be of quality, complete, accurate, up-to-date and disseminated through websites and applications. The government agencies establish a tourism clinic to provide advice and education to the communities involving in tourism and create a system for searching for tourist attractions, accommodation, restaurants, souvenir shops and a place to travel, stay and buy products by viewing information conveniently through an application (App) as a distribution of income to the community and local (Thailand Tourism Directory). This is a part of the intermediary system in the development of tourism business to community (Digital Tourism Platform) under the administration of the government's Digital Tourism project. The government agencies are also responsible to create new websites and applications and create online marketing for the community through online platforms such as Facebook, Twitter, Instagram, Pinterest, Tiktok, Reel and Line official, etc. Likewise, the private agencies that have been successful in utilizing the inter-network reservation system will play a role in creating a global distribution system (GDS) and a property management system (PMS). Computer reservation systems (CRS) by CRS systems, where all innovations and technologies derived from the layout create opportunities for job creation and income generation including continuing the development of the community's tourism routes and increasing the capacity of the community to be able to enter the Smart Village system.

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Social Media as a Language Learning Tool for a Remedial Instruction on Reading and Listening Skills

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Abstract

This paper discusses benefits and the potential method to use social media as a language learning tool for a remedial instruction on reading and listening skills. Learning English language with the help of applications on computers or smartphones is now entirely in vogue among foreign language learners. Low English proficiency students are also able to get benefits of them to improve their reading and listening skills easier than before. The social media not only motivates them to learn English naturally but also gives them chances to practice English actively, effectively, and enjoyably. Foreign language teachers need to use them as tools for their students who attend the remedial class effectively. Teachers have to reframe the learning process, meet the needs of the learners and use them to reinforce reading and listening skills while they are learning. Internet Reciprocal Teaching and Cooperative Learning are also proposed to integrate in the remedial instruction using social media for enhancing the low English proficiency students reading and listening skills.

Keywords: Social media, Remediation, Reading skill, Listening skill, Reciprocal teaching, Cooperative Learning

Introduction

With the emergence of modern interactive media technology, social networking platforms such as YouTube, Facebook, WhatsApp, Twitter, Instagram, Skype, LinkedIn etc., have been invariable used for different purposes to the extent that it is becoming part of everyday life of human beings. People use social media as one of the tools with which to exchange their ideas in everyday communications. It seems that social networking sites had a profound impact on our social structure and intra-social interaction nowadays.

During COVID-19 pandemic, social networking has been proven to be a global phenomenon that has caused a vast paradigm shift in the world of learning and education. The social media allows individuals to learn at their own pace instead of being bound to their classmate in traditional classroom conditions (Muftah, 2022). The new technologies have played an important role for us not only in how they communicate but also in improving learners' social behavior (Desta et al., 2021).

Currently, there is a growing number of research that addresses the benefits of social media on English language learning (Harbi, 2019; Thilaphn, 2020; Elmabruk & Albaseer, 2016; Blaschke, 2014). In addition, many researches showed that social media can be used as a tool to enhance the English underachievers or low achievers in effective ways. Then, it is recommended to help these students to attain the mastery learning in remedial teaching program 3 (Wartona at al., 2018).

As the objective of remedial instruction to improve or rectify a problem area of students' learning process, learning skill, and life-long learning, social media can support in many ways to help students to achieve the mastery learning, to develop their learning style, interpersonal relationship, communication, self-learning, motivation,

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engagement and motivation (Harbi, 2019; Thilaphan, 2020; Elmabruk & Albaseer, 2016; Muftah, 2022; Girma, 2012). In term of basic English skills such as listening and reading which are receptive skill, social media can support the remedial instruction on these skills with the wide range of beneficial sources and learning tools that teachers can selected the ones that are appropriate to students' proficiency level and the course objectives (Yunus et al., 2012)

In teaching reading and listening, the teachers have responsibilities in helping learners to achieve the goal to motivate reading or listening by selecting or creating appropriate texts, to design useful reading or listening tasks, to set up effective classroom procedure, and to create supportive environment for practicing. The strategies or approaches which educators and research recommend to use as the learning strategies for supporting these kinds of responsibility are Cooperative Learning and Collaborative learning such as Reciprocal Teaching (Khori at al., 2018; Hamadi, 2020).

As for the adoption of social media as formal teaching and learning tools by educators remains quite limited and subject to myriads of restrictions (Chawinga, 2017), the integration of social media as a tool for Cooperative Learning and Reciprocal Teaching are proposed by many current studies to develop standard integration model and framework for remedial English instruction of today's new-age learning. The objective of this article is to propose the model that integrates social media to use for remediation and students' learning process of Cooperative Learning Approach and Reciprocal Teaching.

Benefits of Social Media on Education

Many studies revealed benefits of using social media applications and websites for educational purposes; for instances, to develop self-learning and autonomy (Blaschke, 2014; Chartrand, 2012), to support in increasing the attention to the individual differences between students (Kessler, 2013), to expand the educational environment beyond classroom settings (Seaman and Tinti-Kane, 2013), and to be as authentic learning sources (Clavel-Arroitia and Fuster-Ma'rquez, 2014). In addition, the study of Albiladi (2020) found that social media increase student motivation and engagement, enhance teaching practices, and help to build a learning community among students.

Research studies in different disciplines have been conducted to estimate their effectiveness. Al Harbi (2019), Thilaphn (2020), Elmabruk & Albaseer (2016), and showed that using social media can enhance English skills of learners. According to Muftah (2022), using of social media has been significantly impacted positively on learning English language in terms of writing style, reading skills, listening and lexical variation, communication skills and grammar usage. The study of Girma (2012) found that learners have developed their own learning styles through using different interactive media and reading and commenting on other people's posts on social networking sites.

Social Media and Remedial Instruction

For the remedial course, social media can be used to enhance the English underachieves in effective ways. The study of Luo (2009) found that English underachievers in universities of science and technology enhanced their abilities regarding to vocabulary, phrased and listening as a result of using the E-learning web site as a remedial teaching aid after school. Social media can be conducted as a tool for remedial teaching program in the form of special and private

treatment and in accordance with the students' need or type of difficulty and the method used with direct learning with peer tutor that is recommended to help the students to attain the mastery leaning (Wartona at al., 2018)

Remedial instruction is meant to improve a learning skill or rectify a problem area. The objective of remedial instruction is to support those students who lag far behind their peers in academic performance or basic academic skills (Abraham, 2019). A remedial program is designed to enable students to gain the skills necessary to complete college-level courses and academic programs successfully (Bullakowski and Umisko, 1997). The effective strategies in remedial instruction are as follows: 1. diagnosis of problem or error of learners 2.considering individual difference in learning 3.using various strategies 4. adapting different methodologies 5. using technology such as computer assisted learning, and 6.providing private tuitions (Abraham, 2019)

Website and social networking platforms can be the important sources for designing, modifying, and grading of the purpose for the corrective teaching task for remedial instruction because published materials have been designed for group teaching, not for special individual learning purposes. Teachers have to use the materials that are appropriate to students' proficiency level and the course objectives (Yunus et al., 2012). Social media provides a wide range of beneficial sources and learning tools that can be used in EFL classes. It challenges for English teachers today to find effective ways to incorporate them into their lesson plans and their own teaching contexts.

Lin et al. (2016) suggested for using social media in English classrooms that instructors would plan instructional guidance for students carefully and use well-designed activities in order to use social media efficiently to enhance their students learning process. For remedial instruction, teachers have to apply many strategies to meet the special needs of the students. Teachers should identify students' diverse learning needs and design appropriate learning tasks for effective learning process, and give proper feedback on the right time.

The Importance of Listening Skill & Reading Skill

Listening skill has a crucial role in simplifying the process of second language learning (Dirjal et al., 2020). Language learning depends on listening since it provides the aural input that serves as the basis for language acquisition and enables learners to interact in spoken communication. It provides the foundation for all aspects of language and cognitive development and it plays a life-long role in the process of communication (Feyton, 1991; Malkawi, 2010). The study of Litticharoenporn (2014) found that the general listening comprehension skills, effective participation in class or group discussion, project or study group, and communication with teachers in and out of class were ranked as the top three most important skills.

For the reading skill, the basic goals of reading are to enable students to gain understanding. Therefore, developing comprehension is very essential in visual discrimination, association, and interpretation. Reading comprehension is a complex process of constructing meaning by coordination of a number of skills related to decoding, word reading, and fluency, the integration of background knowledge, vocabulary, and previous experiences.

Social Media as the Learning Tool to Enhance Listening Skill & Reading Skill

Social media can be effectively utilized for enhancing the listening and) reading skills of ESL learners using its potential to engage learners beyond the traditional classroom scenario. Listening and reading which play a great role in the development of productive skills, speaking and writing, social media under the guidance of a teacher promotes autonomous learning as the learner can access materials wherever and whenever he/she wants and learn at his/her own pace (George, 2018).

Low level learners of the EFL have problems in listening comprehension and listening seems the most demanding skills. There are many problem factors of the students in learning and communication situation. One of the factors is that EFL learners are less exposed to listening materials. (Cubalit, 2016). Social media, especially YouTube and Snapchat, can be effectively used as a pedagogical tool to enhance the listening skill of EFL learners (Harbi, 2019).

English reading ability is a great demand as English is used worldwide not only as global language but also the language of science, technology, and advanced research. In addition, reading is the primary means for independent learning, whether the goal is performing in academic tasks, learning more about the subject matter, or improving language ability (Pangsapa, 2012). Thai students have experienced difficulties in English reading and understanding English text because they cannot apply the correct reading strategies especially on reading comprehension (Rungswang and Kosashunhanan, 2021). Social media promotes information sharing, enhancing interaction and engagement, boosting collaboration and cooperation (Brown et al., 2016; Gruzd et al., 2018) that enhance reading strategies of the learners.

Social Media, Cooperative Learning Reciprocal Teaching and Remedial Instruction

The opportunities offered by social media in education are not limited to boosting interactions between students and instructors but also extend to support evidence-based learning such as Cooperative Learning (Zhegn et al., 2015). As many approaches or methods should be adopted in remedial teaching (Abraham, 2019), individualized educational program, and Cooperation Learning approaches are suggested to use in order to develop students' generic skills including interpersonal relationship, communication, problem-solving, self-management, self-learning, independent thinking, creativity and the use of information technology (Bani et al., 2010; Kessler, 2013).

To promote reading and listening strategies of the low level EFL learners, many research proved that Cooperative Learning and Reciprocal Teaching is the effective ways to enhance learning process (Leu and Reinking, 2010; Huang and Yang, 2015; Colwell, Hunt-Barron, and Reinking, 2013). The Collaborative Learning strategy between Reciprocal Teaching strategy and Cooperative Learning strategy can help the students to solve their problem in reading comprehension. By using these strategies, the students' learning process can be very effective, constructive, and valuable (Khori et al., 2018).

The integrated Model

It is important to understand how social media is being used in educational settings in order to effectively integrate it in higher education classroom (Al-Rhmi et al., 2018). To implement social media as a learning tool in

educational settings is driven by the shift towards adopting learner-centred environments (Liburd and Christensen, 2013). This approach is based on active learning where the instructor is a facilitator of the learning process rather than the disseminator of knowledge, where students interact and participate in the learning process (Freeman et al., 2014).

One of the active socialization instructions used for practicing reading skill is Reciprocal Teaching. It includes four components which are previewing, generating questions, clarifying unclear information and summarizing main points (Palinscar & Brown, 1989). This method is based on the principles of active learning, which views learners as knowledge builders. They are at the heart of the learning process, as they seek to find meaning in their learning experiences and learners become much more engaged in and responsible for their learning.

Internet Reciprocal Teaching has been introduced as an updated version of the recent instruction model of the conventional reciprocal teaching approach, which has proven its effectiveness in improving reading comprehension (Castek, Henry, Coiro, Leu & Hartmen, 2015). It is an online version of reciprocal teaching that takes place through a process of enquiry and problem solving as readers try to find answers to questions by using of the internet for the sake of comprehension and learning (Kuiper and Volman, 2008). The Internet Reciprocal Teaching model is introduced as an alternative online model for teaching comprehension skills.

The other approach which are proposed to integrate for remedial instruction is Cooperative Learning Approach. With the help of its learning strategy, students can solve their problem in reading comprehension. It is a learning strategy which covers both individual and small group learning in a heterogeneous team. In its process, the learning activities are designed to improve student's cooperation and independence in comprehending materials.This learning strategy emphasizes the role of individual participation to determine the group achievement in the learning process.

Conclusion

It has been proven by many research that social media provide benefits for both learners and educators as it can be used as an educational tool for developing reading and listening skill including the low level English proficiency learners as well . Social media can be an effective tool to enhance students' learning process, learning strategies, motivation, interpersonal relationship, self-learning and self-management while improving their generic skill and basic English skill for reading and listening. Modern researchers in the fields of English language learning try to find the method of the standard integration model for using social media as the formal teaching and learning tools. Current researches point to the development of the integration framework that social media Collaborative Learning, Internet Reciprocal Teaching and Cooperative Learning are implement in the normal and remedial English instruction.

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