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Full Length Article

Design and Analysis of Mixed Flow Pump Impeller

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ABSTRACT: Centrifugal pumps are used extensively for pumping water over short to medium distance through pipeline where the requirements of head and discharge are moderate. This project is devoted to enhance the performance of the centrifugal pump through design modification of impeller. Theories on pump characteristics are studied in detail. Vane profile of the impeller is generated using point by point method. The impeller is modeled in Solid works 2012 software and CFD analysis is done using fluid flow simulation package. CFD analysis enables to predict the performance of the pump and a comparative analysis is made for the entire control volume by varying meshing Pump impeller models have been developed for critical design parameters of the pump. CFD analysis is done in the models to predict the pump performance virtually. Experimental analysis is to be carried out during the second phase of the project work..
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Keywords: Solution growth; powder X-ray diffraction; nonlinear optics.

1 Introduction

A pump is a mechanical device for moving a fluid from a lower to a higher location, or from a lower to a higher pressure area. Mechanical energy is given to the pump and it is then converted into hydraulic energy of fluid. Pumps produce negative pressure at the pressure at the inlet so that the atmospheric pressure pushes the fluid towards the pump. The fluid coming into the pump is pushed the towards the outlet mechanically where positive pressure is generated. The Centrifugal pumps are the most popular pump used and are the chief pump type in the class of kinetic pumps, Used in various sectors such as: agriculture, power generation plants, municipal, industries, domestic purposes, etc., Common uses include: air, water, sewage, and petroleum, petrochemical pumping. Many researches are going on in the field of centrifugal pump to improve the performance and to reduce the losses, such as turbulence loss, Shock losses, impeller friction losses, Volute friction losses, disk friction losses and recirculation losses and also power consumption. Experimental investigations are generally carried out on pumps which are expensive, time consuming and limited to some extent. To reduce the number of experimental works, virtual analysis can be carried out on different pump models with the use of CFD packages and pump performance can be predicted. Types of centrifugal pump Centrifugal pumps are most often associated with the radial flow types. However, the terms Centrifugal Pumps can be used to describe all impeller type rotodynamic pumps including the radial, axial and mixed flow variations. A pump is a device used to move liquids by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. A wide variety of pump types have been constructed and used in many different applications in industry. Pumps must have a mechanism which operates them, and consume energy to perform mechanical work by moving the fluid. Pumps are classified in number of the ways according to their purpose, specifications, design, environment etc.

1.1. Radial Flow Pumps

These pumps are often simply referred to as centrifugal pumps. The fluid enters along the axial plane, is accelerated by the impeller and exists at right angles to the shaft (radially).Radial flow pumps operate at higher pressures and lower flow rates than axial and mixed flow pumps.

The radial flow pumps, by its principle, are converse of the Francis turbine. The flow is radially outward, and the hence the fluid gains in centrifugal head while flowing through it. Because of certain inherent advantages, such as compactness, smooth and uniform flow, low initial cost and high efficiency even at low heads, centrifugal pumps are pumps are used in almost all pumping systems.

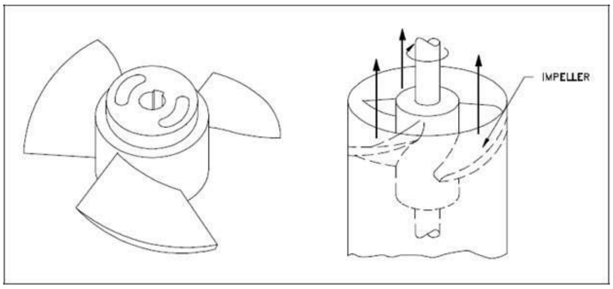

Fig 1.1.1.Radial flow pump

1.2. Axial flow pumps

Axial flow pumps differ from radial flow in that the fluid enters and exits along the same direction parallel to the rotational shaft. The fluid is not accelerated but instead — lifted by the action of the impeller. They may be linked to a propeller spinning in the length of the tube. Axial flow pumps operate at much low pressures and higher flow rates that radial flow pumps.

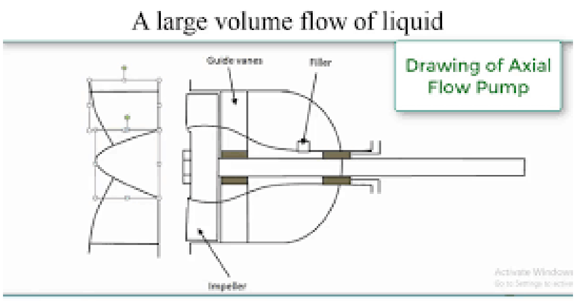

Fig 1.2.1.Axial flow pump

1.3. Mixed flow pumps

Mixed flow pumps, as the name suggests, function as a compromise between radial and axial flow pumps, the fluid experiences both radial acceleration and lift and exists the impeller somewhere between 0-90 degrees from the axial direction. As a consequence mixed flow pumps operate at high pressure than axial flow pumps while delivering higher discharges than radial flow pumps.

The exit angle of the flow dictates the pressure head discharge characteristic in relation to radial and mixed flow.

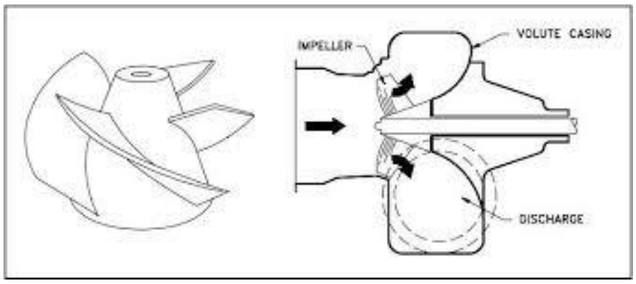

Fig 1.3.1 Mixed flow pump

2. MATERIAL DESCRIPTION

Table 1 Physical properties

Phase at STP	solid
Melting point	300 °C (**540 °F**)
Boiling point	2743 K (2470 °C, 4478 °F)
Density (near r.t.)	7.874 g/cm^3
when liquid (at m.p.)	7.63 g/cm^3

Table 2 Other properties

Natural occurrence	primordial
Crystal structure	body-centered cubic (bcc)
Speed of sound	(rolled) 5130 m/s (at r.t.)
Thermal expansion	12.5 µm/(m·K) (at 25 °C)
Thermal conductivity	79.5 W/(m K)
Young's modulus	120.5 G Pa
Shear modulus	46.34 G Pa
Bulk modulus	76 G Pa
Poisson ratio	0.35
Mohs hardness	4.5

Vickers hardness	246 M Pa
Brinell hardness	415 M Pa
CAS Number	7439-89-6

3. Modelling

3.1. Introduction of CAD/CAM

CAD/CAM is a term which means computer-aided design and computer-aided manufacturing. It is the technology concerned with the use of digital computers to perform certain functions in design and production. This technology is moving in the direction of greater integration of design and manufacturing, two activities which have traditionally been treated as district and separate functions in a production firm. Ultimately, CAD/CAM will provide the technology base for the computer-integrated factory of the future.

Computer – aided design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. The computer systems consist of the hardware and software to perform the specialized design functions required by the user firm. The CAD hardware typically includes the computer, one or more graphics display terminals, keyboards, and other peripheral equipment.

The CAD software consists of the computer programs to implement computer graphics on the system plus application programs to facilitate the engineering functions of the user company. Examples of these application programs include stress-strain analysis of components, dynamic response of mechanisms, heat-transfer calculations, and numerical control part programming. Computer-aided manufacturing (CAM) can be defined as the use of computer systems to plan, manage, and control the operations of manufacturing plant through either direct or indirect computer interface with the plant's production resources.

3.2 The Design Process

The process of designing is characterized by six identifiable steps or phase

1. Recognition of need
2. Definition of problem
3. Analysis and optimization
4. Evaluation
5. Presentation
6. Synthesis

3.3 Application of Computers For Design

The various design-related tasks which are performed by a modern computer-aided design system can be grouped into four functional areas:

1. Geometric modelling
2. Engineering analysis
3. Design review and evaluation
4. Automated drafting

3.4 Geometric Modeling

In computer-aided design, geometric modeling is concerned with the computer-compatible mathematical description of the geometry of an object. The mathematical description allows the image of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by the computer and the human designer.

There are several different methods of representing the object in geometric modeling. The basic form uses wire frames to represent the object. Wire frame geometric modeling is classified into three types, depending on the capabilities of the interactive computer graphics system.

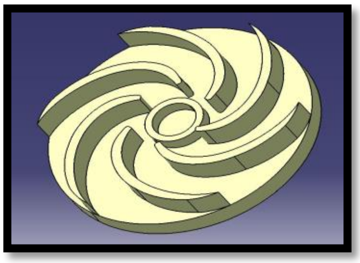

Fig 3.4.1.Impeller

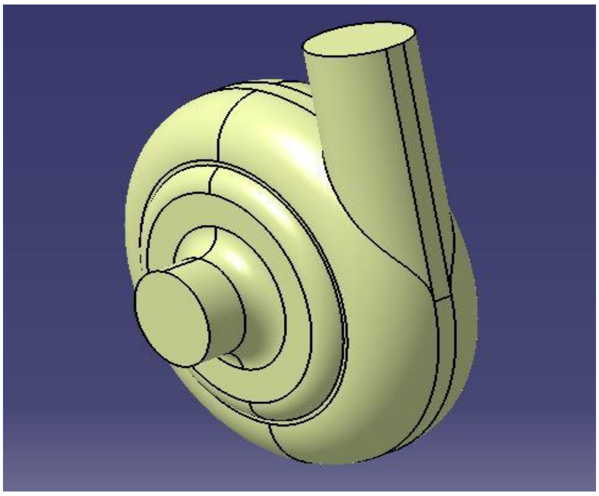

Fig 3.4.2.Centrifugal pump

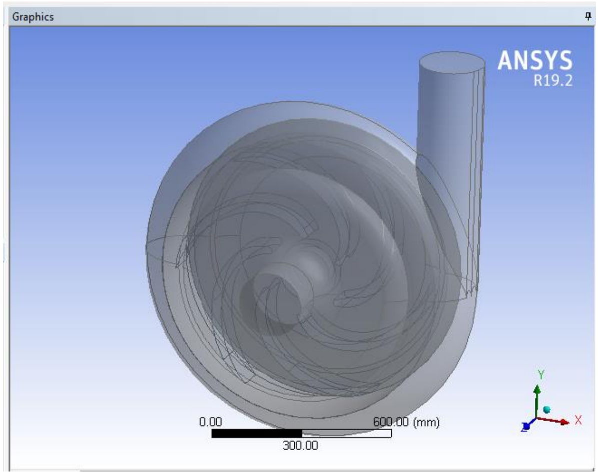

Fig 3.4.3.Pump with impeller

4. Analysis

4.1 Introduction of FEM

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses variation methods (the calculus of variations) to minimize an error function and produce a stable solution. FEM encompasses all the methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain.

The subdivision of a whole domain into simpler parts has several advantages:

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution
- Capture of local effects

4.2 Meshing

Meshing is done using triangular element. Meshing is the process of dividing a component or a product design into finite elements for the mathematical calculations. It can be minimum or maximum based upon the requirements of the result accuracy r the type of result.

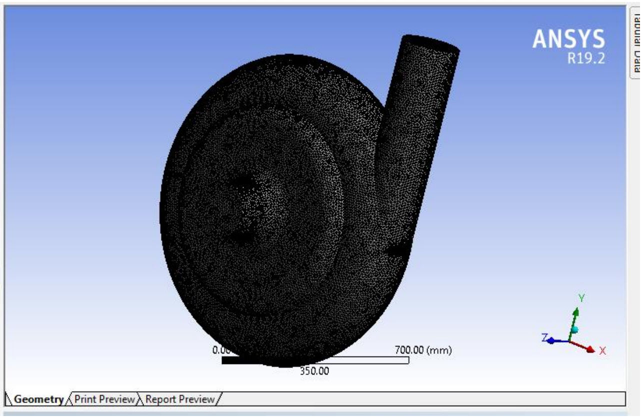

Fig 4.2.1.Meshing

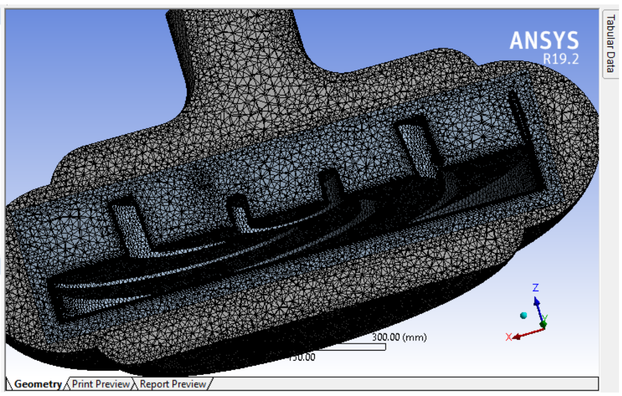

Fig 4.2.2.Interior Meshing

5. Results

Using the optimum element size, the analysis of impeller blades has been done for the angle of less than ninety degree and greater than ninety degree. By comparison of these results forward curved blades (>90^0) has more efficiency in both velocity and pressure analysis

Table 3 Comparison of Velocity and Pressure Rate of Different Configuration

	Blades ($>90^0$)	Blades ($<90^0$)_
Velocity stream line (m/s)	60	53.5
Pressure contour (pa)	1.15×10^6	1.61×10^5

6. Conclusion

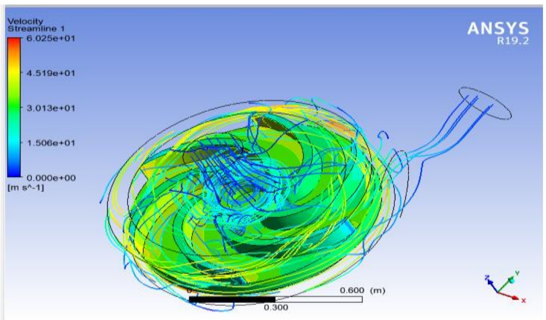

Fig 5.1 Velocity streamline of centrifugal pump impeller

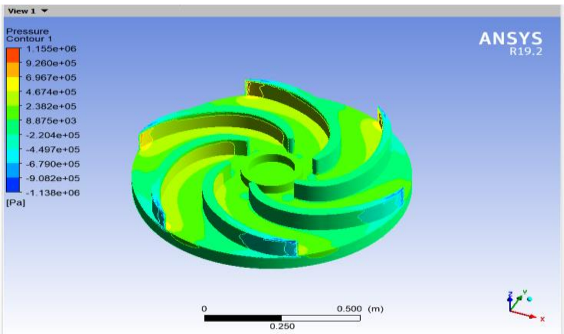

Fig 5.2 Pressure Contour of Impeller Blades

It is concluded that forward curved blades ($<90^0$) have more efficiency with increase in pressure and velocity while compared with backward curved blades ($>90^0$) and in future the impeller efficiency has been increased in many ways by increasing number of blades, changing van angles etc.., A prominent information from the literature is that only a little attention has been given to a detailed investigation on the pump performance of a multistage mixed-flow submersible pump while considering the axial gap.

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