

Performance Variations of Centrifugal Sort Boiler Feed Pump For Different Blade Numbers

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Abstract- In the gift study, style and analysis of boiler feed pump having a flow of 2300 m³/hr, head of 475 m and operational at 140±10o C has been obsessed. the assorted pump parameters square measure obtained from style and pump model is developed victimization modeling package Creo constant quantity. To gauge the results at given operational conditions, CFD analysis is meted out victimization Ansys CFX module. Blade range has nice influence on the pump performance. Therefore, CFD analyses square measure meted out for the pump with five, six and seven blades. supported performance of each pump model, the most effective feed pump style is chosen. a gradual state CFD analysis is meted out victimization the K-e turbulence model to resolve for the Navier-Stroke's equation

Key Words: feed pump, pump design, CFD analysis, pump performance, blade ranges.

I. INTRODUCTION

A centrifugal pump is as same as rotodynamic pump which makes use of a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are in general used to maneuver beverages by means of a piping approach. The fluid enters the pump impeller close to or along the rotating axis and is accelerated with the aid of the impeller, flowing radially outward into a diffuser, from the place it exits into the downstream piping method. Like most pumps, a centrifugal pumps converts energy from a motor to energy of a moving fluid; one among the energy goes into K.E. of fluid motion, and a few into potential energy, represented through a fluid stress or by means of lifting the fluid in opposition to gravity to a greater degree. The energy generated due to mechanical rotation of impeller is transferred to the movement and strain of the fluid. this process is as a rule described in phrases of

centrifugal drive, especially in earlier sources written before the modern idea of centrifugal force as a fictional force in a rotating reference body used to be good articulated. The idea of centrifugal drive is not in reality required to describe the action of the centrifugal pump. In latest centrifugal pump, lots of the energy conversion is due to the outward drive that curved impeller blades impart on the fluid. Continuously, one of the energy also pushes the fluid right into a round motion, and this circular motion might also carry some power and expand the stress at the outlet. The relationship between these mechanisms was described, with the common combined conception of centrifugal drive as often called that time. Pumps are used in a extensive variety of industrial and residential functions. Pumping gear is particularly diverse, various in kind, measurement, and substances of development. There were giant new developments in the subject of pumping gear. They are used as boiler feed pumps, hot good pumps, sewage and sump pumps, irrigation and drainage pumps, paper mills, deep well pumps and hearth pumps. Centrifugal pumps leave an extraordinarily small discipline for reciprocating pumps, a discipline the place capacities are too low and pressures too excessive to permit a good kind for a centrifugal pump. Nonetheless, this field is being step by step lowered extra. Such development within the development and software of centrifugal pumps is as a result of a couple of motives.

- Their excessive adaptability for high pace electric motor and steam driver.
- Minimal of moving elements and,
- Small size and low price for the amount of liquid moved

Centrifugal pump: A machine accustomed transport fluids by the conversion of motion K.E. to the hydraulics energy of the fluid flow.

- Centrifugal pumps square measure the oremost in style pump used and square measure the chief pump kind within the category of kinetic pumps.
- Used in various sectors such as: agriculture, power generation plants, municipal, industries, domestic purposes, etc.
- Common uses include: air, water, sewage, petroleum, petrochemical pumping.
- Consist of two major parts:
 1. Impeller (a wheel with vanes)
 2. Circular pump



Figure .1 Centrifugal Pumps

Centrifugal Pump Applications

- Energy & Oil Industries
 - Refineries and Power Plants
- Building Services
 - Pressure boosting, heating installations, fire protection sprinkler systems, drainage, air conditioning
- Industry and Water engineering
 - Boiler feed applications, water supply (municipal, industrial), wastewater management, irrigation, sprinkling, and drainage and flood protection
- The Chemical and Process Industries
 - Paints, chemicals, hydrocarbons, pharmaceuticals, cellulose, petro-chemicals, sugar refining, food and beverage production.

II. RELATEDWORK

Hu-sekietal. conducted analysis of regulation characteristics of boiler feed pump. They stressed on fitting characteristics equation of feed-

water pump underneath totally different operations, determinant characteristics of feed water pipeline underneath sliding-pressure operation, corresponding resistance constant, and at last deducing the equation of raise, potency and rotating speed once {different totally totally different completely different} hundreds and different sliding-pressures square measure tailored solely by main feed-water pump variable speed adjusting.

They took one power station 600MW critical unit as an example to check the energy consumption of various operation modes, and so puts forward a a lot of appropriate operation mode underneath totally different masses, providing theoretical basis for the sensible application of project.

Babuet.al did condition watching and vibration analysis of boiler feed pump. throughout their investigation they found that for the BOILER FEED pump the vibration readings show that values square measure over traditional readings. qualitative analysis was done on readings and located that mass unbalance in vanes. it absolutely was corrected supported part analysis and vibration readings were ascertained once modification which provides the values at intervals traditional vary. It eliminates extra gap of apparatus with goodish savings in personnel resources.

Birajdaret.al studied concerning the sources and designation strategies to manage vibration and noise in centrifugal pumps. They studied concerning the unwell effects of vibration and ended that in the operation of a boiler feed pump, precise designation of vibration and noise sources is incredibly tough in centrifugal pumps as this might be generated because of system or the instrumentality itself. therefore they addressed just some of the problems.

Ravindra Anandrao Thorat conducted performance analysis of Centrifugal sort Boiler Feed Pump by variable blade variety. He found that blade variety has nice influence on the pump performance. Therefore, he allotted CFD analyses for the pump with five, six and seven blades. supported the analysis, he ended that the feed pump model with 5 variety of blades showed higher performance.

Bhawaret.al did style and analysis of Boiler Feed Pump Casing acting at warmth by victimisation ANSYS.

They given the generation of model, structural and seismic analysis, and necessary geometrical modifications were performed by them for pump casing.

Agrati et al. allotted study on time period horizontal boiler feed pump from hydraulic and structural purpose of read. In their investigation, a whole calculation of rotor dynamic behaviour in each configurations had been performed victimisation the finite part technique. The model of the shaft had been meshed victimisation beam components, whereas linearized coefficients had been evaluated so as to simulate stiffness and damping of sleeve bearings, blade wear rings, equalisation drums and inter-stage seals. Undamped crucial speed map, damped mode shapes and Joseph Campbell diagrams were given and mentioned.

Abraham et al. allotted AN assessment on style parameters and vibration characteristics of boiler feed pump for auxiliary power consumption. They reduced discharge pressure of BFP, thereby found the foremost economical technique of reduced power consumption, that accrued the potency of the plant. They replaced the gear box and studied vibration behavior of the pump. In their investigation, experimental and numerical analysis of vibration characteristics was conjointly conducted.

Elemermackay studied concerning the issues encountered in boiler feed pump operation and classified them into hydraulic and dynamic instabilities. He studied the interaction between hydraulically evoked forces and bearing style parameters and their influence on rotor vibration characteristics. Friction evoked partial frequency modes were conjointly mentioned in his investigation. From the higher than literature review it's ascertained that little work has been done on the planning of oil guard employed in oil thrower in boiler feed pump.

III. SYSTEM OVERVIEW

As it has already been expressed centrifugal pumps area unit used largely for prime discharge and low to medium head at the outflow thanks to this most pumps area unit designed to maximize the ability to discharge magnitude relation. the foremost common thanks to do that is thru ever-changing the angle of the blade blades. The angle of the blades also will have an impact on discharge to move magnitude relation as shown within the graphs.

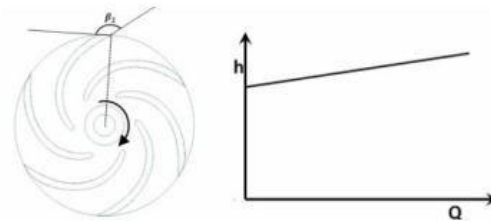


Figure .2 Forward Curved Blades

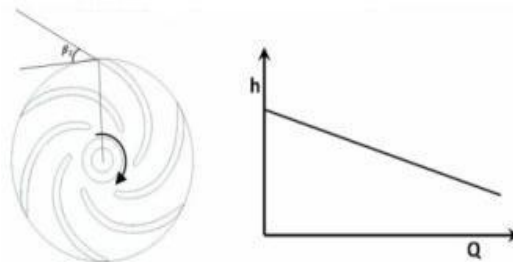


Figure .3 Backward Curved Blades

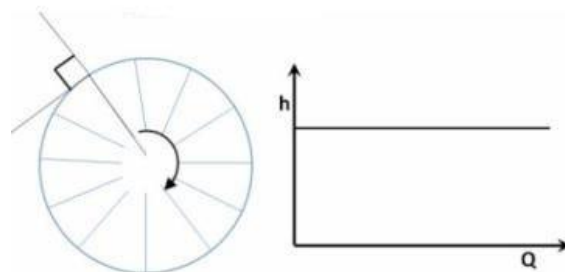


Figure .4 Straight Curved Blades

3.1 Blade Angle

The most economical blade angles can forever be backward flexuous, this is often as a result of the a lot of move force the blades impart on the fluid the a lot of energy the pump should place out the get a similar discharge. As a textbook explains if the vanes of the wheel square measure straight and radial; however if they're flexuous, as is a lot of ordinarily the case, the outward force is part made through the medium of force, and part applied by the vanes to the water as a radial element of the oblique pressure, which, in consequence of their

obliquity to the radius, they apply to the water because it moves outward on them”.

IV. DESIGN

In style of pump, the elements to be designed are: shaft, impeller, vane, casing, and choice of bearing, to style these elements totally different methodologies will be obtained through literature survey. From the given conditions, the particular speed is obtained [5]. in keeping with needed head, the rate of flow and from specific speed, pump of double volute, double suction and single stage sort is chosen. The minimum shaft diameter will be obtained by victimisation most shear stress theory. blade and vane square measure designed in keeping with methodology provided by Church [6]. to style the vane empirical relations square measure used. API customary [7] is employed to style the volute and for bearing choice. There square measure totally different ways for volute style, however “throat space from graph of quantitative relation of throat speed to blade peripheral speed vs. specific speed” technique is employed to style a volute. The conversion of KE to alphabetic character is extremely vital in pump which will be achieved with the fine form of volute. in keeping with choice criterions explicit in API customary [7], choice of bearing has been done. Specifications of feed pump are cited in Table I.

Specification	Value
Head, H	475 m
Flow Rate, Q	2300m ³ /hr
Speed, N	4500 rpm
Shaft Power	2.87 MW
Temperature	130°C to 150°C
Pressure	6 bar
Density	1000kg/m ³

Table I Specifications of Feed Pump

The performance characteristics head and potency of a pump are influenced by the blade variety, that is one in all the foremost vital style parameters of pumps [14]. Therefore, dynamical the blade numbers, CFD analyses are allotted to check the pump performances. the simplest and appropriate blade configuration is opted when finding out the obtained pump performances. The minimum shaft diameter is calculated on basis of strength victimization most shear stress theory. This theory predicts the yielding of ductile material. in line with this theory, it's assumed that yield happens once the shear stress exceeds the yield strength [8]. The issue of safety is

assumed as four. The hub diameter, DH shown in Figure five ought to be (5/16) to (1/2) times larger than shaft diameter [6]. From minimum shaft diameter, the various dimensions of stepped shaft are finalized. The stepped shaft is intended on the premise of article of furniture of ordinary components on shaft like; wear rings, throat bush, shaft sleeve, bearings and bearing housings, etc.

Therefore, 3 completely different models with five, half-dozen and seven variety of blades are developed and people are used for analysis purpose. The grid generation is finished victimization Ansys ICFM CFD code which is able to permit the user to get unstructured tetrahedral non-uniform mesh. A finer mesh has generated close to blade, hub and shroud region wherever the pure mathematics features a giant influence on the flow and wherever large speed or pressure gradients were assumed to occur.

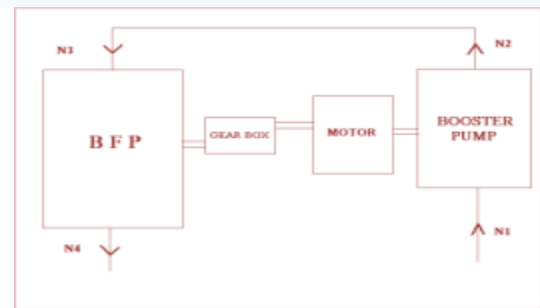


Figure .5 Plan of System

To ease the discretization method, model was separated into 2 domains as stationary and rotating domains. Stationary domain includes water domain and outlet domain. Blades, hub, shrouds square measure enclosed in rotating domain. The model has rotating mesh and stationary mesh region. Therefore, interface between these 2 regions was simulated as multiple organization, MRF and stage kind. supported best practices from CFX and results obtained for these 2 cases, it absolutely was discovered that each interfaces gave similar results. MRF kind interface is chosen to unravel within the pump simulation. The meshed model of vane is shown in Figure vi. the top developed by the pump will be calculated by victimization pressure at water of vane and pressure developed at outlet.

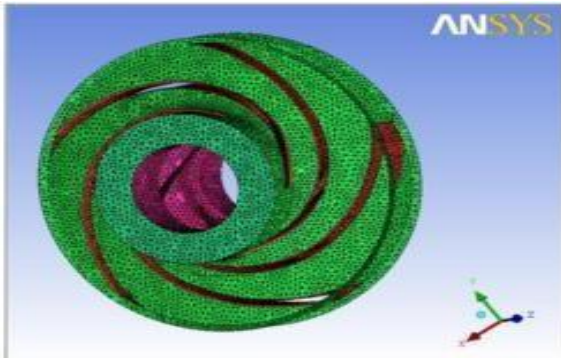


Figure 6 Meshed Impeller

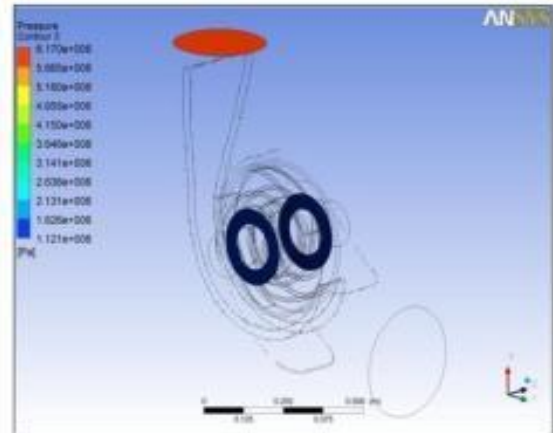


Figure . 8 Pressure Contour for 5 Blades

After meshing, CFX-Pre is supplied with input file and boundary conditions are applied to unravel the issues. At water of pump, water pressure (14 bar) and at outlet of pump, the specified flow (2300 m³/hr) is provided. Density (1000 kg/m³) as material property and operative temperature (140o C) is given to fluid domain. The movement degree of freedom, 4500 revolutions per minute is applied to vane. Applying these boundary conditions, the matter is resolved with a thousand iterations and at the top of iterations resolution is converged.

Further, the analyses for a pump with 6 and 7 blades can be carried out. For analysis of a pump with 6 and 7 blades, the geometry is changed to 6 and 7 blades. The analysis procedure is similar as that for 5 numbers of blades. Therefore, following the same steps, the analysis results can be obtained. The input data as well as the boundary conditions are same only. Results for velocity and pressure distribution with 6 and 7 numbers of blades can be seen in Figures 9, 10, 11 and 12 respectively.

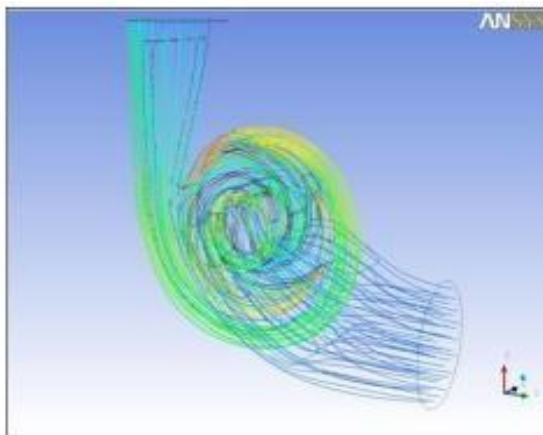


Figure 7 Velocity Streamline for 5 Blades

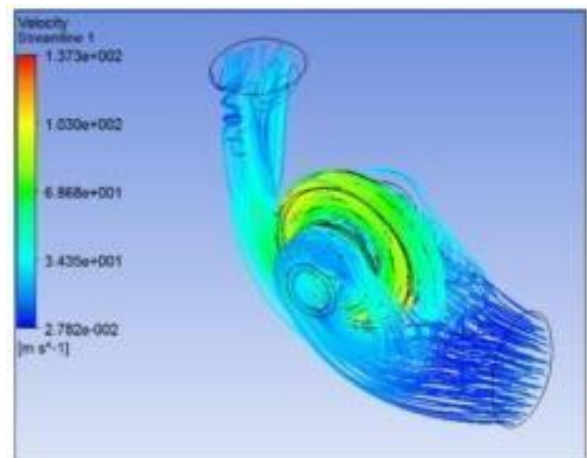


Figure 9 Velocity Streamlines for 6 Blades

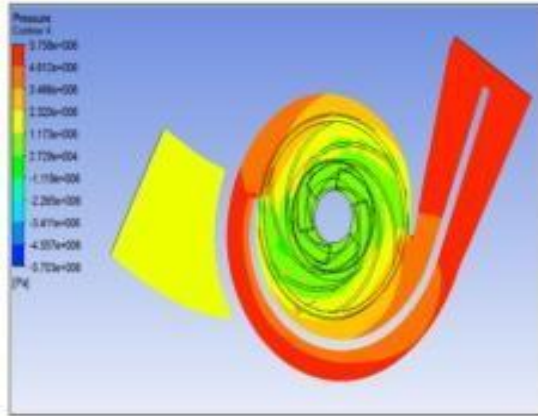


Figure 10 Pressure Contour for Blades

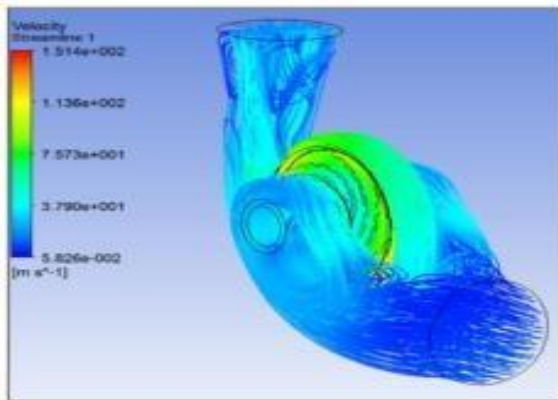


Figure 11 Velocity Streamlines for 7 Blades

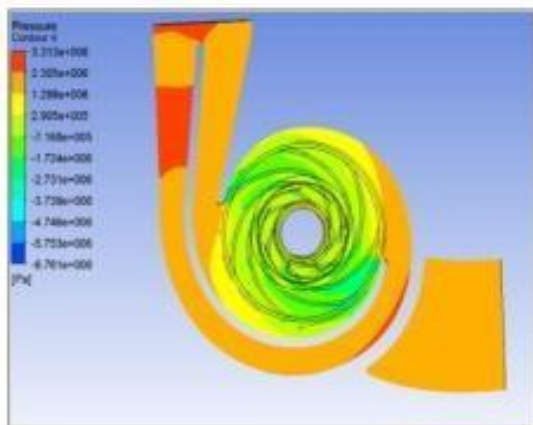


Figure 12 Pressure Contour for 7 Blades

After playing CFD analysis for feed pumps with five, half dozen and seven blades, analysis results are obtained. These results are necessary to pick out the most effective suited pump model to satisfy the wants. Results can show the clear image of 3 cases with totally different blade blades. From CFD analyses of the pump with five, half dozen and seven blades, numerous results are obtained. These analysis results are compared in Table III and Figures 13 and 14.

According to results obtained from the pump analyses with five, half-dozen and seven blades, it will be ascertained that the flow of a pump with five blades is power tool than that with half-dozen and seven blades. just in case of a pump with half-dozen and seven blades, the flow streamlines area unit admixture at outlet. From the pressure contours for a pump with five, half-dozen and seven blades, it will be ascertained that the pressure at water to vane is reducing. If the pressure at water can most low then there could also be possibilities of cavitation within the pump. Therefore, cavitation purpose of read, the pump with five blades is at safer aspect.

No. of Blades	Head, m
5	482.17
6	484.20
7	489.40

The limitation of area between blade and flow stream gets raised with increase in blade range. the world of depression region at the suction of blade water grows unendingly. With increase of the blade range, total pressure within the region of flow grows unendingly. the pinnacle of pump grows all the time with the rise of blade numbers and total pressure too, however the amendment in hydraulic potency with variation in blade range is advanced.

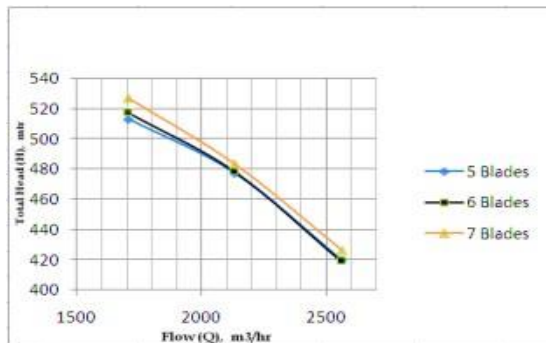


Figure 13 Flow vs. Head

If the blades square measure too a lot of, the situation result development at the vane is serious and also the rate of flow will increase, additionally the will increase of interface between fluid stream and blade can cause the increment of hydraulic loss [14]. The vital speed is reciprocally depends upon the shaft deflection. Therefore, if the shaft deflection is a lot of, lower the vital speed. The machine shouldn't fall below the permissible limit of vital speed.

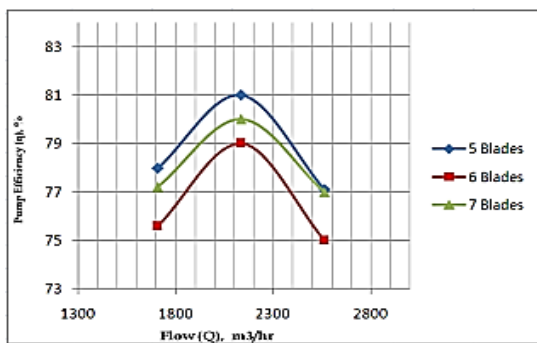


Figure 14 Flow vs. Efficiency

Therefore, critical point of view, the system is on safer side with 5 blades. The pump model with 5 numbers of blades provides the better performance, therefore it can be selected as best performing model and the analysis results are obtained.

V. CONCLUSION

Centrifugal Pumps transfer movement K.E. to extend the hydraulics energy and head of fluid flow. once coming up with a pump, Blade Angle, Rotations per Minute, and also the range of vane blades all impact the potency and discharge of a pump. Some conclusions on the planning and CFD analysis of centrifugal kind feed pump are,

- o The dimensions suggested for all elements of the pump are meeting the planning necessities.
- o CFD analysis shows that, feed pump with five blades has the most effective performance compared to six or seven blades.

vi. REFERENCES

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