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Design and Performance Analysis of Centrifugal Pump

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ABSTRACT:

This paper deals with the design and performance analysis of centrifugal pump. In this paper, centrifugal pump is analyzed by using a single-stage end suction centrifugal pump. Two main components of a centrifugal pump are the impeller and the casing. The impeller is a rotating component and the casing is a stationary component. In centrifugal pump, water enters axially through the impeller eyes and water exits radially. The pump casing is to guide the liquid to the impeller, converts into pressure the high velocity kinetic energy of the flow from the impeller discharge and leads liquid away of the energy having imparted to the liquid comes from the volute casing. A design of centrifugal pump is carried out and analyzed to get the best performance point. The design and performance analysis of centrifugal pump are chosen because it is the most useful mechanical rotodynamic machine in fluid works which widely used in domestic, irrigation, industry, large plants and river water pumping system. Moreover, centrifugal pumps are produced by manufacturing processes in Myanmar

I. INTRODUCTION: Pumps are used in a wide range of industrial and residential applications. Pumping equipment is extremely diverse, varying in type, size, and materials of construction. There have been significant new developments in the area of pumping equipment. They are used to transfer liquids from low-pressure to high pressure in this system, the liquid would move in the opposite direction because of the pressure difference. Centrifugal pumps are widely used for irrigation, water supply plants, stream power plants, sewage, oil refineries, chemical plants, hydraulic power service, food processing factories and mines. Moreover, they are also used extensively Khin Cho Thin is with the Mandalay Technological University. Mandalay, Myanmar. Mya Mya Khaing, Associate Professor, is with Yangon Technological University. Khin Maung Aye, Professor, is with West Yangon Technological University. in the chemical industry because of their suitability in practically any service

and are mostly used in many applications such as water pumping project, domestic water raising, industrial waste water removal, raising water from tube wells to the fields. A centrifugal pump delivers useful energy to the fluid on pumpage largely through velocity changes that occur as this fluid flows through the impeller and the associated fixed passage ways of the pump. It is converting of mechanical energy to hydraulic energy of the handling fluid to get it to a required place or height by the centrifugal force of the impeller blade. The input power of centrifugal pump is the mechanical energy and such as electrical motor of the drive shaft driven by the prime mover or small engine. The output energy is hydraulic energy of the fluid being raised or carried. In a centrifugal pump, the liquid is forced by atmospheric or other pressure into a set of rotating vanes. A centrifugal pump consists of a set of rotation vanes enclosed within a housing or casing that is used to impart energy to a fluid through centrifugal force. A pump transfer mechanical energy from some external source to the liquid flowing through it and losses occur in any energy conversion process. The energy transferred is predicted by the Euler Equation. The energy transfer quantities are losses between fluid power and mechanical power of the impeller or runner. Thus, centrifugal pump may be taken losses of energy. The kinds of loss of centrifugal pumps can be differentiated in internal losses and external or mechanical losses. The internal loss is hydraulic losses or blade losses by friction, variations of the effective area or changes of direction losses of quantity at the sealing places between the impeller and housing at the rotary shaft seals. The external or mechanical loss is sliding surface losses by bearing friction or seal friction.

The subject of this thesis is design, construction and performance evaluation of a centrifugal pump to be used in a dishwasher, especially for Arçelik Inc. Dishwasher Plant. Not only laboratory experiments but also numerical experiments by means of Computational Fluid Dynamics (CFD) are to be conducted in order to approach the problem from two sides. Using CFD will provide the agent with save of time, money, and effort since the parameters which are included in hydraulic design can easily be manipulated and their effects can easily be investigated by this method. This thesis covers the issue within three main parts: theoretical design, numerical experimentation (CFD), and laboratory experimentation. In theoretical part, the desired pump is to be designed by using the basic empirical methods commonly used in

literature. In CFD part, theoretically obtained parameters are to be used to generate Computer-Aided Design (CAD) models. Then these models are to be tested under several conditions by using commercial CFD software. In the final part –laboratory experimentation part-, previously analyzed models (by CFD method) are to be prototyped and tested at the same conditions to validate the accuracy between numerical and actual tests.

1.2 Literature Survey

1.2.1 General Information on Dishwashers

"A dishwasher is a mechanical device for cleaning dishes and eating-utensils.", [1]. A domestic dishwasher operates according to the following principle: Dishes are loaded into the device manually. Upon starting any desired program, residual water from the previous operation is drained first by means of a drain pump. Then the dishwasher takes certain amount of water from the mains and fills a sump located at the bottom to collect washing water. Then a circulation pump takes water from the sump and delivers to spray arms, which are the main actuators of the cleaning action. The spray arms rotate with momentum supplied by the circulating water, and spray water towards the dishes. The water then passes through the filtration system located at the bottom center by means of gravitational force and reaches to the sump again. Circulation of washing water continues in this manner up to a certain time. When a washing step ends, soiled water is drained, [2]. There are mainly four steps in standard programs in which water circulation mentioned above takes place: pre-wash, main wash, cold rinse, and hot rinse. The last step of a dishwasher operation is the drying step, but water is not circulated here. In main wash step, detergent is added to solve the soil and to provide hygiene; whereas in rinsing steps, rinsing agent is added for superior drying performance. In main wash and rinsing steps, the water is heated for optimum detergent/rinsing agent activation, [2]. It is seen that, the circulation pump of a dishwasher is operated with water which is first clean, then soiled, then mixed with detergent and rinsing agent. This requires a suitable design which is flexible enough to withstand these condition changes. To summarize, a dishwasher takes water, circulates it to clean the dishes (according to the step, water is heated, mixed with detergent, and mixed with rinsing agent), drains the soiled water, and dries the dishes, [2]. Although there are a lot of detailed systems which play crucial roles, such as safety systems, water softening system, electronic control system and so on, only the

circulation system is mentioned up to here since this thesis covers only the design of its circulation pump.

1.2.2 General Information on Centrifugal Pumps

1.2.2.1 Classification of Pumps

It is better to start with the concept of "turbomachine" since a pump is a kind of this device. "Turbomachine is a device that exchanges energy with a fluid using continuously flowing fluid and rotating blades". A pump is a type of turbomachines which extracts energy from a liquid, [4]. Pumps are also classified into several types, but mainly into two: rotodynamic (or simply dynamic) pumps, where the fluid velocities within the pump are increased by continuous energy adding such that they exceed the values of discharge velocities resulting in pressure rise towards the outlet;

General Information on CFD

Although the experimental fluid dynamics have prospered for years, it is sometimes not possible to construct a test setup for every design study. This may be due to time considerations, economical reasons, space availability, and so on. Thus, an alternative branch of fluid dynamics to solve this problem is developed called computational fluid dynamics (CFD). It is a cost-effective way to simulate real flows numerically by solving related governing equations by means of advanced computers, [15]. Today, there are several commercial or open source CFD software, some of which are Fluent, CFX, SimulationCFD (CFdesign), OpenFOAM, Star-CD, Cradle, and so on. As cited in Fletcher (2006, p. 2), Chapman et al., Green, Rubbert, and Jameson point to the following major advantages of CFD compared to experimental approach in fluid dynamics, [15]:

- Reduction in lead time in design and development.
- Simulation opportunity of non-reproducible flow conditions in experimental method.
- Availability of more detailed and comprehensive information.
- Developing cost efficiency compared to wind-tunnel testing.
- Reduction in energy consumption.

Although there are a number of arguments about the first appearance of CFD, the history dates to mid-1900's. According to Wendt (2008, p. 6), the study of Kopal in 1947 can be counted as the first remarkable CFD example, [16].

CONCLUSION We show some looses of centrifugal pump with the values Q and H are determined for the various operating points. Centrifugal pumps are fluid-kinetic machines designed for power increase within a rotating impeller. In centrifugal

pumps, the delivery head depends on the flow rate. This relationship, also called pump performance, is illustrated by curves. To get characteristic curve of a centrifugal pump, values of theoretical head, slip, shock losses, recirculation losses and other friction losses are calculated by varying volume flow rate. In a today competitive and sophisticated technology, centrifugal pump is more widely used than any other applications because the advantages of following factors are effect on the centrifugal pump. 1. Its initial cost is low 2. Efficiency is high 3. Discharge is uniform and continuous flow 4. Installation and maintenance is easy. 5. It can run at high speeds without the risk of separation of flow. The performance analysis of centrifugal pump is also predicted in this paper. The impeller friction losses, volute friction losses and disk friction losses are considered to less the friction effect on centrifugal pump. Moreover, recirculation losses are also considered. And then, the actual performance curve of centrifugal pump is predicted obtained.

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