

Design and Optimization Techniques Used in Horizontal Openwell Submersible Pump

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ABSTRACT: In India, Bureau of Indian standards gives only an overall configuration about horizontal open well submersible pump. Most of the Indian manufacturers produce horizontal open well submersible pumps on trial and error basis. They make their own winding combination in order to optimize the performance. In case of submersible pumps various parameters are redesigned in various stages to maximize the performance.

This project deals with the modification in the existing design of radial flow impeller made out of plastic material in many cases may be called rotor. By modifying the design of impeller either by changing the blade angle or by changing the width we could achieve a considerable increase in the output discharge which will be shown in the further work. Ansys software is used to analyze the performance of pump and the equivalent output of the new impeller design and use Pro-e for the design of impeller. After modeling the impeller we will calculate the equivalent theoretical efficiency so as to prove that the impeller that is designed newly is of better design than the previous one.

KEYWORDS: Submersible pump & Impeller design

I. INTRODUCTION

A pump is a device or an apparatus used for conveying a fluid from one point to other, usually through a pipe. A pump may, therefore, be defined as a mechanical device which translates the mechanical energy imparted to it from an external source (electric motor, diesel engine or even manual energy) into hydraulic energy in the fluid handled by it. As a consequence, the energy level of fluid handled by the pump or flowing through the pump is augmented, making it possible for the fluid to move from a lower level to a higher level, against gravity and friction. Generally pumps are selected for certain characteristics referred to as "rated service conditions" & with a few exception represent those conditions at or near which the pump will operate the major part of the time.

Centrifugal pumps can operate over a wide range of capacities from near zero to well beyond the rated capacity. Since a centrifugal pump will always operate at the intersection of its Head-Volume rate of flow curve with system head curve, the pump's operating volume rate of flow may be altered either by throttling the pump volume rate of flow {hence altering the system head curve} or by varying the pump. This makes the centrifugal pump very flexible in a wide range of services and applications.

Pump selection is based on lifting water from the source (surface or ground) to purification works or to the service reservoir. Boosting water from source to low service areas and to the upper floors of multi storied buildings and Transporting water through treatment works, draining of settling tanks and the other treatment units, withdrawing sludge, supplying water, especially water under pressure to operating equipment and pumping chemical solutions to treatment units.

In submersible motor pump sets, both pump and the unusually long, small diameter motor are installed deep inside the tube well so that suction lift is minimized which make it possible to lift water from depths as low as 450 metres. These pumps are essentially single or multistage centrifugal turbine pumps designed to form a compact unit in conjunction

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 3, March 2017

with a coupled wet type squirrel cage induction motor both of which operate totally submerged below the surface of water. A submarine armoured cable and a small copper oil tube form the only connection beside the discharge pipe between the pumping unit and the surface of the ground.

Submersible pumps with radial flow impellers are made for low discharge with high total heads, whereas pumps with mixed flow type impellers are made for medium discharge range with medium heads.

Criteria for Pump Selection

- Nature of liquid, water (raw or treated) or chemicals to be handled.
- Type of duty required, i.e. whether continuous, intermittent or cyclic.
- Present and projected demands and pattern of change in demand.
- The details of head and flow-rate required.
- Type and duration of the availability of the power supply.
- Selecting the operating speed of the pump and suitable drive/driving gear.
- The efficiency of the pumps and consequent influence on power-consumption and the running costs.
- Possible permutations of the parameters of the pumping system, including capacity and number of pumps (with stand byes), combining them in series or in parallel.

II. METHODOLOGY

This project work is carried out in following sequence:

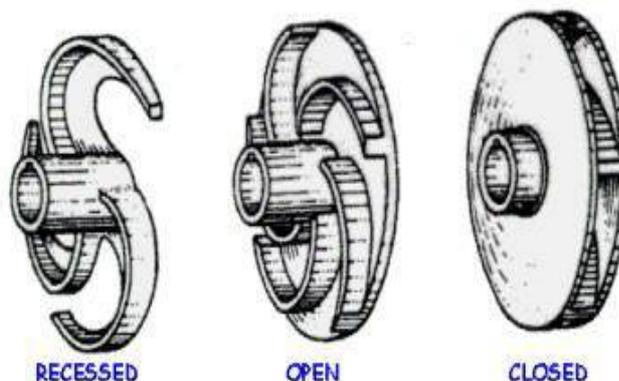
- Review of literature.
- Testing the Performance of Existing impeller.
- Design Calculation for new design.
- Drafting the component for new design.
- Analyzing the new designed components.
- Testing the Performance of new designed pump.
- Documentation of the project work.

III. DESIGN AND THEORITICAL ANALYSING OF IMPELLER DESIGN IN SUBMERSIBLE PUMP

IMPELLER

The rotating part of a centrifugal pump is called an impeller. It consists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor. An impeller is a rotor inside a tube or conduit used to increase (or decrease in case of turbines) the pressure and flow of a fluid.

TYPES OF IMPELLER



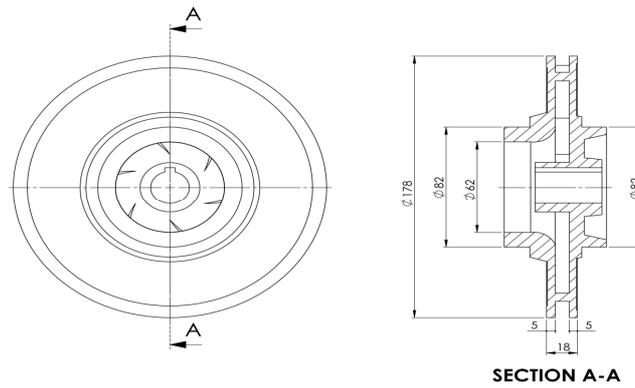
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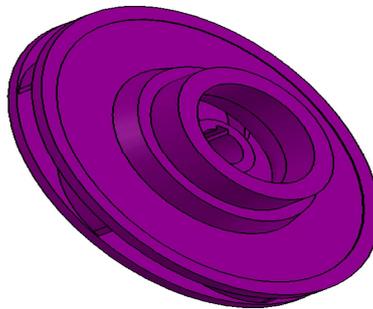
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Vol. 6, Issue 3, March 2017

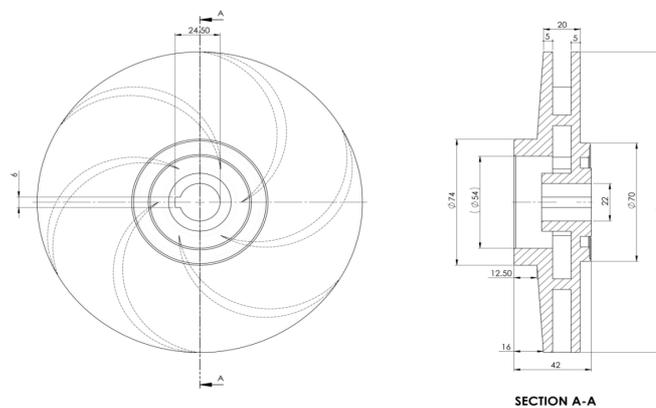
COMPARISON OF EXISTING DESIGN & PRESENT DESIGN



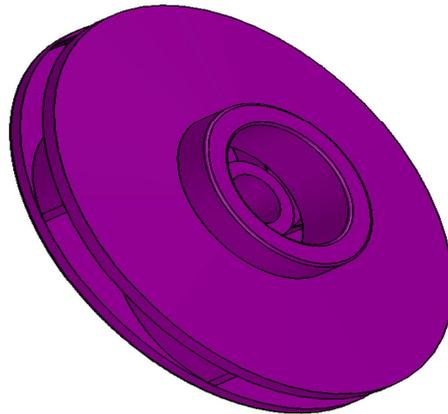
Existing Impeller Design 2D view



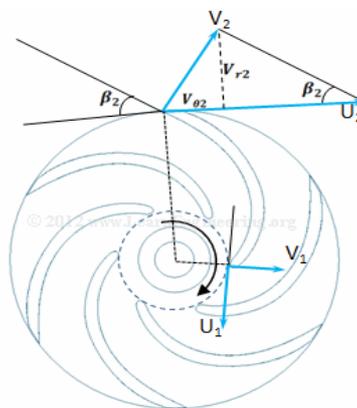
Existing Impeller Design 3D view



Modified Impeller Design 2D view



Modified Impeller Design 3D view



Exit blade angle view

EXISTING CONCEPT

The main objective of this project is to improve the pump's efficiency by changing various parameters of impeller. So by using the reverse engineering process various dimensions of the impeller are obtained. As per the Existing concept, The Exit blade angle, which is denoted by the letter (β_2) is **53.4°**.

PROPOSED CONCEPT

Theoretical calculation were made several types by changing various parameters of the impeller in order to achieve the increase in output efficiency. Finally it is achieved by changing the Exit Blade Angle (β_2) to **72.5°**.

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Vol. 6, Issue 3, March 2017

IV. METHODOLOGY FOR MODEL PREPARATION

Reverse Engineering

Reverse engineering is the process of discovering the technological principles of a device, object, or system through analysis of its structure, function, and operation.

It often involves taking something (a mechanical device, electronic component, computer program, or biological, chemical, or organic matter) apart and analyzing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing without using or simply duplicating (without understanding) the original.

Dimensions Extracted by Reverse Engineering

- A) Inlet blade angle (β_1) = 17.19°
- B) Exit blade angle (β_2) = 72.5°
- C) Radius
 - i. D = 9.35mm, R = 9.675
 - ii. D1 = 41.18mm R1 = 20.59mm
 - iii. D2 = 54.36mm R2 = 27.18mm
 - iv. D3 = 72.68mm R3 = 36.37mm
- D) Radius of Curvature
- E) RC1 = 12.974mm
- F) RC2 = 32.83mm
- G) RC3 = 76.013mm.
- H) Width of the impeller (B) = 4.30mm (0.0043m)
- I) Outer diameter of the impeller = 72.74mm

INTRODUCTION TO HYPERMESH & ANSYS FLUENT

Meshing

Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results. Hyper Meshing technology provides a means to balance these requirements and obtain the right mesh for each simulation in the most automated way possible. Hyper Meshing technology has been built on the strengths of stand-alone, class-leading meshing tools. The strongest aspects of these separate tools have been brought together in a single environment to produce some of the most powerful meshing available.

Fluent

ANSYS Fluent software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications ranging from air flow over an aircraft wing to combustion in a furnace, from bubble columns to oil platforms, from blood flow to semiconductor manufacturing, and from clean room design to wastewater treatment plants. Special models that give the software the ability to model in-cylinder combustion, aero-acoustics, turbo-machinery, and multiphase systems have served to broaden its reach.

VI. RESULT

- It is evident from the results that there is improvement in the efficiency value in both the methods, theoretical and analysis, adopted. The improvement in theoretical value is completely governed by the exit blade angle of the impeller.

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Vol. 6, Issue 3, March 2017

- There is 3% approximately improvement through theoretical calculation. Also by analysis method using fluent the pump discharge capacity is calculated and the results of the analysis shows the improvement in the discharge value.
- The discharge value of the existing impeller model is 0.60045 Kg/s (0.81215 l/s) and that of the new impeller model is 0.65267 kg/s (0.88278 l/s).
- Both the results in favour of the re-design impeller it is therefore recommended to the company to go for production based on the newly designed model of impeller.

VII. CONCLUSION

The modeling of the impeller is one critical parameter that should be the prime concern when considering the efficiency of the pump. Submersible pumps are used in clear water, sewage water and also in seas. Considering all these factors we need to model an impeller in a more practical way to suit to all these conditions. Not only is the angle of the blade that determines the output but also the height of the blade in a closed type radial flow impeller a parameter to be kept in mind. However there also other parameters but they have a minor impact on the pump efficiency. The software used are Pro-e and Ansys for modeling and analysis respectively. After completing the modeling and analysis the theoretical value of the pump efficiency is also calculated considering all the parameters.

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