Analysis to Improve the Service Life of Condensate Extraction 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 condensate extraction pumps just place after the condenser. Condensate pump is a specific type of pump used to pump the condensate (water) produced in an HVAC (heating or cooling), refrigeration and condensing boiler furnace or steam system. While analyzing the design of condensate pump, it was observed that a cut-less rubber bearing was incorporated between the rotating (shaft sleeve) and stationary (Bowl ,bell mouth etc.) parts of the pump to increase the pump service life but due to the tendency of wear it lead to poor service life and wear and tear of the pump parts. In the present investigation, analysis was carried out on a rotary condensate pump of power rating 500 KW. In the pump, peek metal was introduced between the rotating and stationary parts and the design was analyzed. It was observed that the service life improved by 1.5 times(3 years). Also the wear and tear of parts reduced tremendously and unwanted replacement of parts was prevented.

Key words: CEP, Bush bearing, Ketron peek metal

I. INTRODUCTION

A. *Pumps:*

Pumps are general classified as Centrifugal Pumps and positive displacement Pumps [1]

B. *Classification Of Pumps:*

1) *Dynamic Pumps:*
- End suction centrifugal
- Split case
- Vertical turbine
- Special effect pumps

2) *Displacement Pumps:*
- Reciprocating
- Rotary [2]

3) *Classification Of Centrifugal Pump:*
- Overhung Type
- Between Bearing
- Vertically suspended

4) *Classification of Vertically Suspended Pump:*
- Wet pit, vertically suspended, single-casing diffuser pumps with discharge through the column shall be designated pump type VS1
- Wet pit, vertically suspended, single-casing volute pumps with discharge through the column shall be designated pump typ VS2
- Wet pit, vertically suspended, single-casing axial-flow pumps with discharge through the column shall be designated pump type VS3
- Vertically suspended, single-casing, volute, line-shaft-driven sump pumps shall be designated pump type VS4
- Vertically suspended, cantilever sump pumps shall be designated pump type VS5
- Double-casing, diffuser, vertically suspended pumps shall be designated pump type VS6
- Double-casing, volute, vertically suspended pumps shall be designated pump type VS7 [3]

5) *Application Of Pumps:*
- Thermal power plants
- Nuclear power plants
- Oil and gas industry
- Paper, sugar, cement plants
- Marine industry
- Waste supply
- Agricultural purpose
- Desalination industry

6) *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

II. LITERATURE REVIEW

Hulse 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]

Babu et. 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 are more 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]

Birajdar et. 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]

Ravindra Anandrao Thorat 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 numbers of blades showed better performance. [7]

Bhawar et. 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]

Agrati et. 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 interstate seals. Undamped critical speed map, damped mode shapes and Campbell diagrams were presented and discussed.

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. [9]

Elemer mackay 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. [10]

From the above literature review it is observed that very little work has been done on the design of bush bearing used in condensate extraction pump.

III. Design Analysis of CEP Pump Bearing

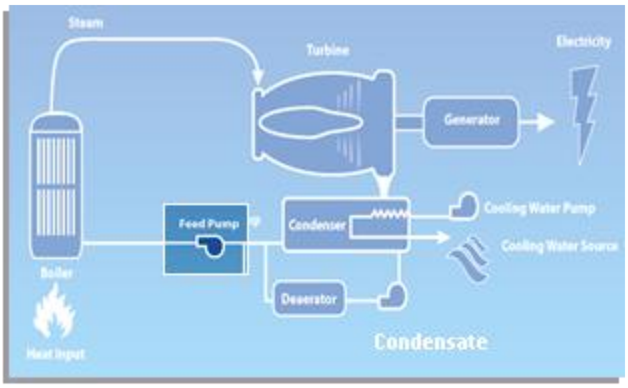

Fig. 1: Typical power plant layout

A condensate extraction pump is a pump which is used in a thermal power plant just after the condenser to extract the condensed water from the condenser and to send it to the to deaerator .Fig.1 shows the typical layout of a power plant and the position of pumps in the power plant cycle

These pumps are specially designed for Condensate Extraction service in power plants to meet the low NPSHa criteria (API requirements are not applicable).

There are two distinct designs for the CEP pumps. Single Suction and Double Suction

- The condensate pump is a specific type of pump used to pump the condensate water produced in the condenser
- The condenser pressure is near vacuum in order to maximise the efficiency of the steam cycle
- Due to near vacuum conditions NPSH (a) is very low hence a canister pump is offered to increase the NPSH (a)
- The length of the canister pump is decided based on the NPSH(r) for the first stage of impeller

Fig. 2: Condensate Extraction Pump & Canister

Fig.2 shows the condensate extraction pump and the canister inside which it is incorporated

1) Technical Data:
- Capacity: < 2,500 m3/hr / 11,000 gpm
- Delivery head: < 400 m / 1,330 feet
- Temperature: < 180 oC/ 350 oF
- Speeds: Usually 4 Pole

2) Design Features / Options:
Engineered to suit customer requirements
- Above or below floor suction
- Single or double entry 1st stage impeller
- Thrust in pump or motor
- Various material options

3) Key Applications:
- Condensate extraction
- Heater Drain

The condenser is kept nearly to the vacuum pressure after the turbine. The steam from the turbine after expansion directly comes to the condenser and get stored into it in the form of water. The exchange of heat takes place in the condenser well and then the water goes into the deaerator and so on to complete the cycle of the power plant. The condenser is kept at a vacuum or nearby vacuum pressure to avoid the back pressure to the turbine and increase the efficiency of the turbine, as the liquid has the tendency to flow toward the low pressure area from the high pressure area easily that is why the condenser is maintained at a vacuum pressure with the help of vacuum pump and its very often mounted below the ground level to achieve that pressure difference which is desired to bring the liquid back to the condenser. As the pump is mounted below the surface and is maintained at a vacuum pressure which make it unable to automatically transfer the water to the deareater and a Condensate Extraction Pump is needed just after the condensate well to extract the condensate the water from the well and pass it on to the deareater.

But as the condensate is at very low or vacuum pressure so the NPSHa for the pump is very low and to achieve this NPSHa a canister is provided which is filled with condensate water and the condensate extraction pump is dipped into that canister which provide the NPSHa to the pump and meet the demand as per the NPSHr of the pump.The length of the canister is directly proportional to the NPSHr of the condensate pump and is so designed that the pump can be easily installed inside it and there will be no dry running and the NPSHr demand will be met at all the time of the operation.

The length of the canister is some time more as the NPSHa for the condensate pump is very low Due to this canister the pump is dipped into it and the length of the pump is increased and which make it more venerable to the wobbling of shaft inside the pump as the pump shaft length increases

To avoid this wobbling of the shaft and to make it steady bearing's are provided at different part of the pump to make the pump shaft stable and to provide the easy rotation to it over the course of the length

One of the bearing which was used traditionally was cut-less rubber bearing, which was incorporated inside various stationary parts such as bell mouth, bowl, trouser leg casing etc. over which the shaft rotates.Fig.3 explain the design of a cut-less rubber bearing bush used inside the bowl assembly

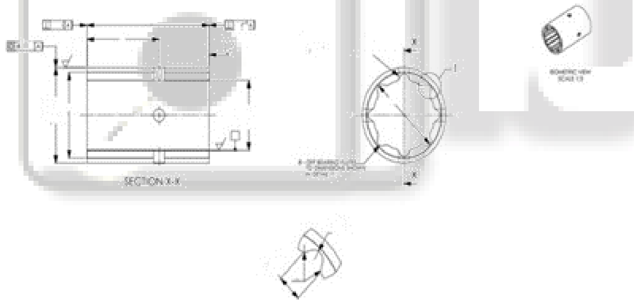

Fig. 3: Cut-less rubber bearing bush

But as the shaft is a single piece assembly and is a expensive part so a shaft sleeve is provided just above the bearing so that it will be exposed to the bearing instead of the shaft and if any wear or tear occurs in the shaft then it can bear it and can be easily replaced

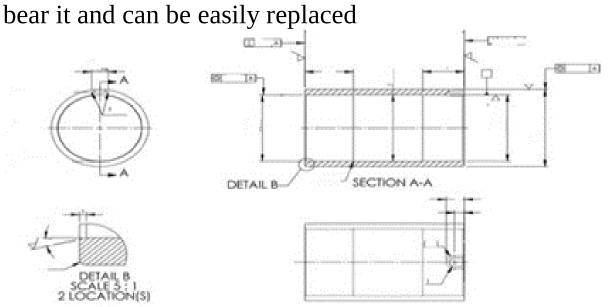

Fig. 4: Shaft Sleeve

So the cut-less rubber bearing was incorporated inside the stationary parts and shaft sleeve was fitted over the shaft area exposed to the bearing.Fig.4 shows the design of the shaft sleeve which is incorporated above the shaft and run over the veering assembly

As the pump was commissioned and was operated as per the operation manual it was noticed that the vibration of the pump was increased at a constant level and the performance of the pump was dropped down which bring down the service life of the pump

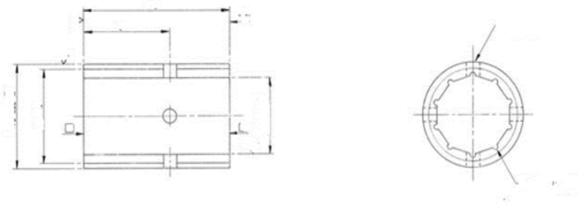

Fig. 5: Cut-less rubber bearing cross section view& front view

The study was carried out and it was found that the vibration was due to the axial vibration of the pump shaft and upon the further research we came to a conclusion that the main cause was the wear of the cut-less rubber bearing before it actual life cycle claimed .Fig.5 shows the design of typical cut-less rubber bearing cross sectional view, we found that the water entering into the condensate pump was at a temperature of about 70^{0}C -120^{0}C and there is a thin film of water maintained between the shaft sleeve and pump bearing and as the pumping liquid temperature is increased and due to the rotational speed of the pump shaft the film get dispersed there is a wear in the cut-less rubber bearing .The major reason for the wear out is due to the property of the rubber to expand in the water by absorbing it and in this case the transmitted liquid was hot which make it more venerable for the rubber and it expand very quickly and which decreases the clearance between the shaft sleeve and the cut-less rubber bearing and the bearing start wearing and the shaft sleeve get more area to rotate Due to this the wobbling in the shaft starts and after that the shaft sleeve itself starts wearing as it comes with the direct contact of the outer metal part of the cut-less bearing and after the wearing of some portion of shaft sleeve it finally result in the seizing of pump Which causes decrease in the service life of the pump and increases the service cost .One of the major drawbacks of this effect was the quality of water. As the power plant work on the closed cycle and the water used in the power plant cycle is demineralised and due to the wear of the parts the water was getting poor in quality and effecting the other operation. So considering all the above reasons in consideration a detailed study was carried out for the remedy of this problem and the solution was found in the form of Ketron Peek metal bearing which elude all the defects and drawback carried by the cut-less rubber bearing.The ketron peek metal bearing was not affected by the temperature of the pumping fluid and has a special property of anti-seizer, which makes it perfect for the bearing material of the condensate extraction pump bearing .Fig.6 shows the bearing bush with new modified design and with all new kerton peek material

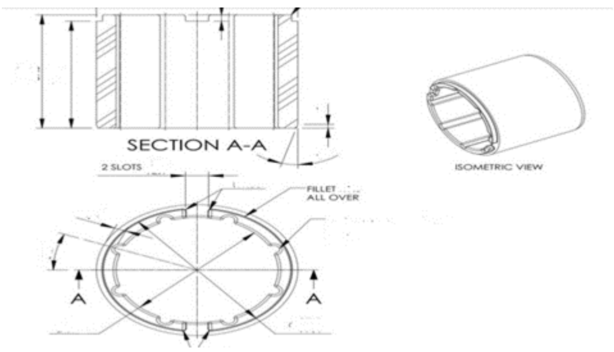

Fig. 6: Ketron Peek Metal Bearing

After different experiments and comparison of physical and chemical condition it was observed that it is far better then cut-less rubber bearing.

IV. CONCLUSIONS

So some of the slight modification was made in the design and the bearing was prepared with all new Ketron peek material and was installed in the pump and it was commissioned again and it was noticed that there was no change in the quality of water as there was no wear from the bearing and the pump life was significantly increased up to 1.5 times.

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