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Wells Turbine-Blade Profile and Design using Computational Fluid Dynamics

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Abstract: *One of the most intensively studied principles of harnessing the energy from ocean waves is the Oscillating Water Column (OWC) device. To harness that power, wells turbine is used. However, Wells turbine has inherent disadvantages in comparison with conventional turbines, which are, relative low efficiency at high flow coefficient, poor starting characteristics and aero acoustic noise associated with its operation. In order to overcome these problems, booster turbine as well as rotor blade skew are added and it is also recommended that the shape of blades be altered. ANSYS Fluent CFD software was used in order to determine the variation in efficiency of the Wells turbine due to the mentioned modifications*

Keywords*: Ocean Waves, Oscillating Water Column, CFD*

1. INTRODUCTION

Wells turbine was developed by Prof. Alan Arthur Wells of Queen's University Belfast in the late 1970s. Several of the wave energy devices being studied under many wave energy programs in the United Kingdom, Japan, Portugal, India and other countries make use of the principle of an oscillating water column (OWC) [1]. In such wave energy devices, a water column which oscillates due to wave motion is used to drive an oscillating air column which is converted into mechanical energy. The energy conversion from the oscillating air column can be achieved by using a self-rectifying air turbine such as Wells turbine. Wells turbine has high noise level and maintenance problem because of high rotational speed and poor starting characteristics.Therefore, an asynchronous generator is used as the starter engine, consuming energy. Although a number of OWC based wave energy plants using Wells turbine have been constructed and tested to date, the total conversion efficiencies of the plants were approximately 15%.

2. EXPERIMENTAL APPARATUS AND PROCEDURE

The main feature of the Wells Turbine is its capacity of producing a time averaged positive power from cyclically reversing power from cyclically reversing flow. The performance of Wells turbine was tested on NACA0020.The geometry is shown in the figure.

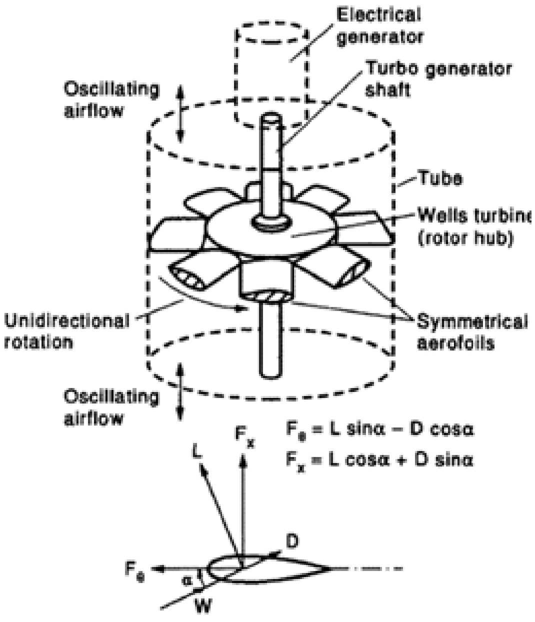

Fig. 1. The Wells air turbine

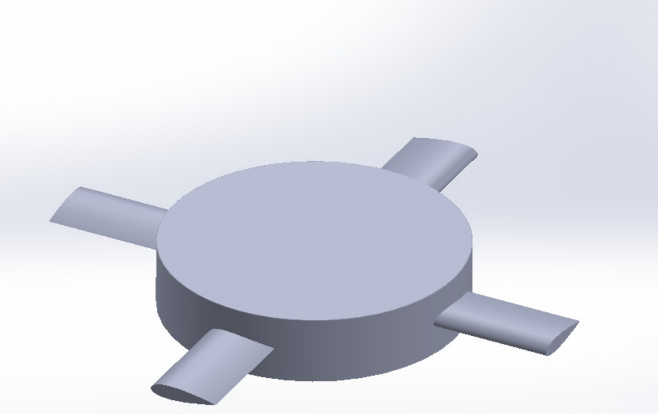

Fig. 2.

The turbine is characterized by the following parameters: tip radius=132.5mm, number of blades=4.Turbine was tested on various inlet velocities. The commercial code FLUENT is used to carry out the simulations. The steady incompressible three-dimensional Reynolds-averaged Navier-Stokes (RANS) equations are discretized by means of a finite volume approach. The pressure-velocity coupling is achieved by means of the SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) algorithm. Concerning the turbulence effects, model that has been used is kw-SST. Another geometry which includes the addition of shark teeth gurney flaps is also shown in the figure.

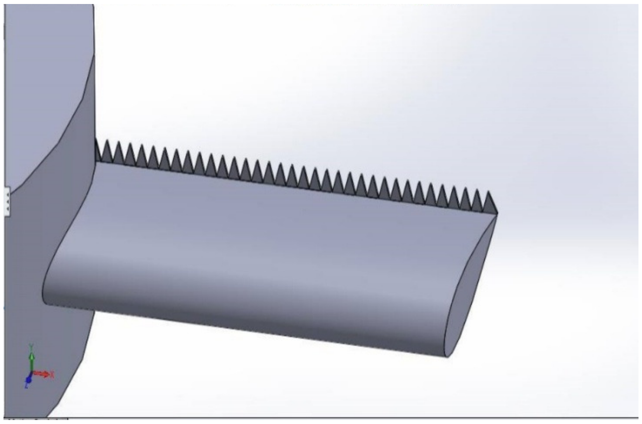

Fig. 3.

Meshing is done using extreme care and the experience of the author. Turbine is enclosed within a cylinder and the mesh is shown in the figure.

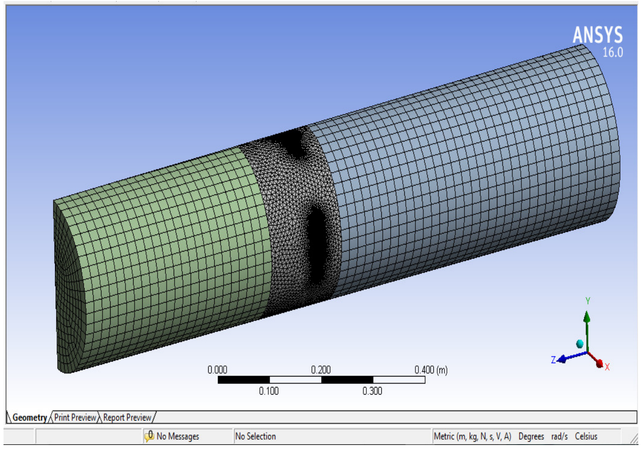

Fig. 4.

3. EXPERIMENTAL RESULTS

The performance of the turbine is analyzed using the following parameters:-

Torque coefficient= $T/ (p*\omega^2*r^5)$

T is torque, p denotes the density of air and r is the radius of tip.

Efficiency= $T\omega/VP$

V is volume flow rate and P is pressure drop.

TABLE 1.

Inlet velocity	Torque coefficient
10.4	0.0721
11.7	0.069066
13.2	0.05468

4. CONCLUSIONS

It is proposed that additional of gurney flaps add additional noise to the turbine. Altering the shape of blade increases the efficiency to a good extent.

5. ACKNOWLEDGEMENT

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