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**Potong yang tidak berkenaan*

STUDY OF CENTRIFUGAL PUMP PERFORMANCE

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Laporan ini dikemukakan sebagai
memenuhi sebahagian daripada syarat penganugerahan
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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya"

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ABSTRACT

Centrifugal pump is the most important equipment and extensively used in all industrial plants where fluid handling is involved. The operation of a centrifugal pump is solely depends on its own flow-head characteristic curve. The operating point is always where the pump curve meets the flow-head system resistance curve of pumping system that particular pump is handling. Hence the importance of using those curves and the calculation to determine the operating point parameters cannot be overemphasized. Selecting the right pump for any application and the right manufacturer are two of the most important decisions that will have to make for the life of the product. Poor pump selection is the major contributor to the failure of processes that demand reliable fluid movement. In this project pump performance is investigated with certain experiment like series and parallel and result will be analyzed by plotting graph flow capacity against head to calculate pump efficiency.

ABSTRAK

Pam empar adalah peralatan yang sangat penting dan digunakan secara meluas dalam semua industri yang membabitkan penghantaran bendalir. Pam empar beroperasi mengikut sifat lengkung turus dan kadar alir. Titik operasi pam terjadi apabila lengkung pam bersilang dengan lengkung sistem pam tersebut. Kepentingan mengunakan lengkung dan pengiraan untuk mengetahui titik operasi tidak boleh diambil ringan. Untuk memastikan jangka hayat yang lama untuk pam yang digunakan, terdapat dua cara yang paling penting iaitu memilih pam yang sesuai untuk semua kegunaan dan memilih pengeluar yang bagus. Kesilapan memilih pam yang sesuai adalah antara penyumbang terbesar dalam kegagalan di mana proses yang memerlukan pergerakan air yang boleh dipercayai. Di dalam projek ini kecekapan pam akan dikaji dengan ujikaji secara selari dan sesiri dan hasil ujikaji akan di analisis dengan melukis graf kadar alir melawan turus bagi mengira kecekapan pam tersebut.

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LIST OF DEFINITIONS AND SYMBOLS

D	diameter of pump
g	acceleration due to gravity (= 9.81 m/s^2)
H	pump head in column of water (m)
Mg	weight used to balance the torque arm (N)
N	rotational speed of pump (rpm)
P_s	shaft power of pump (kW)
P_W	water power (output power) of pump (kW)
V	flow rate through pump (m^3/s)
R	length of the torque arm
Re	Reynolds number = $D^2N\rho/\mu$
T	input torque to pump (Nm)
c	discharge velocity of pump (m/s)
η	efficiency of pump = P_w/P_s
μ	dynamic viscosity (Ns/m^2)
ρ_w	density of water (kg/m^3)
$C_H = \psi$	head coefficient of pump = $gH/(ND)^2$
$C_Q = \phi$	flow coefficient of pump = Q/ND^3

CHAPTER I

INTRODUCTION

1.1 Background

A pump is a device used to move fluids, such as gases, liquids or slurries. A pump displaces a volume by physical or mechanical action. One common misconception about pumps is the thought that they create pressure. Pumps alone do not create pressure; they only displace fluid, causing a flow. Adding resistance to flow causes pressure. Pumps fall into five major groups: direct lift, displacement, velocity, buoyancy and gravity pumps. Their names describe the method for moving a fluid.

The centrifugal or rotor dynamic pump produce a head and a flow by increasing the velocity of the liquid through the machine with the help of a rotating vane impeller. Centrifugal pumps include radial, axial and mixed flow units. The positive displacement pump operates by alternating of filling a cavity and then displacing a given volume of liquid. The positive displacement pump delivers a constant volume of liquid for each cycle against varying discharge pressure or head.

1.2 Problem Statement

Inability to deliver the desired flow and head is just one of the most common conditions for taking a pump out of service. There are other many conditions in which a pump, despite suffering no loss in flow or head, is considered to have failed and has to be pulled out of service as soon as possible. These include seal related problems (leakages, loss of flushing, cooling, quenching systems, etc), pump and motor bearings related problems (loss of lubrication, cooling, contamination of oil, abnormal noise, etc), leakages from pump casing, very high noise and vibration levels, or driver (motor or turbine) related problems.Studies about centrifugal have been done to improve the pump performance and user friendly. In this project, the performance of pump is calculated in laboratory test.

1.3 Objectives

The main objectives of this thesis is to study and evaluate performance parameters and to design the new test rig that more accurate to calculate the performance and more user friendly.

1.4 Scopes

The scope of this study is to identify all the parameters that are involved in centrifugal pump performance as well as the working condition on fluids. After getting enough information about centrifugal pump, an experiment must be done to take out the data from centrifugal pump model GUNT Multi Pump Test rig HM360 in UTEM fluid mechanic lab.

CHAPTER II

LITERATURE REVIEW

2.1 Centrifugal Pump

A centrifugal pump is a rotor dynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid. Centrifugal pumps are the most common type of pump used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radically outward or axially into a diffuser or volute chamber, from where it exits into the downstream piping system. Centrifugal pumps are typically used for large discharge through smaller heads.

2.2 History

A water or mud-lifting machine that, according to the Brazilian historian of science Reti, "must be characterized as the prototype of the centrifugal pump" 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 1600's, when Denis Papin made one with straight vanes. The curved vane was introduced by British inventor John Appold in 1851.

2.3 Pump Clasification

There are two classifications of pumps as identified by the fluid power industry as shown in Figure 2.2.

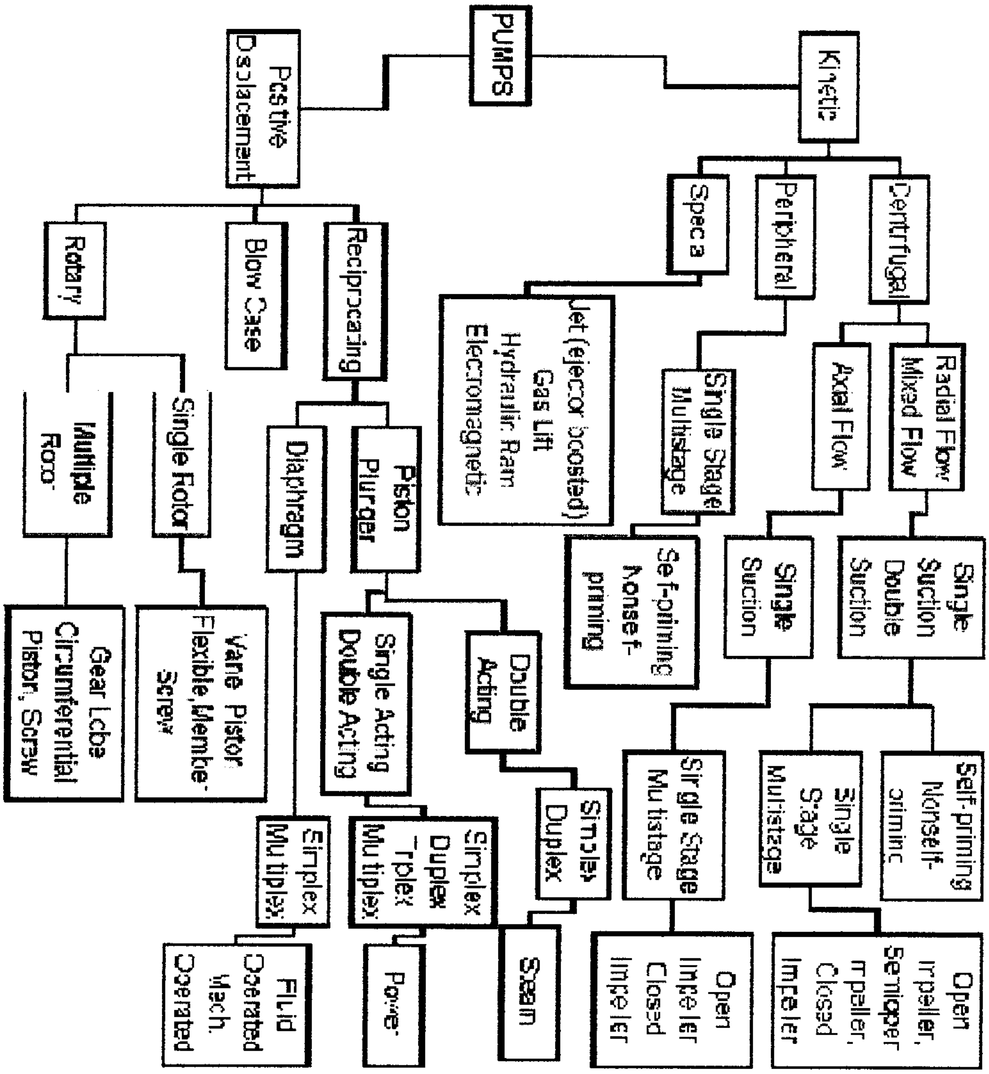

Figure 2.1 ; Pump Clasification

2.3 Generation of Centrifugal Force

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the cavities between the vanes outward and provides centrifugal acceleration. As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force. This force acting inside the pump is the same one that keeps water inside a bucket that is rotating at the end of a string. A centrifugal pump works by the conversion of the rotational kinetic energy, typically from an electric motor or turbine, to an increased static fluid pressure. This action is described by Bernoulli's principle. The rotation of the pump impeller imparts kinetic energy to the fluid as it is drawn in from the impeller eye (centre) and is forced outward through the impeller vanes to the periphery. As the fluid exits the impeller, the fluid kinetic energy (velocity) is then converted to (static) pressure due to the change in area the fluid experiences in the volute section. Typically the volute shape of the pump casing (increasing in volume), or the diffuser vanes (which serve to slow the fluid, converting to kinetic energy in to flow work) are responsible for the energy conversion. The energy conversion results in an increased pressure on the downstream side of the pump, causing flow.

2.4 Conversion of Kinetic Energy to Pressure Energy

The key idea is that the energy created by the centrifugal force is kinetic energy. The amount of energy given to the liquid is proportional to the velocity at the edge or vane tip of the impeller. The faster the impeller revolves or the bigger the impeller is, then the higher will be the velocity of the liquid at the vane tip and the greater the energy imparted to the liquid. This kinetic energy of a liquid coming out of an impeller is harnessed by creating a resistance to the flow. The first resistance is created by the pump volute (casing) that catches the liquid and slows it down. In the discharge nozzle, the liquid further decelerates and its velocity is converted to pressure according to Bernoulli's principle.

2.5 General Components of Centrifugal Pumps

The general components, both stationary and rotary, are depicted in Figure 2.1. The main components are discussed in brief below. Figure 2.2 shows these parts on a photograph of a pump in the field.

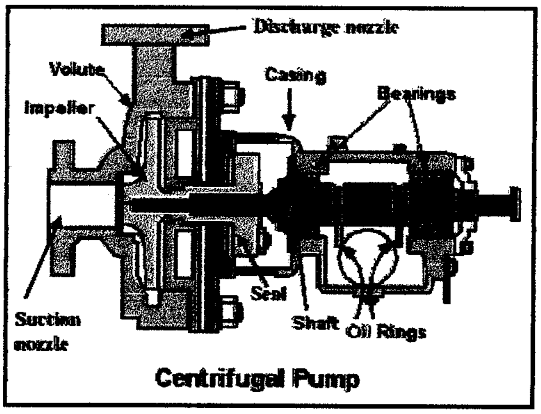

Figure 2.2: General components of Centrifugal Pump

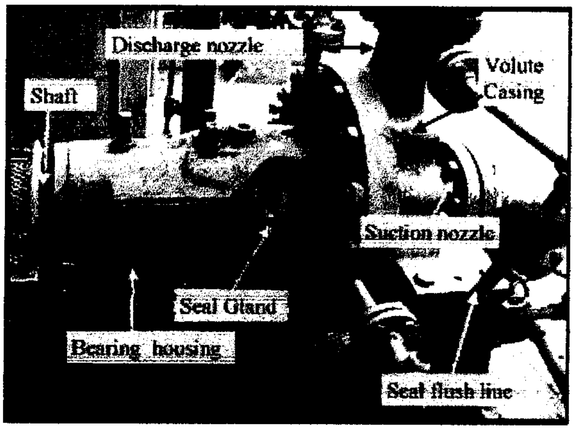

Figure 2.3: Centrifugal Pump

2.6 Suction and Discharge Nozzle

The suction and discharge nozzles are part of the casings itself. They commonly have the following configurations.

2.6.1. End suction/Top discharge

The suction nozzle is located at the end of, and concentric to, the shaft while the discharge nozzle is located at the top of the case perpendicular to the shaft. This pump is always of an overhung type and typically has lower NPSHr because the liquid feeds directly into the impeller eye.

2.6.2. Top suction Top discharge nozzle

The suction and discharge nozzles are located at the top of the case perpendicular to the shaft. This pump can either be an overhung type or between-bearing type but is always a radially split case pump.

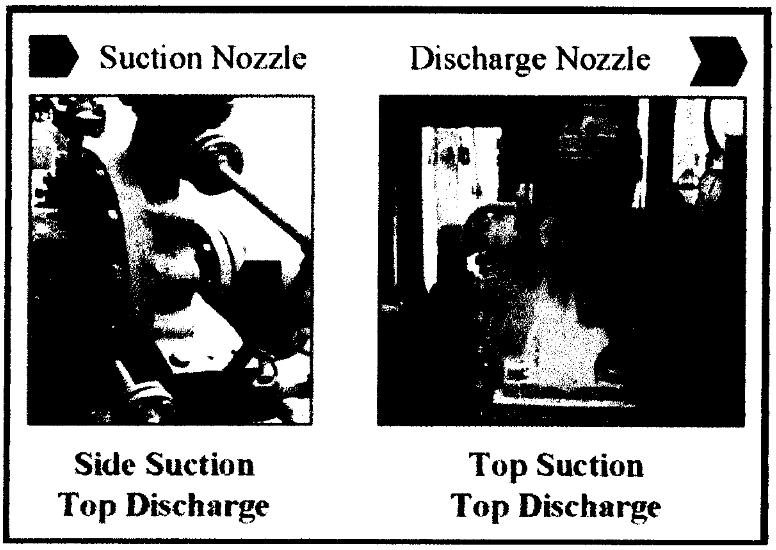

Figure 2.4: Suction and Discharge Nozzle Locations

2.6.3. Side suction / Side discharge nozzles

The suction and discharge nozzles are located at the sides of the case perpendicular to the shaft. This pump can have either an axially or radially split case type.

2.7 Impeller

The impeller is the main rotating part that provides the centrifugal acceleration to the fluid. They are often classified in many ways. Closed impellers require wear rings and these wear rings present another maintenance problem. Open and semi-open impellers are less likely to clog, but need manual adjustment to the volute or back-plate to get the proper impeller setting and prevent internal re-circulation. Vortex pump impellers are great for solids and "stringy" materials but they are up to 50% less efficient than conventional designs. The number of impellers determines the number of stages of the pump. A single stage pump has one impeller only and is best for low head service. A two-stage pump has two impellers in series for medium head service. A multi-stage pump has three or more impellers in series for high head service.

2.8 Shaft

The basic purpose of a centrifugal pump shaft is to transmit the torques encountered when starting and during operation while supporting the impeller and other rotating parts. It must do this job with a deflection less than the minimum clearance between the rotating and stationary parts.

2.9 Auxiliary Components

Auxiliary piping systems include tubing, piping, isolating valves, control valves, relief valves, temperature gauges and thermocouples, pressure gauges, sight flow indicators, orifices, seal flush coolers, dual seal barrier/buffer fluid reservoirs, and all related vents and drains. All auxiliary components shall comply with the requirements as per standard codes like API 610 (refinery services), API 682 (shaft sealing systems) etc.

2.10 Pump Head Selection

Tubing pumps consists of three major components which is pump head, tubing and drive. Pump head consists of only two parts which is rotor and the housing. The tubing is placed in the tubing bed between the rotor and housing where it is occluded. To make the best choices, each component should be evaluated individually. The selection of a pump head for any application is a critical step. The use of the proper pump head eliminates unnecessary problems that can develop during setup and operation. The following are the features of the pump head to consider:

- Flow Range

  Flow range requirements dictate the size of tubing and ultimately the type of pump head for a specific application.

- Number of rollers

  Fewer rollers on a given size rotor allow quicker fluid transfer, but at greater pulsation. More rollers produce pulsation and improve dispensing accuracy but decrease flow rate and tubing life. Vacuum and pressure performance of a pump improve as the number of rollers occluding the tubing at one time increases.

- Fixed or Variable Occlusions

  Fixed occlusion pumps optimize the performance for repeated uses and reduce the chance of operator error. When operated with precision extruded tubing, they deliver excellent repeatable service.

- Ease of Loading

  The method of tube loading greatly affects user satisfaction with the pump. Pharmaceutical, food service and printing applications frequently require several tubing changes over the course of a shift or day. In view of time saved during cleanup or changeovers, easy loading pumps translate into hundreds of dollars in labor savings as shown in Figure 2.34.

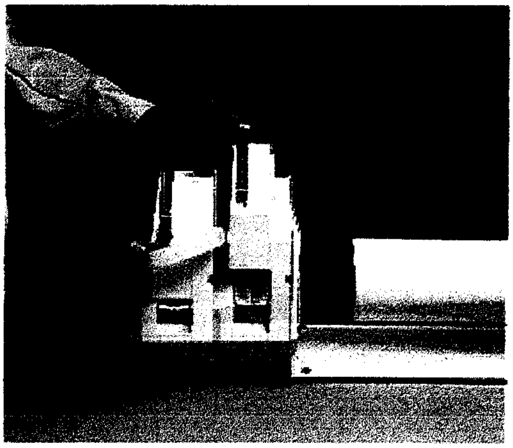

Figure 2.5: Easy loading pump head

(Source: Pharmed, 2004)

- Materials of Construction

  Chemical-resistant materials of construction and shielded bearings help pumps withstand exposure to aggressive fluids or rugged environments. Pump heads with high performance plastic bodies provide a lightweight, chemically resistant product at an attractive price.

- Number of Tubing Sizes Accepted

  A pump head design that accepts only one tubing size can maximize the performance like pressure, vacuum, and flex life for that one tubing size. A pump head designed to handle a range of tubing sizes has some averaged design features. This gives the user greater flexibility in the range of flow rates with one pump head.

- Stack ability

  Design a multichannel pump with one drive system. The number of flow channels possible depends upon the additional torque required for each tube channel up to the limits of the drive. Select from a stack of individual pump heads or a more compact cartridge pump head. Individual pump heads offer a wider range of performance options. Cartridge pump heads have become increasingly popular for their small overall package size. Several individual cartridges mount on one pump body. They are ideal for applications requiring very low flow rates and synchronous flow.

- Specialty Pump Heads

  Unique pump head designs meet specific market needs. Pump heads are now available for smooth fluid transfer, fast dispensing volumes, long pump operation, and extraordinary chemical resistance. These pump heads have special features that are enable them to maximize a particular benefit. Smoother fluid transfer is accomplished by combining two flow channels that have offset pulsation. A special tube set is matched with a special pump head to provide chemical resistant or high purity fluid transfer.

2.11 Tubing Selection

Proper tubing selection is as important as selecting the optimal pump head. General purpose pump heads accept a wide range of nominal tubing sizes. Specialty pumps usually require special tubing profiles, tubing sets with collars or special fittings. Many types of flexible tubing materials are available on the market at a wide range of prices. Only a few of these materials are suitable for pump tubing. Similar looking materials can deliver vastly different pump performance characteristics. A good pump tubing possesses good tensile and compression capabilities. Most pump manufacturers offer a range of prequalified tubing for use in their pumps. These tubing formulations offer consistent flex life and flow rate. Select tubing materials based on the requirements of the application and the preferences of the operator. Here are the criteria:

- Chemical Compatibility

  When considering tubing pumps for pumping aggressive fluids, it is critical to select the correct tubing material. The wrong tubing can lead to hazardous situation with potential to damage equipment and harm people. Consult the pump and tubing manufacturer's chemical compatibility charts for every new application. With new or unrated chemicals, test the tubing in the fluid before testing in the pump. Immerse a short section of tubing in the fluid. Check for changes in tubing size, color, weight and strength. If possible, test the tubing in the pump before extended use. The flexing of the tubing during the occlusion process works the chemical into the tubing wall and accelerates any decomposition that may take place due to weakness in the tubing material.

- Flex life in the pump head

  Different tubing materials have differing abilities to withstand the repeated squeezing action of the rollers. Each tube size, tube material, pump head style, and operating speed in combination has its own life characteristics in general. Service life, or flex life in the pump, is the primary concern in a new application. Pump performance is very consistent in a specific application. The life of the pump can be maximized by selecting a tubing