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Design and analysis of impeller- openwell monoblock pump efficiency improvement

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Abstract - This article is proposed based on the experimental analysis of open well monoblock pump. Pump is a mechanical component used for transportation of fluid which may be linear or vertical manner, with the use of two main components Impeller and casing. The efficiency of the pump is based on the discharge (lps) and total head (m). In this modern era, with the usage of analysis and modeling software, the pump efficiency is calculated based on the key parameters of the Impeller design & volute casing. This research is stipulated on the use of theoretical analysis in combination with CFD concepts to determine the optimum value of blade vane angles for maximum efficiency. The efficiency obtained from CFD (flow test) is compared with the original data's from pump xzmanufacturer through testing and efficiency improved by changing vane angle.

KEYWORDS: CFD, Total head, discharge, Impeller, Volutecasing,etc.

I. INTRODUCTION

In present, of submersible pump (or sub pump, electric submersible pump (ESP)) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface as opposed to jet pumps having to pull fluids. Submersibles are more efficient than jet pumps.

Ca. 1928 Russian oil delivery system engineer and inventor Armais Arutun off successfully installed the first submersible oil pumps. In 1929, Pleuger Pumps pioneered the design of the submersible turbine pump, the forerunner of the modern multi-stage submersible pump. In the mid-1960 the first fully submersible deep-well water pump was developed by Poul Due Jensen who later went on to start Grundfos.

Fig.1 Casing and Impeller

Fig. 2Cutting Process

421

Ravichandran D et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–06(01) 2018 [420-424]

Fig.3 Cross Section of Impeller

equal divisions and varying vane inlet angle from hub to shroud. The model prepared is been analyzed in CFD tool CFX and its performance is analyzed at different flow rates. At, inlet the boundary conditions was 0 pa, and at outlet 500 m3/hr, 1800 rpm. Finally, concluded that increase in efficiency is due to little twist provided at the leading edge of the vane by varying the leading edge angle from hub to shroud, and small modification in the vane can give very good results.

II. LITERATURE SURVEY

[1] Bacharoudis, 2008 In a research by, Stated that, the influence of the outlet blade angle implicit the performance of pump along with CFD simulation. By varying the outlet blade angle, performance curve becomes smoother and flatter. In this study, the performance of impeller with same outlet diameter having different outlet blade angles is evaluated and concluded that, when pumps operate at nominal capacity, the gain in the head is more than 6% than the previous head, If the outlet blade angle is increases from 20° to 50°.Hazeeb Halid et al, conducted an experimental analysis of solid desiccant wheel dehumidifier and stated that regeneration temperature increases more moisture is removed from the process air due to enhanced heating of desiccant wheel surface.

[2] Manivannan, 2010 An empirical study by about the CFD analysis of mixed flow impeller is done and the results are compared with the existing impeller having head H = 19.24 m and efficiency □ = 55%. In the analysis three modified model of the impeller were created by changing the inlet and outlet vane angles and concluded that by varying the outlet angle performance is effected the most.

[3] Rajendran 2012 In another research similar to, describes that the simulation of flow in the impeller of a centrifugal pump having head H = 10m and discharge Q = 0.0125 m3/sec. The flow pattern, pressure distribution in the blade passage, blade loading plot at 50% span, stream wise variation of mass averaged total pressure was presented. He concluded that CFD predicted value of head at the design flow rate is approximately H =9.4528 m, and pressure contours show a continuous pressure rise from leading edge to the trailing edge of the impeller due the dynamic head developed by the rotating pump impeller.

[4] Urankar 2012 Additional to above statement, also predicted that, the impeller and volute designed by Walter K Jekat method of error triangle method,

[5] Mitul G. Patel, 2014 A review study by, mentioned that analysis of the impeller used in the mixed flow submersible pump. Fluid flow (CFX) is used for the analysis purpose and due to constant mass flow rate, same boundary condition, i.e. the mass flow rate at the inlet and outlet was applied, the hub and shroud was defined as a wall. And obtained (1) pressure and velocity distribution in meridional view of impeller and in blade to blade view of impeller and concluded that the head generated by the CFX showed good agreement with the experimental head.

III.POSTIVE DISPLACEMENT PUMP BEHAVIOR AND SAFETY

Positive displacement pumps, unlike centrifugal or roto-dynamic pumps, theoretically can produce the same flow at a given speed (RPM) no matter what the discharge pressure. Thus, positive displacement pumps are constant flow machines. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate. A positive displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, both.

A relief or safety valve on the discharge side of the positive displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually only used as a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank provides increased safety.

IV. POSITIVE DISPLACEMENT TYPES:

A positive displacement pump can be further classified according to the mechanism used to move the fluid:

⬜Rotary-type positive displacement: internal gear, screw, shuttle block, flexible vane or sliding vane, circumferential piston, flexible impeller, helical twisted roots (e.g. the Wendelkolben pump) or liquid-ring pumps

⬜Reciprocating-type positive displacement: piston pumps, plunger pumps or diaphragm pumps

⬜Linear-type positive displacement: rope pumps and chain pumps

V. PROBLEM IDENTIFICATION

The Existing design is analyzed on two parts of the pump. They are

Impeller

Casing

For both the parts the existing design is analyzed and it is found that overall efficiency while using the existing design is low and with an adjustable energy consumption. The maximum overall efficiency is found to be 26.36% at 2.21 lps. The need of the company is to improve the overall efficiency of the pump by 10% without affecting the energy consumption.

The Impeller can be redesigned in such a way that it can be able to perform much efficiently. Modification should be made on the vane angle of the impeller or surface area of the casing.
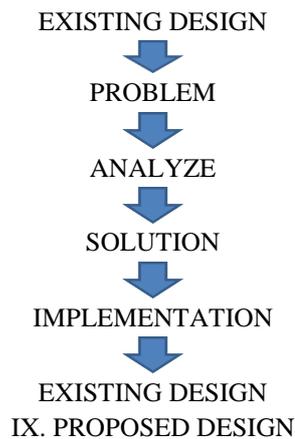
VI. SCOPE OF THE PROJECT

⬜Changing the design of the impeller and casing in the open well submersible pumps.

⬜Design and simulate the existing pump.

⬜Analyzing the discharge and the efficiency given to the pump is studied.

⬜Altering the vane angle and surface area of the casing.

⬜Overall efficiency gets increased.

⬜The energy consumption will be reduced.

⬜Time consuming for the discharge is also reduced.

VII. SYSTEM SPECIFICATION:

While considering the system specification.
The following things should be considered.

1. Impeller
2. Casing
3. Motor
4. Shaft
5. Bearing assembly

VIII .METHODOLOGY:

EXISTING DESIGN
⬇
PROBLEM
⬇
ANALYZE
⬇
SOLUTION
⬇
IMPLEMENTATION
⬇
EXISTING DESIGN

IX. PROPOSED DESIGN

The main objective of this project is to improve the efficiency of the given open well pump by modifying the design of the Impeller and Casing. Surface area of the Casing and vane angle of the Impeller are modified in the design and the above changes are analysed on the analysing software. Existing and modified design are made by using the solid works 2016 model and the above design is analysed though the solid works flow analysis. The existing design is having a medium range efficiency by doing this project, the efficiency of the pump gets increased and energy consumption gets decreased o minimized.
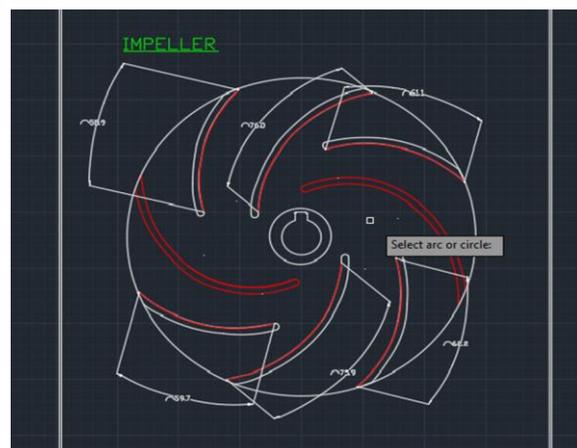

Fig .4 Existing Impeller with dimensions

423

Ravichandran D et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–06(01) 2018 [420-424]

Fig.5 Modified impeller with dimensions

Fig.6 Casing Design
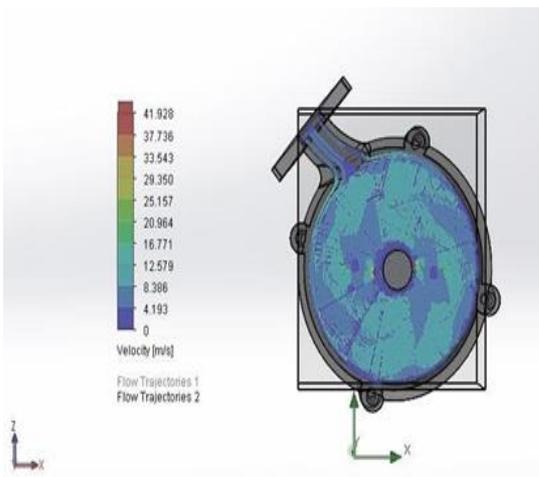
Fig.7 Iteration of impeller

Table .1 Iteration report

Name	Unit	Value	Progress (RPM)	Use in convergence	Delta	Criteria
GG Mass Flow Rate 1	kg/s	2.8546	2855	2.85	3.3528	On
GG Mass Flow Rate 2	kg/s	3.1522	2865	3.15	3.6923	On
GG Mass Flow Rate 3	kg/s	3.4558	2875	3.46	3.8542	On
GG Mass Flow Rate 4	kg/s	3.8634	2885	3.86	4.2521	On
GG Mass Flow Rate 5	kg/s	3.7372	2890	3.78	3.5682	On
GG Mass Flow Rate 6	kg/s	2.5568	2895	2.5	2.5268	On
GG Mass Flow Rate 7	kg/s	0.5602	2950	0	0.655	On

X. DESIGN CALCULATION

Discharge Q $= 3.86$ Ips$=3.86 \times 10^2$ m^3/s

Total head H $=19.39$ m

Power input $=2.42$ kw

Over all efficiency $= \dfrac{\text{discharge x Total head}}{102 \text{x Power input in kw}}$

$(\tilde{\eta}_{overall})$

$= \dfrac{3.86 \times 10^2 \times 19.37}{102 \times 2.42}$

$=30.29\%$

Improved overall $= $ [Overall efficiency at the end of modification]- [Overall efficiency at the Initial stage]

Efficiency

$= 30.29\% - 26.36\%$
$= 3.93\%$

XI. CONCLUSION

The project carried out by us made an astonishing task in the industry. The experimental research of this project, overall efficiency of the 1HP open well mono block pumps discharge has been increased almost **9%** (**2.38 lps to 3.86 lps)** @ 2800 rpm, whereas efficiency of the pump has been improved 3.93%.

Design calculation to support the software analysis is attached in this report.

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