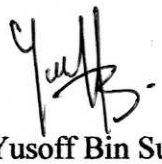
"I declare that I have read this thesis and in my opinion, it is sufficient in term of scope and quality for the award of the Bachelor Degree of Mechanical Engineering (Design And Innovation)

Signature : 

Supervisor : Dr Yusoff Bin Sulaiman

Date : 8 MEI 2007

STUDY AND IMPROVEMENT OF INDUSTRIAL PUMP IMPELLER DESIGN

RUDY IDZUAN SAMSUDDIN

A project report is submitted to the Faculty of Mechanical Engineering in partial fulfillment of the requirements for the award of the Bachelor Degree of Mechanical Engineering (Design And Innovation)

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

Date : 8 MEI 2007

I hereby declare that this thesis entitled **"STUDY AND IMPROVEMENT OF INDUSTRIAL PUMP IMPELLER DESIGN"** is the result of my own research except as cited in the references.

Signature : 

Name : RUDY IDZUAN SAMSUDDIN

Date : 8 MEI 2007

To my beloved family, Mohamad Faisal,Rohani Said,Kairil Idzuan and Daniel Adib,

Thank you for your support.

ACKNOWLEDGEMENT

The Projek Sarjana Muda's report would not have been successful without the support and cooperation accorded to me by the people that surround me. Therefore, would like to take this opportunity to express my sincere gratitude to those who have willingly helped me without failing to motivate me and give me many encouragements.

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I would like to express my appreciation to the staffs of UNIVERSITI TEKNIKAL MALAYSIA MELAKA – lecturers, technician and anyone whom I had to work for throughout my attachment in several projects and also to the non-technical people who had shown me the correct path and procedure in completing the project. Without their valuable input, it would have been tough for me to find the tune and the rhythm to be successful in completing this report.

Lastly, to all of my supportive friends who keep giving me support and keep being helpful in terms of material, supporting data, time etc. All of your help goes a long way in making me mentally and physically prepared for the rigors of working life, soon after I had completed my studies.

ABSTRACT

The paper works of Improvement of Industrial Pump Design and Usage covers all on-the-job needed in order to reach the objectives and purpose of the study. During the period of developing the paper study, the purpose of this study is reached such as to investigate the performance characteristics of industrial pumps impeller in terms of the design and the usage (abilities) that available, and to develop improvement systems in term of design and pattern of the emphasis component and part using computer aided design (CAD).

In the first chapter, the paper study will go through on the literature review of the pumps, components contained in the pump and its weaknesses. Generally, the chapter will goes as a brief discussion for the proposed machine – in this case submersible pump. Followed up by the emphasis component in the pump, which is the impeller that will be focused for the remaining chapters and discussions, also types of impeller and the existing studies are elaborated for further understanding. For this chapter, the objective of the project, milestone and the project planning are the part that needed to be emphasized most. As for the last chapter, the analysis and the output of the study will become the priority and would be explained in the term of software used to analysis the root topic, the material selected for the material analysis study and the specification of the material involved in the studies.

The report's preparation is made based on the experimental results and (therefore) this report conforms to UTEM faculty's standard guidelines in preparing Final Year Project's report.

ABSTRAK

Kertas kerja yang bertajuk Peningkatan Pam Industri & Kepengunaan ini telah meliputi kesemua kerja kerja - dan skop - skop yang diperlukan untuk mencapai objektif kajian ini. Disepanjang tempoh pengkajian kertas kerja ini, adalah dipastikan bahawa tujuan pengkajian kertas kerja ini adalah untuk mengenalpasti kemampuan pam industri dari segi rekabentuk dan kepengunaannya, dan sekaligus membangunkan sistem rekabentuk komponen yang ditumpukan dengan menggunakan Rekabentuk Berbantu Komputer.

Didalam bab yang pertama, kertas kerja ini akan menerangkan tentang kajian ilmiah mengenai pam, komponen - komponen yang terkandung didalamnya serta kelemahannya. Secara umumnya, bab ini membincangkan secara ringkas mengenai pam industri dan diikuti dengan komponen khusus didalam pam tersebut iaitu bilah (impeller) yang akan akan diterangkan didalam bab - bab seterusnya. Jenis - jenis bilah termasuk juga pengkajian ilmiah yang telah siap dilaksanakan sebelum ini juga akan diterangkan untuk pemahaman yang lebih mendalam. Selain itu, didalam bab ini, perancangan dan perangkaan projek adalah perkara yang akan diberi perhatian yang khusus. Seterusnya untuk bab yang terakhir, analisa dan ouput akan ditunjukkan sebagai hasil akhir projek dan diterangkan bagaimanakah hasil hasil tersebut didapati dengan menggunakan perisian - perisisan tertentu. Input pengkajian disini adalah bahan yang digunakan serta spesifikasi bahan untuk pengkajian ini.

Proses penyediaan kajian kertas kerja ini dilakukan dengan berdasarkan hasil ujian dan eskperimen dan oleh itu, adalah dipastikan bahawa ianya telah memenuhi standad yang telah ditetapkan oleh UTEM untuk diserahkan sebagai laporan Projek Sarjana Muda atau Projek Tahun Akhir pelajar.

NOMENCLATURE

V	Mean Velocity
f	Friction coefficient
ΔP	Differential pressure
k	Pressure gradient factor
Dm	Mean diameter
N	Speed, rpm
$D1$	Outside diameter
$D2$	Inside diameter
v	Volume flow rate
n	Number of holes
U	Velocity of the coolant into each hole
A	Area of cross section of the hole
ϑ	Kinematics' viscosity
H	Distance between the coolant entry and the coolant diversion
D	Diameter of the hole
G	Single nozzle function
$K1$	Thermal conductivity
h	Heat transfer convective coefficient
Dg	Mean diameter of the groove

CONVERSION FACTORS

0.3048 m = 1 ft

2.54 cm = 1 in

3.281 ft = 1m

4.448 N = 1 lb

7.48 gal = 1 ft^3

12 in = 1 ft

25.4 mm = 1 in

60 min = 1 h

60 s = 1 min

100 cm = 1m

100 kPa = 1 bar

101.3 kPa = 1 atm

144 in^2 = 1 ft

100 N = 1kN

1000 L = 1 m^3

1000 mm = 1 m

1000 Pa = 1 kPa

1728 in^3 = i ft^3

3600 s = 1 h

86400 s = 1 day

1 000 000 N = 1 MN

1 000 000 Pa = 1 Mpa

1 000 000 000 N = 1 GN

1 000 000 000 Pa = 1 GPa

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TERMS IN CENTRIFUGAL PUMPS

In any discussion of centrifugal pumps - there are several terms that are interrelated:

- Head
- Capacity
- Horsepower consumption
- Efficiency

As an example, the formula for measuring the water horsepower or the horsepower out of the pump is

$$\text{Horsepower out} = \frac{\text{Head(feet)} \times \text{Capacity(gpm.)} \times 8.33(\text{lbs./ gallon}) \times \text{specific gravity}}{33{,}000 \text{ foot pounds / minute}}$$

Efficiency is defined as the horsepower (water horsepower) out of the pump divided by the horsepower (brake horsepower) into the pump. The formula to calculate it with head and capacity numbers is

$$\text{Efficiency} = \frac{\text{TDH} \times \text{GPM}}{\text{HP} \times 3960}$$

- TDH = the total discharge head measured in feet
- GPM = gallons per minute.
- HP = horsepower required. This number is shown on the pump print.
- 3960 = a conversion number we get by dividing 8.333 (the weight, in pounds, of one gallon of water) into 33,000 (foot pounds in one horsepower).

Like all mathematical formulas - the formula in industrial pumps can be changed in order to calculate a different term. As an example - tot calculate total discharge head

$$TDH = \frac{Efficiency \times HP \times 3960}{GPM}$$

Or the formula to read gallons per minute

$$GPM = \frac{Efficiency \times HP \times 3960}{TDH}$$

Horsepower required might be another choice

$$HP = \frac{TDH \times GPM}{Efficiency \times 3960}$$

The other way instead to do calculate all these is to use a chart like the one attached. Using chart, the user will need to know any of the following three numbers as the chart will figure out the fourth

- Head (TDH)
- Capacity (GPM)
- Efficiency
- Horsepower in (HP)

FINAL YEAR PROJECT

Final Year Project or widely known as Projek Sarjana Muda (PSM) is a task that focuses on research and scientific which involving the studies in Faculty and must be completed by student as a compulsory requirement in order to complete the course. Every student has to complete one of the projects that proposed or entitled by colleague authorities involving research and investigation process on title in every field preferred by student. Mentioned before, this project is a compulsory for all final year students in Mechanical Engineering Faculty in order to be awarded a Bachelor's degree.

In the process of studying, students were taught with the basic of mathematics and engineering knowledge as well exposed to the application of knowledge and practical from the lab studies and this including the 20 weeks internship training .Therefore this program is actually helping the student to interpreted their experience into report developing skills, besides developing skills in work ethics, writing, and management towards attaining UTeM mission in producing well-rounded graduates who possess technical competence, communication and behavioural skills, lifetime learning capacity, critical thinking, business acumen, practical aptitude and solution synthesis ability.

Students are required to complete the project or thesis in order to increases more knowledge and their skill in domains especially with the problem occurred and find out the solution of the problem. Thus, the engineering skill of figuring, analyzing and solving industrial problems will be applied into UTeM's students. With guidance from each student's facilitator – student will be guided to not only be

well educated with engineering theories but also practical and skills of adapting and applying their education into real situation and perhaps all of these committed engineering students will one day blossom and becoming a good engineer.

PSM'S OBJECTIVES

In this project, notably that student will has to adapt the ability to relate theoretical knowledge learned in university and practical during 20 weeks internship training with application in the project. Besides developing student's skills in work ethics, communication, writing, and management towards attaining UTeM mission in producing well-rounded graduates who possess technical competence, communication and behavioural skills, this project is also hoped to install the lifetime learning capacity, critical thinking, business acumen, practical aptitude and solution synthesis ability.

Plus students will have an opportunity to get a better understanding on the theoretical learned by having hands on experience on practical application in the industry since the university is providing students with theoretical knowledge.

Students are required to interface the theoretical knowledge gained in UTeM with practical application in project. During the Projek Sarjana Muda, students are able to consult with supervisor or lecturer. The student can develop the level of confidence or improve the communication skills when they interact or communicate with supervisor.

OBJECTIVES OF THE STUDY

The main objectives of this report writing are to analyze the problems occurs in industrial centrifugal pump and how to overcome one of its critical weaknesses.

Scopes

- Generally discussion on the industrial centrifugal pumps
- Common problems and critical weaknesses for industrial centrifugal pumps
- Analysis on the selective problem
- Solution and way of fulfilling the objectives.
- Software analysis and simulation

Scopes of Sources and Information

- 20 weeks experience in Petra Resources (Miri) Sdn. Bhd consisting self experience in handling product and paper works.
- Research process via the certain websites in the internet for every information related to the project.
- Raw in formations from reference books, product's brochures and material promotional sheets.
- Questionnaires and guidance from related field workers.

CHAPTER 1

INTRODUCTION

There are several types of pumps in industries depending on every industry involved. Example water pump for hydraulic industry, air pump etc. However the working system and function of each pump might be different for each of industry and so does industrial centrifugal pump, the system is rather simple but very effective and powerful. Industrial centrifugal pump is types of pumps used widely in petroleum industry and roughly used to pump the oil out of the earth coating.

This mechanical machine will be dealing with high temperature and hard surface down there, therefore a lot of problems on every aspect will always possibly occurs. As for the rotating components and auxiliary components will also needed to be maintenance and serviced in every specific terms for a stabile ability and better performance. The parts that most fragile and faced with problems will be the shaft and impeller (rotating component) as its keep rotating to produce the momentum and in the same time strike by the unnecessary things consist in the fluid pumped in by the pump.

1.1 Pump's Review

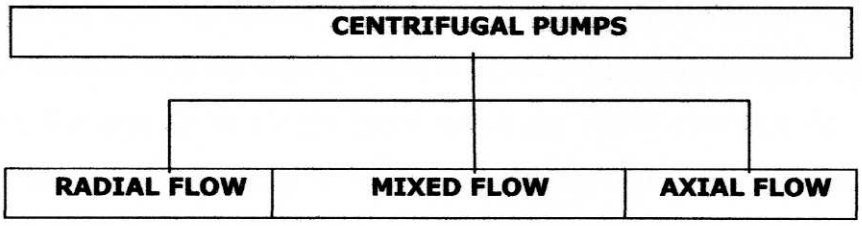
Centrifugal Pump

Centrifugal pump is one of the simplest pieces of equipment. Its purpose is to convert energy of an electric motor or engine into velocity or kinetic energy and then into pressure of a fluid that is being pumped. The energy changes occur at two main parts of the pump, the impeller and the volute. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute is the stationary part that converts the kinetic energy into pressure

Centrifugal Force

Liquid enters the pump suction and then the eye of the impeller. When the impeller rotates, it spins the fluid sitting in the cavities between the vanes outward and imparts centrifugal acceleration. As the liquid leaves the eye of the impeller a low pressure area is created at the eye allowing more liquid to enter the pump inlet.

Centrifugal Pumps are classified into three general categories:



Radial Flow - a centrifugal pump in which the pressure is been developed wholly by centrifugal force.

Mixed Flow - a centrifugal pump in which the pressure is been developed partly by centrifugal force and partly by the lift of the vanes of the impeller on the liquid.

Axial Flow - a centrifugal pump in which the pressure is been developed either by the propeller or lifting action of the vanes on the impeller on the liquid.

1.2 Generally On Pump

Overview

Centrifugal pumps were invented in 1689 by Denis Papin, thought it was not until 1705 that its development began to function properly. They are a multipurpose machine and used in a wide variety of applications around the world including pulp and paper processing, flood control and irrigation, and for cooling nuclear reactors. Specific uses demand certain modification in the basic design of the pump, and due to this there are pumps specially designed to be used with strong acids and corrosive chemicals, pumps made of materials like plastic or stainless steel, and pumps designed to work in vertical, horizontal, and even submergible settings.

Centrifugal pumps are one of the most commonly used types of pumps. They are rather compact and their output is steady. Centrifugal pumps are also known for their smooth and quiet operation, as well as for their low operating costs and high reliability.

There are only three main components of centrifugal pumps: the inlet duct, the impeller, and the volute **Figure 1**. As liquid enters the inlet duct, it encounters the rotating impeller (fan or propeller that spins on a shaft). The rotational energy of the impeller is transferred to the liquid, which is forced outward by the centrifugal force. The liquid, that moving at a high speed enters the volute chamber. As the liquid flows through end of the volute it expands its volume and reduces its rate of flow. The velocity energy of the liquid is converted to pressure energy and that creates a suction effect that helps draw more liquid into the pump in the direction of the flow.

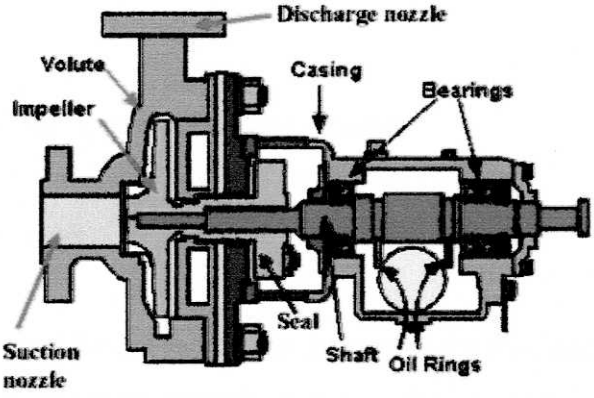


Figure 1 : Centrifugal pump (horizontal)

(Zhang, Tseng, 2002)

There are three basic types of centrifugal pumps, classified by the method by which hydraulic pressure is generated:

Axial Flow - In axial flow centrifugal pumps, pressure energy is created only by the action of the impeller.

Radial Flow - Radial flow pumps create pressure energy only via the centrifugal force expended by the flow of the liquid.

Mixed Flow - Mixed flow centrifugal pumps create a pressure differential via the action of the impeller and the centrifugal force of the liquid.

1.2.1 Stationary Components

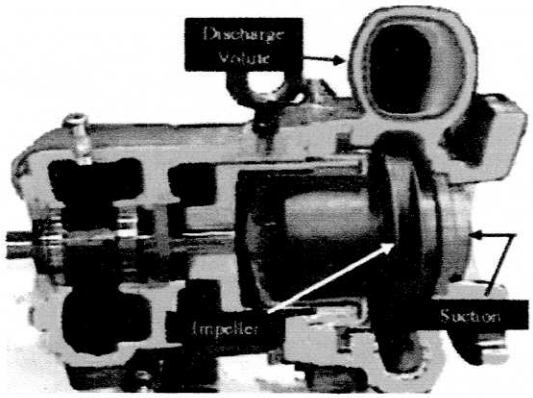


Figure 2 : Cross section of a pump (horizontal)

(Zhang, Tseng 2002)