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An Analysis of Design of Oil Guard Used in Fk-6d-30 Boiler Feed Pump

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Abstract: *In the present scenario, Energy demand is increasing day by day. To meet that demand a lot of thermal power plants are being set up throughout the world. In thermal power plants one of the important role is played by boiler feed pump. A boiler feed water pump is a specific type of pump used to pump feed water into a steam boiler. Feed water pumps range in size up to many horsepower and the electric motor is usually separated from the pump body by some form of mechanical coupling. In these pumps oil thrower is used in bearing housing to prevent the leakage of lubrication oil and to throw it back to the bearing, the oil thrower is covered by oil guard to prevent the leakage of the oil at high pressure. An internal tapping was provided on this oil guard which prevented the leakage of lubricating oil during operation. In the present investigation, analysis is carried out on FK-6D-30 boiler feed pump. During the investigation it was observed that the large pressure was exerted by the lubricating oil and tapping on the oil guard was shorter in length. As a result there was leakage of lubricant oil from the oil guard. Hence the length of the tapping was increased and the design was thoroughly analyzed and it was observed that there was negligible leakage from the oil guard and the lubricant oil pressure is evenly distributed with new oil guard design.*

Keywords*: BFP, FK-6D-30, oilguard, oil thrower*

1. INTRODUCTION

1.1 PUMPS

Pumps are general classified as Centrifugal Pumps and positive displacement Pumps (1)

CLASSIFICATION OF PUMPS

DYNAMIC PUMPS

- End suction centrifugal
- Split case
- Vertical turbine
- Special effect pumps
- DISPLACEMENT PUMPS
- Reciprocating
- Rotary (2)

CLASSIFICATION OF CENTRIFUGAL PUMP

- Overhung Type
- Between Bearing
- Vertically suspended

CLASSIFICATION OF BETWEEN BEARING PUMP

- Axially split, one- and two-stage, between-bearings pumps shall be designated pump type BB1
- Radially split, one- and two-stage, between-bearings pumps shall be designated pump type BB2
- Axially split, multistage, between-bearings pumps shall be designated pump type BB3
- Single-casing, radially split, multistage, between-bearings pumps shall be designated pump type 884. These pumps are also called ring-section pumps, segmental-ring pumps or tie-rod pumps. These pumps have a potential leakage path between each segment. BB4
- Double-casing, radially split, multistage, between-bearings pumps (barrel pumps) shall be designated pump type BB5 (3)

1.2 APPLICATION OF PUMPS

1.Thermal power plants
2. Nuclear power plants
3. Oil and gas industry
4. Paper, sugar, cement plants
5. Marine industry
6. Waste supply
7. Agricultural purpose
8. Desalination industry

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1.3 VARIOUS PUMPS USED IN THERMAL POWER PLANT

- Boiler feed pump
- Condensate extraction pump
- Cooling water pump
- Stand by lube oil pump
- Emergency lube oil pumps

2. LITERATURE REVIEW

Hu-se ki et al. conducted analysis of regulating characteristics of boiler feed pump. They emphasized on fitting characteristics equation of feed-water pump under different operations, determining characteristics of feed-water pipeline under sliding-pressure operation, corresponding resistance coefficient, and finally deducing the equation of lift, efficiency and rotating speed when different loads and different sliding-pressures are adapted only by main feed-water pump variable speed adjusting. They took one power plant 600MW supercritical unit for example to compare the energy consumption of different operation modes, and thus puts forward a more suitable operation mode under different loads, providing theoretical basis for the practical application of project.[4]

Babuet. al did condition monitoring and vibration analysis of boiler feed pump. During their investigation they found that for the BOILER FEED pump the vibration readings show that values aremore than normal readings. Spectrum analysis was done on readings and found that mass unbalance in vanes. It was corrected based on phase analysis and vibration readings were observed after modification which gives the values within normal range. It eliminates unnecessary opening of equipment with considerable savings in personnel resources. [5]

Birajdaret. al studied about the sources and diagnosis methods to control vibration and noise in centrifugal pumps. They studied about the ill effects of vibration and concluded that during the operation of a boiler feed pump, exact diagnosis of vibration and noise sources is very difficult in centrifugal pumps as this may be generated due to system or the equipment itself. Hence they addressed only some of the issues.[6]

RavindraAnandraoThorat conducted performance evaluation of Centrifugal Type Boiler Feed Pump by varying blade number. He found that blade number has great influence on the pump performance. Therefore, he carried out CFD analyses for the pump with 5, 6 and 7 blades. Based on the analysis, he concluded that the feed pump model with five number of blades showed better performance. [7]

Bhawaret. al did design and analysis of Boiler Feed Pump Casing Working at High Temperature by using ANSYS. They presented the generation of model, structural and seismic analysis, and necessary geometrical modifications were performed by them for pump casing.[8]

Agratiet. al carried out study on multistage horizontal boiler feed pump from hydraulic and structural point of view. In their investigation, a complete calculation of rotor dynamic behaviour in both configurations had been performed using the finite element method. The model of the shaft had been meshed using beam elements, while linearized coefficients had been evaluated in order to simulate stiffness and damping of sleeve bearings, impeller wear rings, balancing drums and inter-stage seals. Un-damped critical speed map, damped mode shapes and Campbell diagrams were presented and discussed.[9]

Abraham et. al carried out an assessment on design parameters and vibration characteristics of boiler feed pump for auxiliary power consumption. They reduced discharge pressure of BFP, thereby found the most efficient method of reduced power consumption, which increased the efficiency of the plant. They replaced the gear box and studied vibration behaviour of the pump. In their investigation, experimental and numerical analysis of vibration characteristics was also conducted. [10]

Elemermackay studied about the problems encountered in boiler feed pump operation and classified them into hydraulic and dynamic instabilities. He studied the interaction between hydraulically induced forces and bearing design parameters and their influence on rotor vibration characteristics. Friction induced partial frequency modes were also discussed in his investigation. [11]

From the above literature review it is observed that very little work has been done on the design of oil guard used in oil thrower in boiler feed pump.

3. DESIGN ANALYSIS OF OIL GUARD

In the present investigation design, of oil guard for FK-6D-30 bearing housing is considered. The FK-6D-30 stands for

F- Primarily a boiler feed product

K-Cartridge construction with segmental ring section inside an outer barrel casing

6- No of stages

D-specific speed designation of impeller

30-nominal impeller diameter in cm

The technical specification of the pump under study is as follows:

- Capacity: > 2, 500 m3 /hr / 11, 000 gpm
- Pressure: > 4, 000 m / 13, 300 feet
- Temperature: > 250 deg C / 480 deg F
- Speeds > 7, 000 rpm

- Nozzles: flanged or welded

According to API (American Petroleum Institute) it's a BB4 type pump, but it does not follow the standard set by the API

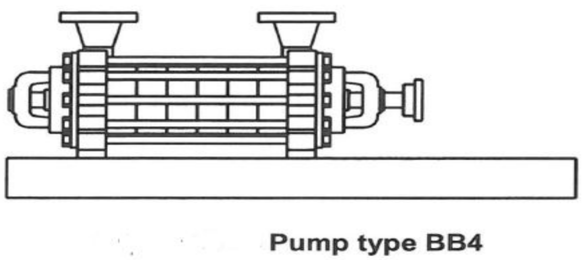

Fig. 1. BB4 Type of Pump

The pumps can be configured with either a through bolt (FT) or studded barrel type (FK) of casing. In the barrel casing option the full cartridge can be removed via the back pull out feature without disturbing the driver or the suction and discharge pipe work.Fig.1 shows the side view of BB4 pump

One of two different hydraulic balance devices can be fitted, a balance disc or balance drum and dependent on the pump size and balance device fitted either a rolling element bearing, forced lubrication hydrodynamic bearing or self-contained hydrodynamic bearing can be fitted to accommodate the residual thrust. Shaft sealing is provided by a range of mechanical seals which can accommodate a variety of seal plans.Designed for both the 50 and 60 Hz markets, the pumps are suitable for a range of 2 pole duties and pressures and come as standard with ANSI B16.5 flanges.

The pump may be supplied as a bare-shaft unit or mounted on a rigid design baseplate complete with driver, coupling and any other ancillary equipment such as seal systems and lube oil systems where required.

CONSTRUCTION

PUMP TYPES

Both casing options are centreline mounted, with upward facing suction, discharge and inter-stage (where applicable) branches. Seal and bearing housings are mounted external to the main casing for easy access inspection and maintenance

PUMP CASING ASSEMBLY

SEGMENTAL RING SECTION (FT PUMP)

Each pump stage consists of a precision cast diffuser / ring section assembly with 'O'-ring sealing between stages. The pump suction and discharge covers are cast to provide a smooth hydraulic profile with minimal losses, ensuring optimal pump efficiency and suction performance. The complete pump assembly is compressed by high tensile steel tie bolts.

BARREL CASING (FK PUMP)

The barrel forms a single pressure boundary component and incorporates the pump suction and discharge branches. An inner "cartridge" assembly comprises the rotating assembly, all ring sections / diffusers and the suction guide and discharge cover. This entire cartridge can be withdrawn from the barrel as one component, complete with bearings, seals and half coupling. This construction simplifies major maintenance and reduces down-time

TABLE 1: Comparison of FT and FK

FT	FK
High Cost	Low cost as compared to FT
Flanged is mounted temporary and maintenance cost is high	Barrel is mounted permanently to the discharge and suction and only cartridge need to be changed

In a FK type pump a bearing housing is used on both the end of the pump to bear the axial and radial load of the pump and to provide the easy rotational movement to the shaft. The journal bearing or a thrust bearing is mounted under the bearing housing in which there is continues supply of the oil to lubricate the bearings, but as the shaft is a rotating part and passes through the bearing housing to get connected with the motor shaft via coupling so there is a clearance given at the bearing housing to pass the shaft .A oil thrower is used at this end of the bearing to protect the leakage of the oil from the bearing housing, the oil thrower rotates with the velocity of the shaft and throws the oil back over the bearing and prevent it from leakage. The oil thrower is covered by an oil guard which maintains a clearance of 0.40mm with the oil thrower and is made up of lead bronze material. The oil guard is divided into two internal chambers, out of which one remains inside the bearing housing and the other internal chamber lays outside the housing along with the oil thrower.

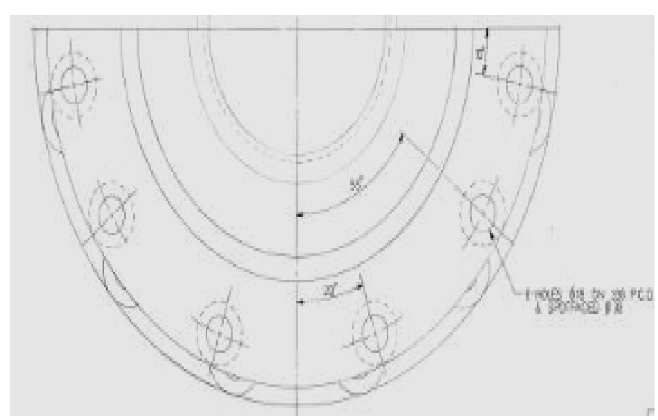

Fig. 2. Bearing housing side view

Over the portion of the oil thrower projected outside the bearing housing a metal line is extruded which divide the column of the oil guard. The purpose of this extruded metal line was to prevent the entry of the oil from the first chamber to the other chamber of the oil guard. Fig.2 shows the side view of a bottom of bearing housing and the shaft along with oil thrower and oil guard is passed from it.

It was observed that the oil surpasses the oil thrower and enters into the first chamber of the oil guard.

In the first chamber of the oil guard which is inside the bearing housing a tapping was given at its bottom to return the oil back into the bearing housing so that there will be not be any leakage from the bearing housing of the pump and the leakage was very nominal from the bearing housing of the pump .

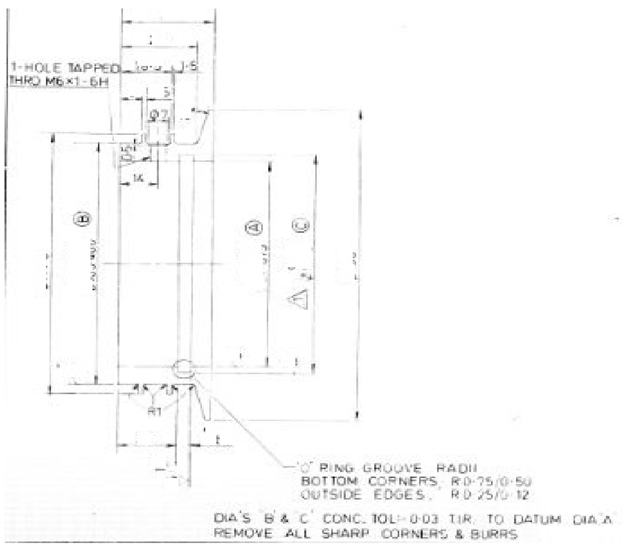

Fig. 3. Oil Thrower

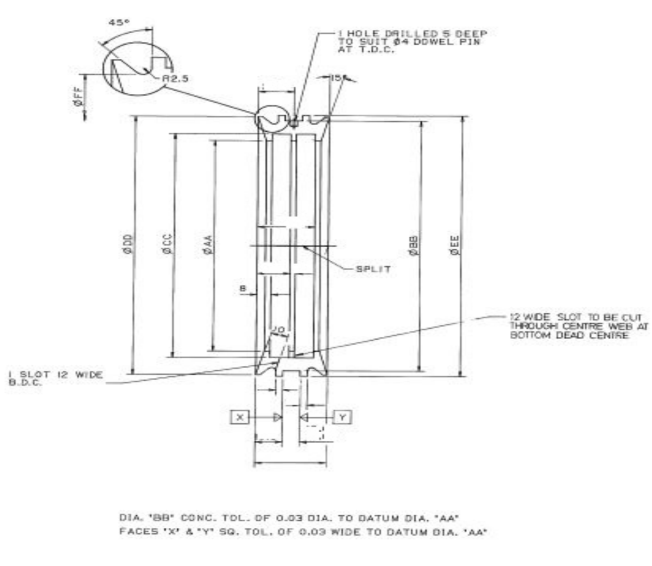

Fig.4. Oil guard used earlier in FK-6D-30 Pump

Fig.3 shows the design of typical oil thrower used in FK-6D-30 boiler feed pump, one can see the metal line extruded out for the settlement of oil guard.

This is a continuous process and goes until the pump come to halt. The extruded metal line on the top of the oil thrower restricts the oil from entering into the second chamber of the oil guard. Fig. 4 shows the design of the oil guard used in the boiler feed pump which guard the oil against the leakage.

But with the course of time it was observed that the pump is facing serious problem of sudden seizure due to bearing locking with shaft

Upon the detail study it was observed that the seizure of the pump shaft with the bearing was due to the lack of lubricating oil inside the bearing housing which was causing the increase in the friction and causing the bearing to fail, due to which the whole pump come to halt and creating a big loss to the power production and a increase in the cost of overhauling of the complete pump unit

The reason behind the shortage of the bearing housing lubricating oil was investigated and upon a deep investigation and observation it was observed that there was a leakage from the second chamber of the oil guard mounted over the oil thrower which was causing the major leakage of the oil from the bearing and becoming a major cause for the failure of the pump

To know that from where the oil is reaching there we again done a deep study on the oil thrower and oil guard and came to a conclusion that due to the continuous running of the pump at such a high rpm the lubricating oil get converted to the mist and by pass the metal extruded line over the oil thrower and goes into the second chamber of the oil guard from where the leakage was noticed

After getting the exact reason behind the leakage the challenge was to solve this major issue which was decreasing the pump life and causing a great loss to production and monetary loss also

The first remedy thought was to increase the height of the metal extruded line over the oil thrower to avoid the trespassing of the oil into the second chamber but since the oil thrower is a rotating part and oil guard is a stationary part and there should be some clearance maintained for its proper working so this idea fails

After a deep and thorough study of the design of both oil thrower and oil guard we came to a conclusion that if the tapping provided in the first chamber of the oil guard can be extended to the next chamber at a certain angle and up to a certain distance then the oil trespassing the first

Chamber can be re-circulated back inside the bearing housing in the same way as it was earlier done by the first chamber.

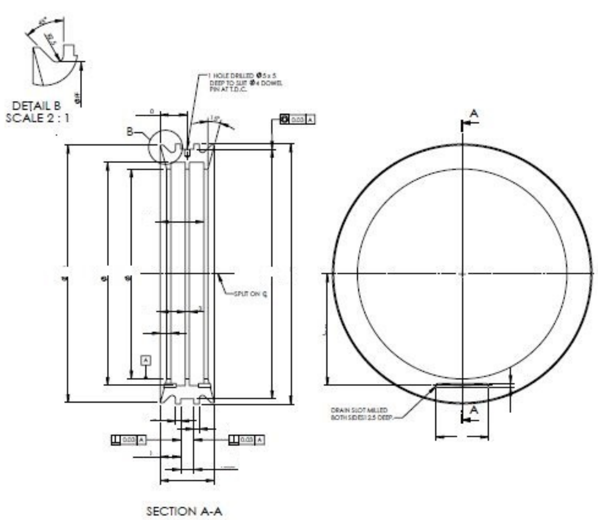

Fig. 5. New oil guard design with Increase tapped section

After the calculations the tapping was made under the oil guard joining the first chamber and second chamber directly connected to the bearing housing which resulted in lowering the spill rate as the oil is returned to the bearing housing only from the tapping.Fig.5 shows the modified oil guard with extended tapping to prevent the spill off the oil from it

The earlier leakage was due the major reason that when the oil reaches the second chamber of the oil guard and there was a continuous rotation of the of the pump shaft which constantly increase the pressure of the oil present in the second chamber and result in the spill off of oil from it, but after the implementation of the new design the pressure formation inside the second chamber was no more possible as the oil directly goes back to the bearing housing through the inter chamber tapping provided inside the oil guard

4. CONCLUSION

Based on detail Study of drawings It can be claimed as a new design because slot design has been absolute. Also in old design from both the groove, drain is given separately with slot and a Hole provision and in new design Slot itself is sufficient to drain from both groove of oil guard.

This resulted in increase in service life of pump from 2 years to 3 years and a low maintenance cost of the pump.

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