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Design and Analysis of Boiler Feeder Pump

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Abstract -Pump is energy absorbing rotodynamic machinery transporting fluid from one place to other, being key parameter and heart of any process plant and thermal and atomic power plant, also used for dewatering and irrigation purpose. Boiler feed water pump feeds condensed return water against high steam pressure produces by the boiler. BFP normally are centrifugal type pump containing a wide number of operating parameters, operator requirement makes this system to work within parameter functioning by the manufacturer on high efficiency regimes.

As pump is centrifugal type pump, water enters axially through impeller eye and exit radially. Generally motor is employed as a major mover to run the pump. In the present study we design and analysis of boiler feed pump having a flow of 138 m^3/hr under a head of 632 m at 3550 RPM and operating temperature range is 200±15 degree Celsius has been taken up in this design judgmental task is to set up a high head with in four stages. The various pump parameter obtained from design is developed using 3D modeling software Pro-E, and analysis is carried out by using Ansys, CFD software module.

Key Words:BFP, RPM, thermal, Pro-E.

1.INTRODUCTION

Pumps are energy-consuming devices being used in many industrial applications and in particular in dewatering, handling water & other fluids and in agricultural, the efficiency improvement of pumps has significant meaning to energy conservation. The entire project work focus affects the performance & efficiency of pump which directly save power. In this project we design a multi-stage centrifugal pump which complies with various aspects require to US boiler feed water pump market.

Feed pumps are an important subsystem of boilers utilized in industrial process plants and called as boiler feed pump (BFP). Normally, BFP is under high pressure unit that takes suction from condensate return system and might be of the centrifugal type pump. In centrifugal pump, water enters axially through the impeller eyes and exits radially. Generally, motor is employed as first cause to run the feed pump. To force water into boiler, the pump must generate sufficient pressure to beat steam pressure developed by boiler.

The usual design is based upon a certain desired head and capacity at which the pump is operated most of time. In design of centrifugal pump, the parts to be designed are: shaft, impeller, vane, casing, and selection of bearing. To design these parts different methodologies can be obtained through literature survey. From the given conditions, the specific speed is obtained. According to required head, the flow rate and from specific speed, pump of double volute, doubles suction and single stage type is selected. The minimum shaft diameter are often obtained by using maximum shear stress theory. Impeller and vane are designed according to methodology provided by Church. To design the vane empirical relations are used. API standard is used to design the volute and for bearing selection.

2. SYSTEM DESCRIPTION

The provision of sufficient pumping capacity to fulfill flow requirements under all operational circumstances. It is normal practice to incorporate a flow margin to accommodate additional demand by the turbine above its design rating during transient flow disturbances. A margin on pump generated head is additionally appropriate to get deterioration resulting from internal wear during times between overhaul. In the interests of keeping pump set sizes and powers to a reasonable minimum, consistent with maintaining the pump best efficiency close to the duty point operation, these margins have been optimized as 5% on flow and 3% on generated head.

Constraints should be considered

- The need to ensure that failure of a single pump set does not impair the start-up of the main unit or affect output capability. Standby capacity equivalent to the largest duty pump set is indicated with a rapid start-up capability, sufficient to prevent the loss of boiler drum level and consequent unit trip.
- The need to ensure that the plant is able to operate satisfactorily during and after a large load rejection by the turbine-generator unit. This requires that the drives for the duty pumps and their power supplies must be suitable for this operating condition. Alternatively, an acceptable rapid start/standby pump set is required.
- The need to provide adequate NPSH margins, taking into account that the pumps are supplied from a direct contact heater (de-aerator), which can be subject to pressure decay following a reduction in turbine load.

- There should be at least two pump sets capable of starting the unit. If a turbine drive is to fulfill this function, then a steam supply independent of the main boiler (i.e., an auxiliary boiler) is required.
- If two or more pumps are required to operate in parallel, then the pump sets should be able to accommodate runout duties following loss of an operating pump.

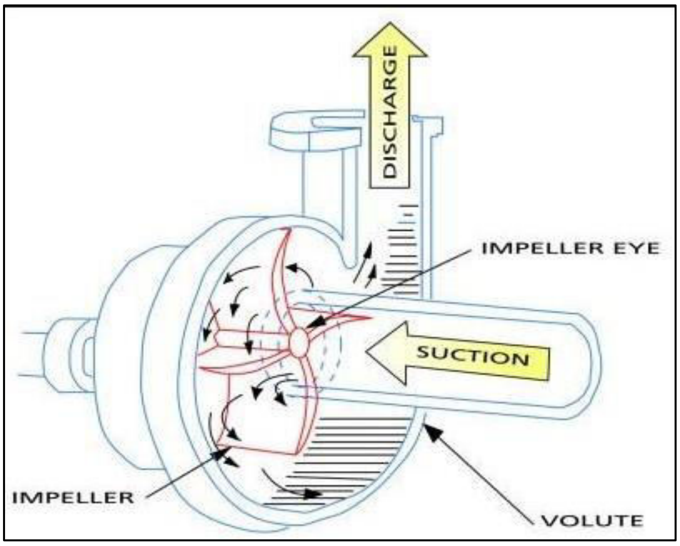

Fig-1: Working of Proposed Model

3. SYSTEM MODELLING

CATIA is a mechanical design automation software is a feature-based, parametric solid modelling design tool which advantage of the easy to learn windowsgraphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent etc.

A. Dimension of Rotor

- Gross Weight of Impeller m = 7.2 Kg
- Total Weight in Newton = 7.2 x 9.81
  W = 68.67 N
- Maximum diameter of impeller = 300 mm
- Minimum diameter of impeller = 125 mm
- Number of blades of impeller = 6
- Angle of blade = 12 ^{0}C
- Impeller exit width = 15

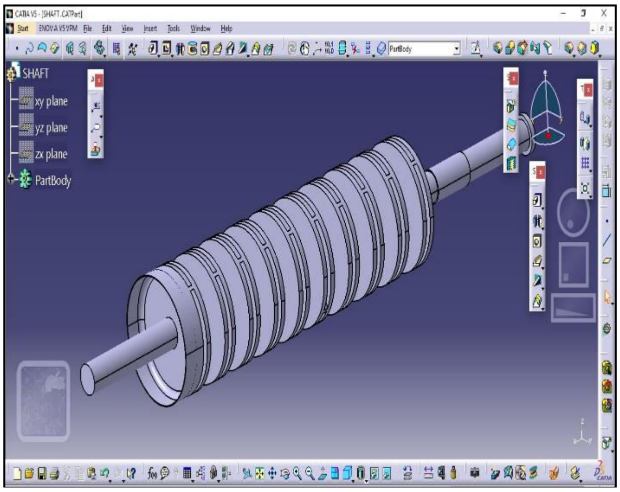

Fig-2: Modelling of Impeller

B. 3D Modeling Casing.

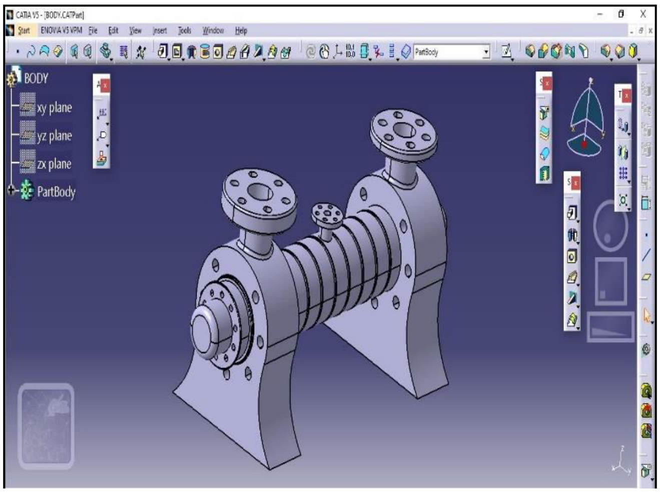

Fig-3:'3D' Views of Casing

Pressure-containing parts are generally made thicker than required for handling a noncorrosive liquid so that full pumping capability will be maintained even after the loss of some material to the corrosive medium.

4. SYSTEM ASSEMBLY

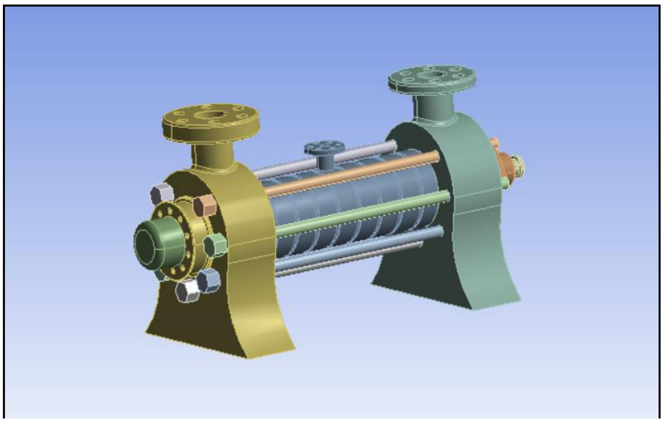

Fig-4:'3D' Views of Assembly of pump

Analysis of Boiler feeder pump Components:

1. Impeller Shaft Analysis

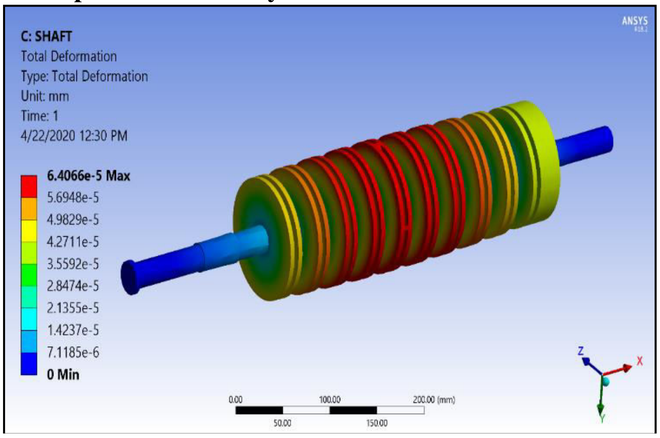

Fig-5: Impeller Shaft Deformation Results

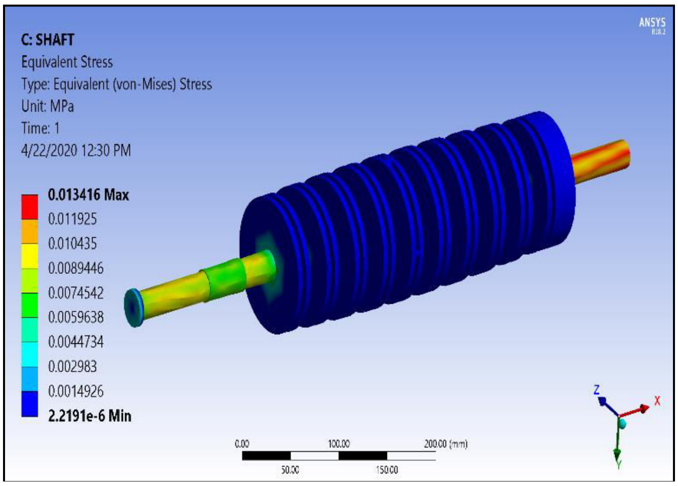

Fig-6: Impeller Shaft Stress Results

End of the shaft at driving side connected to the coupling followed by constraint by the roller support of bearings. Changes in cross section at stuffing box housing produces stress concentration.

Maximum stress occurring at the area is less than the shaft material yield strength of 0.0134 MPa since design is out of danger. Also, blue shade indicates the minimum stress in that area.

2. Casing Analysis

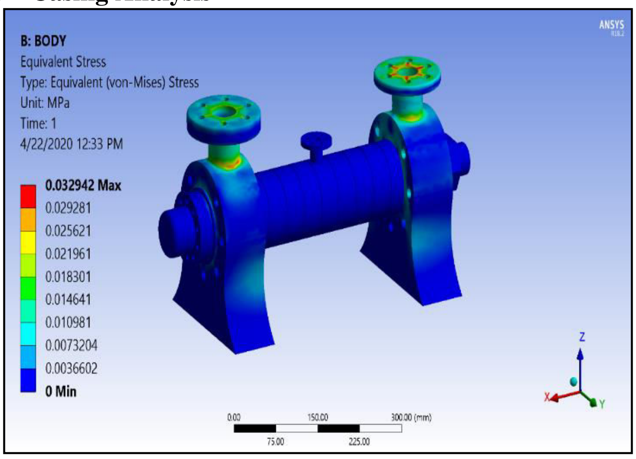

Fig-7: Casing Deformation Results

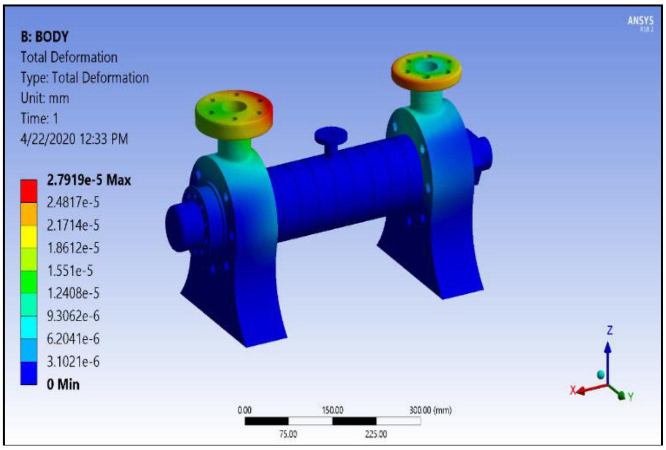

Fig-8: Casing Stress Results

Deflection in impeller is far less than the allowable limit. Deflection in casing is 2.79e-05, which is less than limit specified by API 610.

Table Comparison of Old and New Model

Parameters	Existing pump	New prototype pump
Flow (Usgpm)	440.20	610.90
Pump head(feet)	1320.13	2074.81
Pump efficiency (%)	66.5	68.0
Scale Factor	Base	1.050
Pump input (Kw)	164.75	351.41
Specific Gravity	1.000	1
Pump speed (rpm)	2980	3550
Stages Required	12	10
Motor rating	220	450
NPSH (feet)	15	23
Specific Speed (Ns)	800	800

Table-1: Comparison of old and new model

5. CONCLUSION

As deflection and stress of model is within the range Thus, the design of the model is safe after running pump at 3550 rpm and with enlarged scaled factor 1.05. Result obtained in the final test of the pump is satisfactorily with increase in efficiency by 1.5% to reference. Using the modern state of art composite material, weight of the impeller and shaft will reduce considerably and it optimizes the operation of pump effectively.

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REFERENCES

1. Ralf Dotta, Andreas Genkingera and Thomas Afjeia (2012) 'system evaluation of combined solar &heat pump system', Energy Procedia, Vol.30, pp.562-570

2. Hu Si-ke, GaoHui-fen,JiaXue-jing (2012)' Regulating Characteristics Analysis of Boiler Feed-water Pump when 600MW Unit Sliding-pressure Operating',Energy procedia,Vol.17,pp.1153-1160

3. Benjamin Greening, AdisaAzapagic (2013) 'Domestic solar thermal water heating: A sustainable option for the UK', Renewable Energy, Vol.63, pp.23-36

4. BurkhardSanner, Constantine Karytsas, DimitriosMendrinos, LadislausRyback (2003)'Current status of ground source heat pumps and underground thermal energy storage in Europe', Geothermics, Vol.32, pp.579-588.

5. CuizhenZhanga, Mo Yang,MeiLua,JiaxianZhub and WendongXua (2012)'Thermal economic analysis on LiBr refrigeration-heat pump system applied in CCHP system'' Physics Procedia, Vol.33,pp.672-677.

6. Hu Si-ke, Wang Li-ping (2012)'A Comprehencive Analysis of Boiler Feed-Water Pump when 600MW Unit Sliding-pressure Operating', Energy procedia thermal system Transformation', Energy Procedia, Vol.17, pp.11691176

7. Marcello Aprilea, RossanoScoccia and Mario Motta (2012)' Modeelling and control optimization of a solar desiccant and evaporative cooling system using an electrical heat pump', heat pump system'. Energy Procedia, Vol.30, pp.562-570

8. AnkurGeete, khandwawala, A.I (2013) 'Thermodynamic analysis of 120MW thermal power plant with combined effect of constant inlet pressure (124.61bar) and different inlet temperature case studies, Thermal Engineering, Vol.1, pp.17-25.

9. Khalid.S.Rababa, 2002, "The Effect of Blades number and Shape on the Operating characteristics of Groundwater Centrifugal Pumps",European Journal of scientific research, Vol 2, No.6: 243-251.

10. Ravindra A. Thorat, 'Performance Evaluation of Centrifugal Type Boiler Feed Pump by Varying Blade Number''. International Journal of Scientific and Research Publications, Volume 5, Issue 4, April 2015 1 ISSN 2250-3153.

11. "American Petroleum Institute Standards-610," (Pump Hand book), Eleventh Edition, September 2010, pp.19,24-26.