ISSN:2348-2079

Volume-6 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Design and Fabrication of Radial Flow High Head Impeller in Submersible Pump

M.K.Murthi[1], R.Bhuvaneshwaran[2], S.Karthik[2], K.Manikandan[2], K.Manivasagam[2]
[1]Professor,[2]UG Students
Department of Mechanical Engineering, Nandha Engineering College, Erode-52, Tamil Nadu, India.
murthi.kannusamy@nandhaengg.org[1], manikandanmoorthi05@gmail.com[2]

***Abstract*—The objective of this project is to increase the delivery head of the existing pump by incorporating modifications in the impeller design without altering the existing power consumption. Typical submersible pump used in the industry has 20 stages and it operates with an input power of 7.5HP. For drought hit zone water cannot obtained with at a depth of 210 metres. The present available model of the impeller is thoroughly studied and analysed. Tests are conducted on the present models and reports are generated. With the help of velocity triangles diagram it is found by changing the design of the impeller by reducing the impeller width, the flow decreases which in turn increases the head. Also when number of blades is increased from 4 to 5 pressures is increased. By implementing the above concept and proceeding with the calculations and experiments it is found that the delivery head of the pump is increased.**

***Index and Terms*—Eletricmotor,Pump,Submersible pump,Forging,Ansys software analysis.**

I. INTRODUCTION

A 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.

II. LITERATURE SURVEY

E.C. Bacharoudis, A.E Filios, M.D. Mentzos, D.P. Margarispresentedthe influence of the outlet blade angle the performance with the help of CFD.

He studied that as the outlet blade angle increases the performance curve becomes smoother

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%, when outlet blade angle increases from 20° to 50°.

A studied 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 **η**= 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. Swap nil Urankar, Dr. H S Shivashankar, Sourabh Gupta had presented the impeller and volute designed by Walter K Jekat method and error triangle method, which was modified during this work by taking 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 m^3/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. S.Rajendran and Dr. K. Purushothaman presented the work that describes the simulation of flow in the impeller of a centrifugal pump having head H = 10m and discharge Q = 0.0125 m^3/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 also 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.

Mitul G. Patel, SubhedarDattatraya, Bharat J. Patel carried out the analysis of the impeller used in the mixed flow submersible pump. Fluid flow (CFX) was 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 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.PROBLEM IDENTIFICATION

Due to increasing drought conditionthe existing pump is not capable to water pump for there require head.

IV.METHODOLOGY

The problem found is that the delivery head of the submersible pump is very low and the objective is to increase the delivery head of the pump. So we took various literature survey on submersible pump and their delivery heads. We studied velocity triangle diagram and every parameters of the impeller.

Finally we came to know that if we make design modifications on the impeller and if we increase the number of blades from 4 to 5, the delivery head of the submersible pump can be increased.Design calculations for the 5 blade impeller are calculated then we designed the impeller using CREO software and analyzed using ANSYS. From the analysis result we came to know that there is a increase in the delivery head of the pump and rate of increase of head is also known. Then the design is fabricated using stainless steel material by the method of casting.

V. COMPONENTS

Electric motor

An electric motor is an electric machine that converts electrical energy into mechanical energy.

Pump

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluiddirect lift, displacement, and gravity pumps.Pumps operatege and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources include manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

Single stage pump – When a casing contains only one revolving impeller, it is called a single stage pump.

Double/multi-stage pump – When a casing contains two or more revolving impellers, it is called a double or multi-stage pump.In biology, many different types of chemical and bio-mechanical pumps have evolved, is sometimes used in developing new types of mechanical pumps.Mechanical pumps may be submerged in the fluid they are pumping or be placed external to the fluid.Pumps can be classified by their method of displacement into positive displacement pumps, impulse pumps, velocity pumps, gravity pumps, steam pumps and valve less pumps.

Submersible pump

Submersible pump is centrifugal type of pump which pumps out water from the bored hole or well. The pump is coupled with an electric motor. The shape of the pump and motor is cylindrical which makes it easy to be fitted in drilled bore in the earth. The pump remains dipped in water due to which there will not be any suction trouble. Submersible pump is used for continuous discharge of water in quantity as well as for high heads.A submersible pump (or sub pump, electric submersible pump (ESP)) is a device which has a 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 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.Submersible pumps are found in many applications. Single stage pumps are used for drainage, sewage pumping, general industrial pumping and slurry pumping. They are also popular with pond filters. Multiple stage submersible pumps are typically lowered down a borehole and most typically used for residential, commercial, municipal and industrial w, water wells and in oil wells.Other uses for submersible pumps include sewage treatment plants, seawater handling, fire fighting (since it is flame retardant cable), water well and deep well drilling, offshore drilling rigs, artificial lifts, mine dewatering, and irrigationsystems.Pumps in electrical hazardous locations used for combustible liquids or for water that may be contaminated with combustible liquids must be designed not to ignite the liquid or vapors.

Fig.1submersible pump

Radial flow

A radial flow pump is a centrifugal pump where the fluid being pumped is discharged radially i.e. at right angles to the pump shaft. Radial flow pumps are CP’s standard and required in most applications.centrifugal pump is a rotordynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially. Outwards into a diffuser or volute chamber, from where it exits into the downstream piping system. In contrast to axial flow pumps, in which the fluid exits the pump axially, the flow deflections in the impellers of radial flow pumps generate higher centrifugal forces. This results in higher heads but also lower flow rates in radial flow pumps.Centrifugal pumps work by converting kinetic energy into potential energy measurable as static fluid pressure at the outlet of the pump. This action is described by Bernoulli's principle. With the mechanical action of an electric motor or similar, the rotation of the pump impeller imparts kinetic energy to the fluid through centrifugal force. The fluid is drawn from the inlet piping into the impeller intake eye and is accelerated outwards through the impeller vanes to the volute and outlet piping. As the fluid exits the impeller, if the outlet piping is too high to allow flow, the fluid kinetic energy is converted into static pressure. If the outlet piping is open at a lower level, the fluid will be released at greater speed.Compared to an axial flow turbine a radial turbine can employ a relatively higher pressure ratio per stage with lower flow rates. Thus these machines fall in the lower specific speed and power ranges. For high temperature applications rotor blade cooling in radial stages is not as easy as in axial turbine stages. Variable angle nozzle blades can give higher stage efficiencies in a radial turbine stage even at off-design point operation. In the family of hydro-turbines, Francis turbine is a very well-known IFR turbine which generates much larger power with a relatively large impeller.

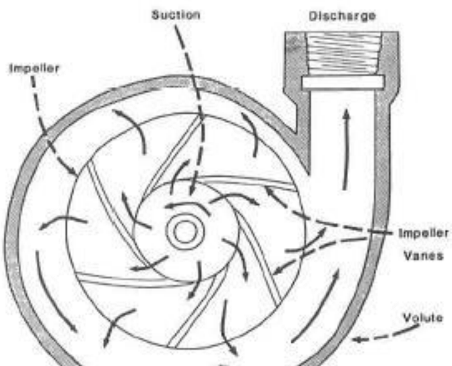

Fig.2 Impeller

Shaft

The major inertia force is due to the force acting on the turbine shaft due to the revolution of its mass center and around its geometrical center constitutes. A restoring force equivalent to a spring force for small displacements, and viscous forces between the gas and the shaft surface, act as spring and damper to the rotating system. The film stiffness depends on the relative position of the shaft with respect to the bearing and is symmetrical with the center-to-center vector. In order to eliminate the need for a heavily loaded thrust bearing,Winterbone has suggested that the diameter of the shaft be made the same as the diameter of the turbine wheel. Shaft speed is limited by the first critical speed in bending . This limitation for a given diameter determines the shaft length, and the overhang distance into the cold end, which strongly affects the conductive heat leak penalty to the cold end. In practice, particularly in small and medium size turbines, the bending critical speeds are for above the operating speeds. On the other hand, rigid body vibrations lead to resonance at lower speeds, the frequencies being determined by bearing stiffness and rotor inertia. The important criteria in choosing the material for shaft are: .The critical frequency should be greater than the operating frequency so as to avoid damage. The stress calculated over the surface should be less than the yield stress of the material chosen. The material of the shaft is 410 stainless steel or K-monel. Stainless steel 410 which was chosen because of its desirable combination of low thermal conductivity and high .

Fig.3 Blade

Casting

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods.Casting process simulation uses numerical methods to calculate cast component quality considering mold filling, solidification and cooling, and provides a quantitative prediction of casting mechanical properties, thermal stresses and distortion. Simulation accurately describes a cast component's quality up-front before production starts. The casting rigging can be designed with respect to the required component properties. This has benefits beyond a reduction in pre-production sampling, as the precise layout of the complete casting system also leads to energy, material, and tooling savings.The software supports the user in component design, the determination of melting practice and casting methoding through to pattern and mold making, heat treatment, and finishing. This saves costs along the entire casting manufacturing route.

- Molten metal before casting.
- Casting iron in a sand mold.
- An investment-cast valve cover

VI.WORKING PRINCIPLE

The submersible pumps used in ESP installations are multistage centrifugal pumps operating in a vertical position. Although their constructional and operational features underwent a continuous evolution over the years, their basic operational principle remained the same. Produced liquids, after being subjected to great centrifugal forces caused by the high rotational speed of theimpeller, lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. This is the main operational mechanism of radial and mixed flow pumps.The pump shaft is connected to the gas separator or the protector by a mechanical coupling at the bottom of the pump. Well fluids enter the pump through an intake screen and are lifted by the pump stages. Other parts include the radial bearings (bushings) distributed along the length of the shaft providing radial support to the pump shaft turning at high rotational speeds. An optional thrust bearing takes up part of the axial forces arising in the pump but most of those forces are absorbed by the protector's thrust bearing.

Impeller

An impeller is a rotating component of a centrifugal pump which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. The velocity achieved by the impeller transfers into pressure when the outward movement of the fluid is confined by the pump casing. Impellers are usually short cylinders with an open inlet (called an eye) to accept incoming fluid, vanes to push the fluid radially, and a splined, keyed, or threaded bore to accept a drive-shaft.The impeller made out of cast material in many cases may be called rotor, also. It is cheaper to cast the radial impeller right in the support it is fitted on, which is put in motion by the gearbox from an electric motor.

Forging

Forging is a manufacturing process involving the shaping of metal usinglocalized compressive forces. The blows are delivered with a hammer (often a power hammer) or a die. Forging is often classified according to the temperature at which it is performed: cold forging (a type of cold working), warm forging, or hot forging (a type of hot working). For the latter two, the metal is heated, usually in a forge. Forged parts can range in weight from less than a kilogram to hundreds of metric tons. Forging has been done by smiths for millennia; the traditional products were kitchenware, hardware, hand usedtools, edgedweapons, cymbals, and jeweler. Since the Industrial Revolution, forged parts are widely used in mechanisms and machineswherever a component requires high strength; such forgings usually require further processing (such as machining) to achieve a finished part. Today, forging is a major worldwide industry.

VII.RESULTS AND DISCUSSIONS

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries.Thus we have developed a “RADIAL FLOW HIGH HEAD IMPELLER” which helps build an efficient. By using more techniques, they can be modified and developed according to the applications. This is just a prototype of our project which can be tested for real life vehicle and can be readily implemented in automobiles and other applications.

VI.CONCLUSION

Pump impeller has high weight as use of existing material as compare to different alloy and composite material. Strength of pump impeller is less due to less stiffness of existing material as compare to different alloy and composite material. The material is selected based on the product application and manufacturing feasibility. FEA is conducted in order to verify the material behaviour under static loading condition.

REFERENCES

[1] [1"Electrical Submersible Pump Analysis and Design" by Weather. Ford published on 30th may 2001.
[2] "ESP Hand book English Ninth Edition by Baker Huges.
[3] Electrical Submersible Pumps Manual, Design, Operation and Maintenance by Gabor Takacs.
[4] Fundamental of Electrical Submersible Pumping in oil well by A.W. Grupping Delft U. of Technology.
[5] Electrical Submersible Pump by W.J.Powers, TRW Reda Pump Division.
[6] Other forms of Artificial lift include Gas lift, Beam Pumping in Plunger lift and Progressive Cavity Pump.
[7] Shapiro, A. H., The Dynamics and Thermodynamics of Compressible Fluid flow - (Vol I and II), Ronald Press, New York, 1953.
[8] Gopalakrishnan, G. and Prithvi Raj, D., Treatise on Turbo Machines, Scitech Publications, Chennai, 2002.
[9] Dixon, S. L., Fluid Mechanics and Thermodynamics of Turbo Machinery, Pergomen Publications, 1998
[10] Yahya, S. M., Turbines, Fans and Compressors, Tata McGraw Hill Publications, New Delhi, 1996.
[11] Larry Bachus and Angel Custodio. 2003. Known and Understand Centrifugal Pump.Japan: Bachus Company. Tokyo 113.
[12] Igor, J., Joseph, P., and Charles, C. 2001. Pump Hand Book.USA: McGraw-Hill Company.
[13] KhinMaung Aye, U. December. 2000. Fluid Machinery for Mechanical Engineering.
[14] Kyshu Institute of Technology. 1996. Fluid Mechanics of Turbomachinery. Kyshu Institute of Technology

[15] Ing.F-K.Berna, Dr. No Date. Measurement of the Characteristic of Centrifugal Pump.Faculty of Engineering Sciences, University Duisburg-Essen.

[16] Tuzson, J. 2000. Centrifugal Pump Design. USA: John Wiley and Sons. Inc.

[17] Stepanoff, A.J, 1957, Centrifugal and Axial Flow Pumps.

[18] Austin. H. Church. 1972. Centrifugal Pump and Blowers. New York: John Wiley and Sons, Inc. [9] William. L. Amminger., and Howard. M. Bernbaum.1973. “Centrifugal Pump Performance Prediction”.

[19] Herbert Addison. 1995. Centrifugal and Other Rotodynamic Pumps. Chapan and Hall.Ltd.

[20] Nemdili, A., and Hellmann, H. 2007. “Investigations on Fluid Friction of Rotational Disk in Real Centrifugal Pump”.

[21] Sam Yedidiah, No Date. Centrifugal Pump User’s Guide Book. an International Thomson Publishing.

[22] Hiroshi Satoh, No Date. Designing an Ultra-Low Specific Speed Pump.Sanso Electric co. Ltd.

[23] Daugherty, L. 1915. Centrifugal Pumps. McGraw-Hill Book Company. Fnc.

[24] Frank, A. 1953. Pumps.2^nd Edition.McGraw-Hill.

[25] Karassik., and Roy Carter, J. 1960. Centrifugal Pump Selection, Operation and Maintenance. McGraw-Hill Book Company.