

DESIGN AND ANALYSIS OF MULTISTAGE CENTRIFUGAL PUMP

Mr. Karan G. Patel

Department of Mechanical Engineering
Smt. S. R. Patel Engineering College, Dabhi, Unjha

ABSTRACT: *The Flow analysis inside the centrifugal pump is highly complex. Mainly, due to 3D flow structure involving turbulence, secondary flow, cavitation's and unsteadiness. The blade number of impeller is important in design parameter of pump which affects the characteristics of pump heavily at present. The investigation focused mostly on the performance characteristics of vertical flow pump. The influence of blade number on inner filed. This experimental CFD research made it possible to undertake an assignment of rotor contribution on the head of centrifugal pump. After modifying the design, the pressure head or flow rate will be increased.*

Keyword: Centrifugal Pump

I. INTRODUCTION

According to Reti, the first machine that could be characterized as a centrifugal pump was a mud lifting machine which appeared as early as 1475 in a treatise by the Italian Renaissance engineer Francesco di Giorgio Martini. True centrifugal pumps were not developed until the late 17th century, when Denis Papin built one using straight vanes. The curved vane was introduced by British inventor John Appold in 1851. Vertical centrifugal pumps are also referred to as cantilever pumps. They utilize a unique shaft and bearing support configuration that allows the volute to hang in the sump while the bearings are outside the sump. This style of pump uses no stuffing box to seal the shaft but instead utilizes a "throttle bushing". A common application for this style of pump is in a parts washer. A centrifugal pump containing two or more impellers is called a multistage centrifugal pump. The impellers may be mounted on the same shaft or on different shafts. For higher pressures at the outlet, impellers can be connected in series. For higher flow output, impellers can be connected parallel. A common application of the multistage centrifugal pump is the boiler feed water pump. For example, a 350 MW unit would require two feed pumps in parallel. Each feed pump is a multistage centrifugal pump producing 150 l/s at 21 MPa. All energy transferred to the fluid is derived from the mechanical energy driving the impeller. This can be measured at isentropic compression, resulting in a slight temperature increase (in addition to the pressure increase)

II. LITERATURE REVIEW

2.1 Pumps

The Pump is a mechanical device which conveys liquid from one place to another place. It can be defined as Hydraulic machines which converts the mechanical energy into hydraulic energy. The purpose of pumps may be increasing the pressure, imparting kinetic energy, lifting and circulating, exhausting or extracting liquids etc.

Pumps are used for various applications in various fields as follows:-

- (1) Thermal Engineering
 - To feed water in to boiler.
 - To circulate water in condenser.
 - To circulate lubricating oil in the proper place in various machines.
- (2) Agriculture and Irrigation
 - To lift water from deep well.
 - To convey water from one place to another.
- (3) Chemical Industries
 - To convey chemical liquid from one place to another place.
- (4) Municipal Water works and draining system:-
- (5) Hydraulic control system:-

2.2 Pump Types:-

The pump may be categorized according to principle by which the energy added to the fluid and their design features as follows:

- (1) Positive Displacement Pump:- These pumps operate on the principle of a definite quantity of liquid is discharged or displaced due to the positive or real displacement of working element. The positive displacement pump can be classified as follows:
 - (i) Reciprocating Pump:-
 - (a) Piston Pumps:-
 - Single cylinder single acting or double acting.
 - Double cylinder single acting or double acting.
 - (b) Plunger Pump
 - (c) Bucket Pump-Hand Pump
 - (ii) Rotary Pump:-
 - (a) Gear Pump
 - (b) Vane/Lobe Pump
 - (c) Screw Pump
 - (2) Roto-Dynamic Pump: - These pumps operate on the principle of the rise in pressure energy of liquid by dynamic action of liquid. This action is carried out by revolving wheel which has curved vanes on it known as Impeller. Classification of Roto Dynamic Pump is as follows:
 - (i) Radial Flow Pump – Centrifugal Pump:-
 - (a) Single Stage
 - (b) Multi Stage
 - In this pump, addition of energy to the liquid occurs when the flow of liquid in its radial path.
 - (ii) Axial Flow Pump: - In this pump, addition of energy to the liquid occurs when the flow of liquid in axial direction.
 - (iii) Mixed Flow Pump: - In this pump, addition of energy to the liquid occurs when the flow of liquid in axial as well as radial directions.

(iv) Other Type of pump:- This types of pumps does not belongs to the category of positive displacement or rotodynamic type pumps as follows:

- (a) Jet pump
- (b) Air Lift Pump

2.3 Different sections of a Pump:-

A centrifugal pump consists of different parts like impeller, casing, suction pipe with foot valve and strainer, and delivery pipe and valves.

(1) Impeller: - It is rotating element of centrifugal pump which consists of finite number of backward curved vanes. The number of vanes normally 6 to 12 in the impeller. The Impeller is mounted on a shaft which is coupled with shaft of electric motor. In impeller the kinetic energy of liquid is increased.

(2) Casing: - It is an air tight passage surrounding the impeller and is designed in such a way that the kinetic energy of liquid coming from impeller is converted into pressure energy before the delivery pipe. Casing is useful for effective conversion of kinetic energy of water coming out of the impeller into pressure.

(3) Suction Pipe with Foot Valve and Strainer:-

Suction Pipe: - It is pipe whose one end is connected to the inlet of the pump and other end dips in to water in a liquid sump.

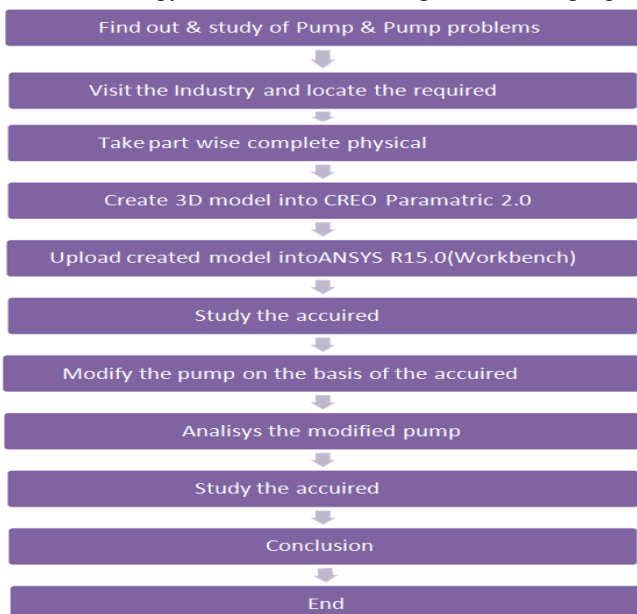
Foot Valve: - It is a non-return valve is essentially for all types of rotodynamic pumps. It helps in allowing the liquid to enter into pump in upward direction only and does not allow the liquid to move downwards.

Strainer: - The strainer is essential for all types of pumps. It protects the pump against foreign material passes through the pump, without strainer pump may be chocked.

(4) Delivery Pipe:- A pipe whose one end is connected to the outlet of the pump and other end delivers the water at a required height is called delivery pipe.

III. METHODOLOGY

The methodology can be described using the following figure



IV. INTRODUCTION OF PARTS

List of Parts

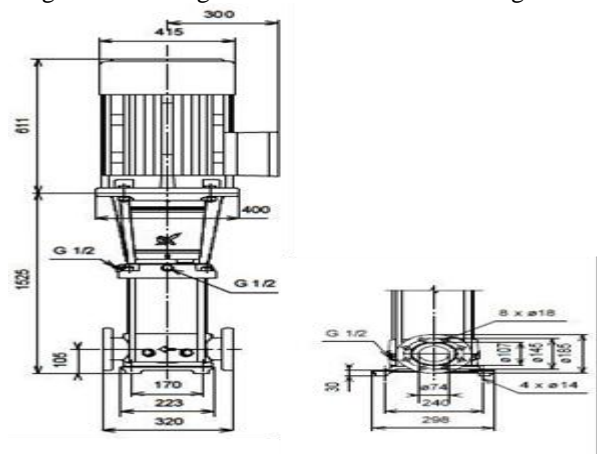
- Impeller
 - i) Split Cone Nut
 - ii) Sleeve
 - iii) Wear Ring
- Chamber (Casing)
 - i) Neck Ring
 - ii) Neck Ring Retainer
 - iii) Neck ring Complete
 - iv) Inlet Part Complete
 - v) Bush
 - vi) Retaining Ring
- Bearing
 - i) Bearing Rotating
- Shaft
 - i) Washer
 - ii) Lock Nut
 - iii) Lock Washer
- Base
 - i) Suction
 - ii) Discharge
 - iii) Pump Head
 - iv) O- Ring
 - v) Drain Plug
 - vi) O- Ring
 - vii) Plug
 - viii)Screw & Washer

V. CFD WORK

- CFD Simulation procedures for the PAT in the Analysis presents here. It would be particularly helpful for modifying or improving the existing designs of the PAT.
- Simulation facilitated to reduce cost and time of the experiment. If once PAT is simulated.
- Then it would be easy to check the performance of the PAT at any condition. Estimating the simulated performance of a PAT is an indispensable tool in design.

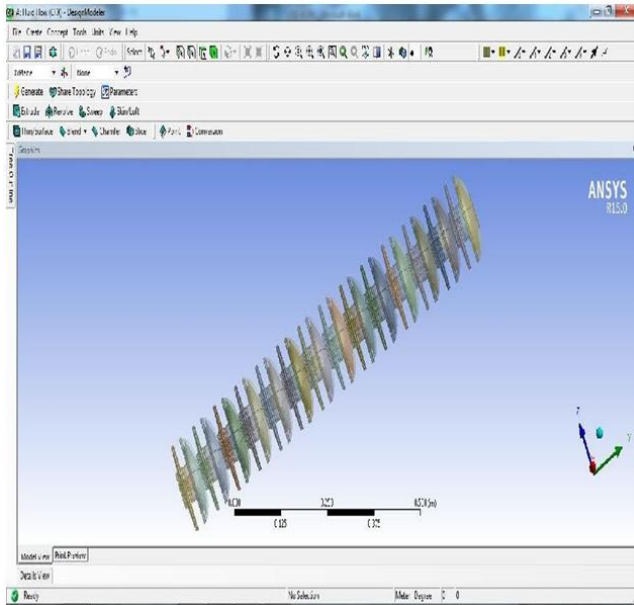
Generation of PAT Models

- PAT model is generated with commercial available modeling software PRO- ENGINEER. 2.0 (CREO 2.0)
- PATs generated using this software is shown in Fig



Generation of Fluid Model

- Fluid model is considered for numerical solution. Fluid model is having different topology compared to actual model.
- In fluid model area of interest for numerical study is only working domain of fluid.
- This fluid model is generated using software ANSYS 15.0. Fluid model for both PATs are generated using same method



VI. EFFICIENCY CALCULATIONS

Here main Three type of efficiency and here we can ignore of the lockage of liquid in the pump.

Mechanical efficiency (η_m):-

$$\eta_m = \rho(Q+q) \times (Vw2xu2)/P$$

$$= 1000 \times (0.014) \times (8.25 \times 16.74) / (4.5 \times 1000)$$

$$= 0.25575$$

$$= 25.575 \%$$

Manometric efficiency (η_{mano}):-

$$\eta_{mano} = Hm/Hi$$

$$= Hm/(Vw2xu2/g)$$

$$= gxHm/Vw2xu2$$

$$= (9.81 \times 15.14) / (10.33 \times 16.74)$$

$$= 0.8589$$

$$= 85.89\%$$

Volumetric Efficiency (η_v)

$$\eta_v = Q / (Q+q) \text{ (q=0)}$$

$$= 1$$

$$= 100\%$$

Overall efficiency (η_o):-

$$\eta_o = \rho g Q Hm / P$$

$$= (1000 \times 0.00834 \times 9.81 \times 15.14) / (45 \times 1000)$$

$$= 0.2750$$

$$= 27.50\%$$

VII. RESULTS

Comparison of Working Model and New Model

Working Model	New Changed Model
D1=0.06 m	D1=0.06 m
D2=0.108 m	D2=0.114 m
V=18.2857 m/s	V=26 m/s
P=30 bar	P=4.29 bar

Table 7.1: Comparison of Working Model and New Model

VIII. CONCLUSION

We change the outlet diameter of Impeller (from 108 mm to 114 mm), and then we get increment in velocity as per requirement of the boiler (from 18.2857 m/s to 26 m/s) in which the pump is utilized for its purpose is satisfied. Due to this, the Performance of boiler is increased

REFERENCES

- [1] Yvon Gardana, A methodology for a function-to-shape translation tool in foundry, aCMCAO/IFTS, 7 Boulevard Jean Delautre, 08000 Charleville-Mézières, France 2000.
- [2] Tycho K. Fredericks, "An ergonomic evaluation of a manual metal pouring operation", Department of Industrial and Manufacturing Engineering, Human Performance Institute, College of Engineering and Applied Sciences, Western Michigan University, Kalamazoo, MI 49008-5336, USA 2007.
- [3] J.C. Ferreira, Integration of reverse engineering and rapid tooling in foundry technology, Department of Mechanical Engineering, Instituto Superior Técnico, Av. Rovisco Pais, P-1049-001 Lisbon, Portugal 2002.
- [4] Ken'ichi Yano, Motion control of liquid container considering an inclined transfer path, Department of Production Systems Engineering, Toyohashi University of Technology, Hibarigaoka 1-1, Tempaku-cho, Toyohashi, 441-8580, Japan 2001.
- [5] Dr. Thoguluva Raghavan Vijayaram, FET Faculty (Engineering and Technology) MMU Multimedia University, Malaysia 2012.
- [6] Yoshiyuki Noda, Precision Analysis of Automatic Pouring Machines for the Casting Industry, Department of Production Systems Engineering, Toyohashi University of Technology 1-1 Hibarigaoka, Tempaku-cho, Toyohashi, Aichi 441-8580, Japan 2008.
- [7] Makoto Tsuji, Automation of Die Casting, Die Casting Machine Division, Toshiba Machine Co., Ltd. 4-29-1 Hibarigaoka, Zama-shi, Kanagawa 228-0003, Japan 2008.
- [8] Rhythm-Wadhwa, Electromagnet Gripping in Iron Foundry Automation Part I: Principles and Framework, Department of Production and Quality Engineering, NTNU Trondheim, 7051, Norway 2007.
- [9] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:1, pp. 5-6

- [10] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:1, pp. 6-7
- [11] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:1, pp. 7
- [12] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:1, pp. 7-9
- [13] NoopurEnterprise, Manufacturer of all grade of ferrous metals, www.nainitagroup.com
- [14] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:2, pp. 46-47
- [15] R. K. Jain, Production technology, 2009, 17th Edition, Ch:3, pp. 85
- [16] S.K. Hajra Chaudhary, Elements of workshop technology, vol:1, 2007, 14th Edition, Ch:11, pp. 307
- [17] P. L. Jain, Principles of foundry technology, 2003, 4th Edition, Ch: 2, pp. 6-15
- [18] P. N. Rao, Manufacturing technology, vol:1, 2010, 3rd Edition, Ch:3, pp; 60-66
- [19] S.K. Hajra Chaudhary, Elements of workshop technology, vol:1, 2007, 14th Edition, Ch:11, pp. 322
- [20] T. V. RamanaRao, Metal casting, 1996, 1st Edition, Ch:2, pp. 21-26
- [21] R. K. Jain, Production technology, 2009, 17th Edition, Ch:3, pp. 91
- [22] A. K. Chakrabarti, Casting technology & cast alloys, 2005, Ch:2, pp. 6
- [23] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:9, pp. 152-153
- [24] P. N. Rao, Manufacturing technology, vol:1, 2010, 3rd Edition, Ch:4, pp. 117-128
- [25] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:11, pp. 220-234
- [26] Dr. O. P. Khanna, A Text book of foundry technology, 1996, Ch:12, pp. 238
- [27] Electronic circuit by millman j. & taub H. Tata McGraw Hill
- [28] J. S. Katre, A Basic Electronics Tech-max Publication, 2009, ch:4, pp.4-1 to 4-5
- [29] Digital Logic design by Morris Mano
- [30] J. S. Katre, A Basic Electronics Tech-max Publication, 2009, ch: 6, pp.6-2 to 6-10
- [31] R. B. Patil, Computer integrated manufacturing Tech-max Publication, 2009, ch: 2, pp.2-40 to 2-45