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Review on Performance Prediction of Pump through Its Fluid Flow Rate

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A B S T R A C T

Pump is used to fetch the water at certain height and also number of applications of pump is available in medical field. Pump is also used in power generation plant to supply the water to the boiler at higher pressure than the atmospheric pressure. Now a day's pump is widely used in refrigeration industries to feed the refrigerant at high pressure to the evaporator and also useful to remove heat as it maintains the pressure through the system while operation. In this paper the performance prediction of pump is evaluated and for that different techniques are used. One of the most famous method CFD is also used for the performance prediction of the pump. Number of changes had done to the design and criteria to the centrifugal pump to increase its efficiency so over all costing of plant can be reduced. To reduce overall losses in the pump number of experiments are done and also the changes in the blade design have accepted by the developer.

Keywords: Electricity consumption, power developed, Losses occurs, Energy required.

1. Introduction.

Pump is a device which can crate higher pressure and it will result in better efficiency of the equipment. Number of Industries that require higher pressure to maintain the internal pressure of pipe and also to maintain the critical level if fluid. In this case pump can full fill the need and also revert with better output. But till date there are number of chances to change in design of pump and it is also noted to do change in the design of impeller and diffuser [1]. Also its parametric study that changes in an angle of blade can change the performance of pump. So number of experiments is done on the angle of blade and also our ward and inward angles are predicted for better performance [2].

As heavy vibration can fail the structure of pump and also create uncertain failure to the pump. Vibration also creates disorder forces that affect the pump impeller and also damage the components of the pump [3]. Uneven vibration can create difference in pressure and also damage the blades of impeller as a surge effect. So vibration must be removed and pump must work in silent within certain amount of vibration that can be tolerated for period of operation [4].

Vibration performance is one of the most important parameters in designing a centrifugal pump. Actually, with the help of CFD analysis one can predict the performance of the pump and also evaluate the efficiency of pump Metamodel technique is useful for finding optimises losses and it can also predict the performance of the pump. So it's a better technique for the developer [5].

2. Problems Existing in the Pump Station

Number of electrical and Mechanical research and experiment was done on the pump to fine out its capacity and working ability in the tough environment. Also changes have been done to the impeller to increase its output.

Result shows that there is damage in the cavity of pump and also blades due to vibration and it also affects the efficiency of pump and creates loss in the target. So overall call the components are working at lower efficiency and give less output. The shaft displacement and the tip clearness have exceeded the allowed values, Displacement of shaft and also considered to the designed values. The pump casing, and diffuser were serious. Moreover, the vibration of the pumping sets was obviously felt and noticed by standing nearby, and the regulation device of blade setting angle was mutilated and adjusting precision affected.

The coiled silicon steel sheet is loosed due to excessive dielectric loss of stator winding this can be resolved by proper insulation and protector. Technical new things must be introduced to the era to minimise losses and give safe, continuous performance.

3. Axial-Flow Pump Hydrodynamic performance

Aiming at the problems revealed in the daily operation, yearly maintenance, and the special accreditation check up, the following technical approaches will be taken to improve the hydrodynamic performance of the axial-flow pump For Axial flow pump ,there are some actions taken to improve the performance of pump and also it will also help to reduce the maintenance cost of pump. It will also reduce the installation amount of pump station and cost of plant,

All four sets of old main pump and motor will be dismantled and eliminated, replaced by bland new ones to achieve technical innovation in pumping facilities.

The pump is made with steel material with inside casing and this will give rust less performance and better cavity quality. The blade of pump is made with SS material and this process of making blades is carried out with Numerical control machines with automatic mode. After carried out of such an action the overall capacity of pumping of water, energy level, and impeller performance in increased to the next level.

The precision casting technique and new surface polishing technology will be adopted in the production of diffuser to realize the precise shape and size of vanes. Those new manufacturing methods will effectively decrease its water head loss.

A ring-type beam, outside of the diffuser, will be added to enhance its structural support and increase its strength and stiffness, so that the vibration of pumping set will be depressed to secure the safety operation of the pumping set. The trash screen in the entrance of the suction box will be removed and a large trash-removal machine will be installed in the approach channel far away from the suction box; thus, automatic trash removal can effectively solve the problem of trash accumulation in the front of the suction box as happened often before the innovation, so that ideal internal flow patterns inside the suction box can be prospected and better flow conditions will be generated for the pump.

4. Pump Selection for the Technical Innovation

In China initially pump were made technology of less improvement but after a decade the European countries introduces the latest technical things that improved the performance of pump and also did a better power saving of electricity that utilised to run the pump. Due to the construction of the development of the proper pump the vibration analysis and impact throw of water were studied and the impeller was made such an exciting technique that improved the efficiency of pump.

There is also issue to the Developer that how to test the pump performance with different capacity as all pumps are used as per their different applications .The Tianjin pump test stand invested by the Ministry of Water Resources of China solved the problem effectively. All pump models from different researchers and institutions were asked to carry out peer contrast tests; thus, comparable test results were obtained since they all came from the same test stand. There is also possibility that pump is made with casting technology and it was costly due to limited production of pump as per their requirement. So after all large production is required and also it is necessary to reduce the power loss in pump for general use.

The selection of pump is done on the basis of that at how much quantity of water that it can pump to the desired place within certain time. With this, also it is priority that pump can work with enough safety factor and gives reliable work while operation and does not fail any time as load increase. The pump is expected to run at the high efficiency zone under the mean head of the pump station, and the designed flow rate is to be met under the design head and under the maximum head the safety and stable operation.

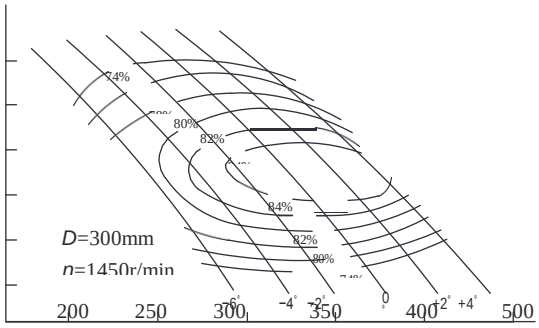

Figure 1 .Flow rate inside pump [2]

Process of pump selection on the basis on calculation, numerical simulation, or model tests after a specific pump is selected to verify the correctness of the estimation.

According to the experience of relevant numerical simulation and model test results, the sum of hydraulic losses of a dustpan-type suction box and a siphon-type discharge passage is in the range of 0.60m to 0.70m, as illustrated in [7]. Therefore, the specific speed of model pump for the technical innovation of Liulaojian pump station ranges from 927 rate of fluid.

Table 1: Comparison of blade angles between the original and the selected pumps.

Section	I	II	III	IV	V
Blade angle of original pump	33.53	29.34	26.12	23.71 °	21.98
Blade angle of selected pump	36.25	31.61	28.34	25.55	23.47

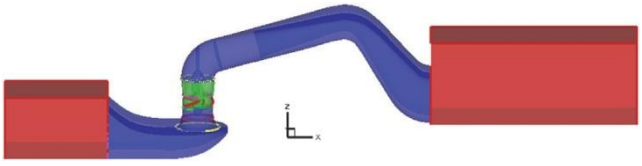

Figure 2. The 3D model for numerical simulation and performance prediction.[4]

5.Centrifugal Pump FSI Simulation

The recommended number of impeller blades for high head centrifugal pumps is usually between five and seven. If the number of blades are increased then it will create higher friction and the number of blades is decreased then it will tend for higher load. Turbulent flow created some losses due to secondary flow and also reduce the efficiency of pump. So after experiment the number of blades is decided to 6.

Target is to achieve main diameter of the impeller to reduce various type of loosed and increase overall efficiency of pump. In addition, among all kinds of centrifugal pumps, After all rotational energy transfer rate is increased and the double suction type pump is selected to increase the co efficient of performance.

Therefore the meridional section of the single suction impeller is actually determined by the solid line and dashed line The solid line is parame- terized by quartic Be´zier curve with 5 control points; the five decision variables for the pump impeller are as follows.

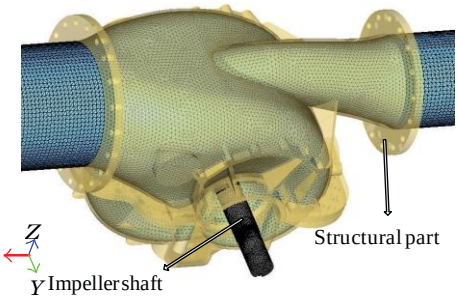

Figure 3. Full model with indication

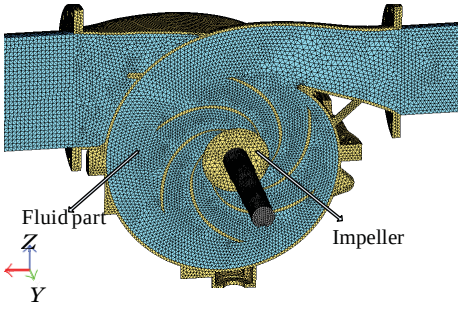

Figure 4 . Cut section view

Summarizes the combinations of decision variables in the sample points. The FSI simulation models are built based on these sample points. Figure 3 shows one case of FSI simulation models. Figure corresponds to a full FSI model with solid and fluid parts. Figure 4 is the cutaway view of the full FSI model, and Figure 4 gives the detailed view of the tongue region. The structural part consists of pump volute casing, impeller, and impeller shaft, while the fluid part is the liquid flowing through the structural part. Moreover, the fluid part is also called the hydraulic model of centrifugal pump.

By finite element analysis the overall performance of the pump can be predicted. The pump volute casing and impeller are both made of aluminium-bronze alloy; the elastic modulus is 125000 MPa, the density is 7630 Kg/m3, and the Poisson's ratio is 0.327. From SS impeller shaft is made with elastic modulus of 206000 MPa, density of 7800 Kg/m3 .3D modelling of the Pumping System. 1st step is to select the proper design of the pump. It is also tough to define the flow rate of pump and also tough to decide whether the pump can run on high load or failed below the designed value.

As per the figure 4 Pro-E software is useful to design the required pump and it is useful to find out the cut section as well as the pre designed value of pump.

Computational fluid dynamics shows the set up for the pump and also indicated the mathematics analysis for the selection of pump and a outlet ward as well as an inlet section and a discharge pool. Supply to the national grid is also accounted and about number of mixed meshes of unstructured four-face body mesh and structured six-face body mesh are generated to accommodate the complex computed models.

The Computational fluid dynamics software which is professional used is Fluent is used to find out the inherent property of fluid.. At the occasion of steady flow and fluid is solid in that case fluent can used to find the mass conservation equation and the time-averaged N-S equations. At the same time Angle of blade is ordered to pump is set at +2 degrees and works at 3.7m of the designed head, rate of flow of pump is 0.37m3/s. It would be 39.51m3/s for the corresponding prototype pumping system by using the pump affinity law, which exceeds 37.5m3/s of the designed flow rate for each pump set, and the pumping system efficiency would be higher than 74% when operating under the designed head.

The selection of pump is done through its discharge and suction capacity and points are mentioned in figure 3. Then the comparative models are selected and the test results can be directly compared and used to verify the correctness in pump selection and performance prediction for the technical innovation for concern department.

As it is also noted that the prediction of pump is also concern with fluid segment and secondary flow of fluid but it is related with turbulent number. So one has to maintain the fluid speed and also needs to manage the flow of fluid at the time of passing through the pipes or any system.

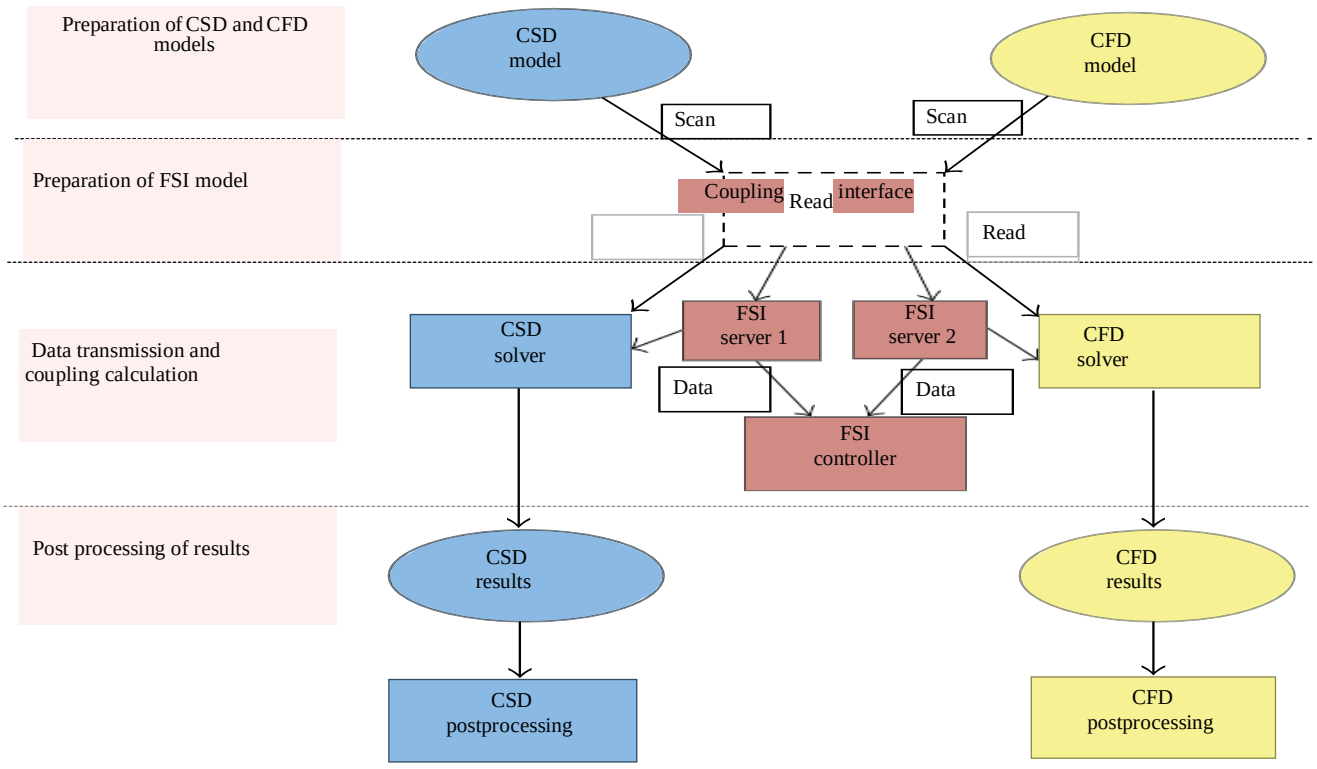

Figure 5. The process of FSI simulation

Conclusion

As the storage pump and other high altitude pump can run with better water flow rate but issue is related with its friction losses as number of blades are increasing , To reduce this losses developer have to reduce the blades but one have too define the proper angle to reduce load the blades.

With help of CFD the transient flow direction and the fluid flow component can be find out with effectiveness and also it will be noted that the friction of laminar flow can be reduced with the proper analysis of fluid flow. Fluent is effective professional software to determine the fluid steady flow situation and prediction for the performance of the pump a the pumping station before installation at the site. So one can predict the life of pump and also the maintenance cost of the pumping station at the end of the year.

Study also shows the cross section of the centrifugal pump and indicated the fluid flow strategy to find out the losses occurs and friction path. So number of optimised solution is effective to reduce cost of the plant and losses. As experiments shows that if number of blades are made doubled for impeller then the overall efficiency of the plant is reduced because of frictional flow of fluid is increasing as the blades are increasing. Also less number of blades create high load to the pump and also affects the life of pump. So developer has to optimise the number of blades that can deal a appropriate number of blades for friction and load calculation.

Radial curve and moment curve is responsible for cyclical fluctuation. If the rotational speed of the impeller is reduced then it is effective to improve its cavitations performance. The use of new pump model, together with the automatic trash removing device, ring-type support beam, stainless steel blades, and other measures will greatly improve the hydrodynamic performance of the pumping system to achieve economic, stable, and safe operation of the pump station.

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