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DESIGN AND DEVELOPMENT STUDIES RELATED TO PERISTALTIC PUMP

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Laporan ini dikemukakan sebagai
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ABSTRACT

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. This project is to study all the related topics of peristaltic pump and design a prototype in any applications. Pump is divided into two major categories which are positive displacement pumps and non positive displacement pumps also known as dynamic pump. Under positive displacements pump, there are also consists of two categories which are reciprocating and rotary pumps. Here, under rotary pump, there lies a peristaltic pump where the usage of the pump is not widely used as centrifugal pump. Peristaltic pump can also be called as flexible tube pump and hose pump. It can be used for sampling, metering and dispensing..

ABSTRAK

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. Projek ini adalah untuk mengkaji segala topic yang berkaitan dengan "peristaltic pump" dan mereka cipta satu model yang boleh digunakan dalam apa jua penggunaan. Pam dibahagi kepada dua jenis iaitu "positive displacement pump" dan "nonpositive displacement pump" yang juga dikenali sebagai "dynamic pump". Manakala dibawah "positive displacement pump", terdapat pula "reciprocating" dan "rotary pump". "Peristaltic pump" terletak di bawah "rotary pump" di mana penggunaannya tidak digunakan secara meluas seperti "centrifugal pump". "Peristaltic pump" juga dikenali sebagai pam hos boleh laras dan pam hos. Ia boleh digunakan untuk mengambil sampel, menyukat dan mengagihkan cecair secara menyeluruh.

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SIMBOL

SIMBOL	KETERANGAN
CR	Contact Relay *(Geganti Sesentuh)*
FKM	Fakulti Kejuruteraan Mekanikal
L	Indicator Lamp *(Lampu Petunjuk)*
LS_BOOK	Limit Switch Book *(Suis Penghad Buku)*
MIG	Metal Inert Gas Welding *(Kimpalan Gas Logam Lengai)*
PB	Push Button *(Butang Tekan)*
PLC	Progammable Logic Control *(Penprograman Kawalan Logik)*
S	Sensor *(Pengesan)*
SB	Stop Button *(Butang Berhenti)*
SOL	Solenoid *(Solenoid)*
STNDBY	Standby *(Sedia)*
T	Timer *(Pemasa)*
UTeM	Universiti Teknikal Malaysia Melaka

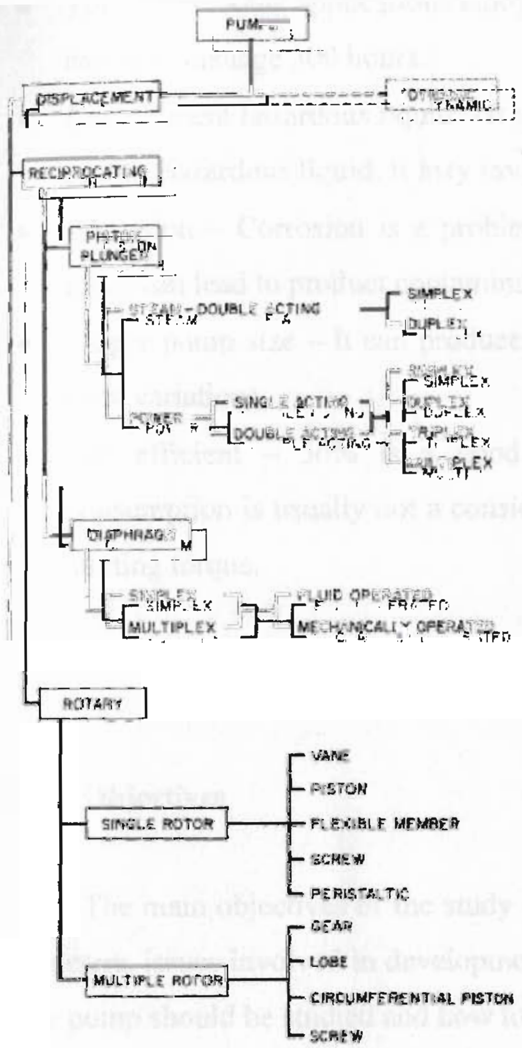
CHAPTER I

INTRODUCTION

1.1 Background

A pump can be defined as a machine that uses several energy transformations to increase the pressure of the liquid. According to Volk (2005),pumps may be classified on the basis of the applications they serve, the materials from which they are constructed, the liquids they handle, and even their orientation in space be constructed. There are two classifications of pumps as identified by the fluid power industry which is positive displacement pump (PD) as shown in Chart 1.1 and nonpositive displacement pumps (dynamic) as shown in Chart 1.2. In this research, only the PD pump will be explained for the main topic on this research is peristaltic pump where the pump is categorized under the rotary pump in PD pump. For dynamic pump, it consist of centrifugal pump and special effect pump while for positive displacement pump, it consist of, reciprocating, diaphragm and rotary pump as shown in Chart 1.1 and Chart 1.2 . In this project, only the rotary pump will be discussed for a peristaltic pump is the main topic for this research.

This study present a set of parameter studies performed on peristaltic pump as a prototype of peristaltic pump should be made after all the information and development studies related to peristaltic pump have been found.



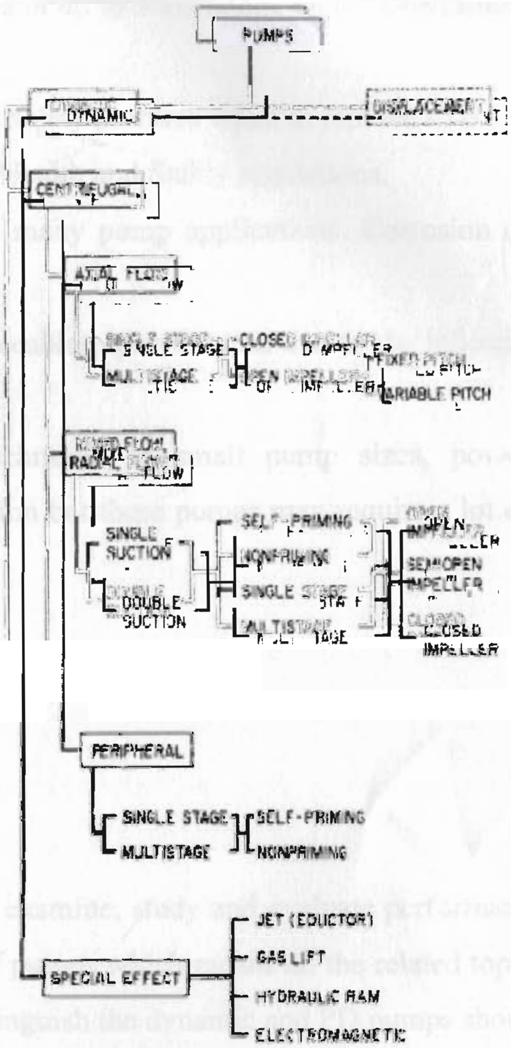


Chart 1.1 Positive displacement pumps   Chart 1.2 Dynamics pump

(Source: Brennan, 2002)

1.2 Problem Definition

According to Majumdar (2001), the principal limitation of the peristaltic pump is that its fluid delivery is not absolutely uniform. There is a trade-off with the tubing diameter between uniform delivery and lifetime and convenience. And here are the other problems for peristaltic pump:

- Tube life – Some applications enjoy lives of up to 3000 hours. Other applications can only manage 300 hours.
- Containment hazardous liquid – It poses safety problem when to remove or clean up this hazardous liquid. It may involve Health and Safety regulations.
- Corrosion – Corrosion is a problem in many pump applications. Corrosion of tubes can lead to product contamination.
- Larger pump size – It can produce noticeable pipe vibration due to the inherent flow variations.
- Not efficient – 50% is a good benchmark. In small pump sizes, power consumption is usually not a consideration but these pumps may require a lot of starting torque.

1.3 Objectives

The main objectives of the study is to examine, study and evaluate performance parameters, issues involved in development of pumps which means all the related topics of the pump should be studied and how to distinguish the dynamic and PD pumps should be considered.

1.4 Scopes

The scope of this study is to identify all the parameters that are involved in peristaltic pump performance as well as the working condition on fluids. After getting enough information about peristaltic pump, a prorotype should be designed by using Solidworks and Autocad, A four years experience in UTeM will be fully used in making this prototype such as welding and grinding.

CHAPTER II

LITERATURE REVIEW

2.1 Positive Displacement Pump

Since the main study for this research is peristaltic pump, which is categorized under the rotary PD, the PD will be explained briefly instead of dynamic pumps. PD pumps can be divided into two major categories; reciprocating and rotary. Most of pump users always refer to the centrifugal pump as the pump itself are more reliable and result in lower maintenance expense instead of PD pump. Centrifugals should be considered first when applying a pump, but they are not always suited to the application. This preference for centrifugal over PD pumps is certainly not always the case and there are certain application criteria that demand the use of a PD pump. Here are the criteria that would lead to the selection of PD pump over centrifugal pump:

- Self-priming
- High viscosity
- High pressure
- Low flow
- Low shear
- Sealless pumping
- Constant flow/ variable system pressure

According to Nesbitt (2004), one of the most important attributes of PD pumps is the ability to pump viscous liquids. It is possible to handle low viscosity liquids with centrifugal pumps. However, efficiency decreased rapidly as viscosity increases and there is an upper limit of viscosity above which it becomes impractical to consider centrifugal pumps due to the excessive waste of energy. Highly viscous liquids cannot be pumped with a centrifugal pump for sure. So, for these liquids, some type of PD pump may be the only practical solution.

Meanwhile, according to Brennan (1995), most PD pump types are inherently self-priming, meaning they can be located above the surface of the liquid being pumped without the necessity of the suction line being filled with liquid in the suction line being removed before starting the pump. Therefore, these pump types can be conveniently mounted on top of transfer tanks with no special external priming devices. Most PD pumps are not nearly as subject to increased leakage back to suction because of wear as are centrifugal pump. Some types exhibit very little slip. These factors make some types of PD pumps ideal for metering applications where an accurate, controllable flow rate of an expensive chemical must be dispensed. For example, to treat water with chlorine. Reciprocating pumps are the most common type of PD pump used for metering pumps, although other types such as peristaltic pumps are also for metering.

Instead of Ramachandra (2005), one of the hydraulic characteristics of PD pumps is that the pump continues to deliver a constant flow rate only if pumping at a constant speed while building up pressure at discharge. This means that the pump continues to build up pressure until something gives if a valve downstream of the pump is inadvertently closed. Normally, one of several things happens to prevent damage to the pump. At constant flow and ever-increasing pressure, the required horsepower may continue to build until the motor is overloaded and trip off. Or, a high pressure or high temperature limit switch may trip the motor. If the motor does not trip or the excessive pressure is not relieved, the pump could eventually build up pressure until it over-pressurizes the pump casing or some component downstream of the pump, causing potentially serious damage. Usually, it is recommended that PD pumps incorporate a pressure relief valve, built into the pump or supplied just downstream of the pump, to protect against over-pressurization.

2.2 Rotary Displacement Pump

A rotary pump as shown in Chart 2.1 is one type of the PD pump and consists of gear, vane and piston pump for common pump and peristaltic pump for the flexible tube pump.

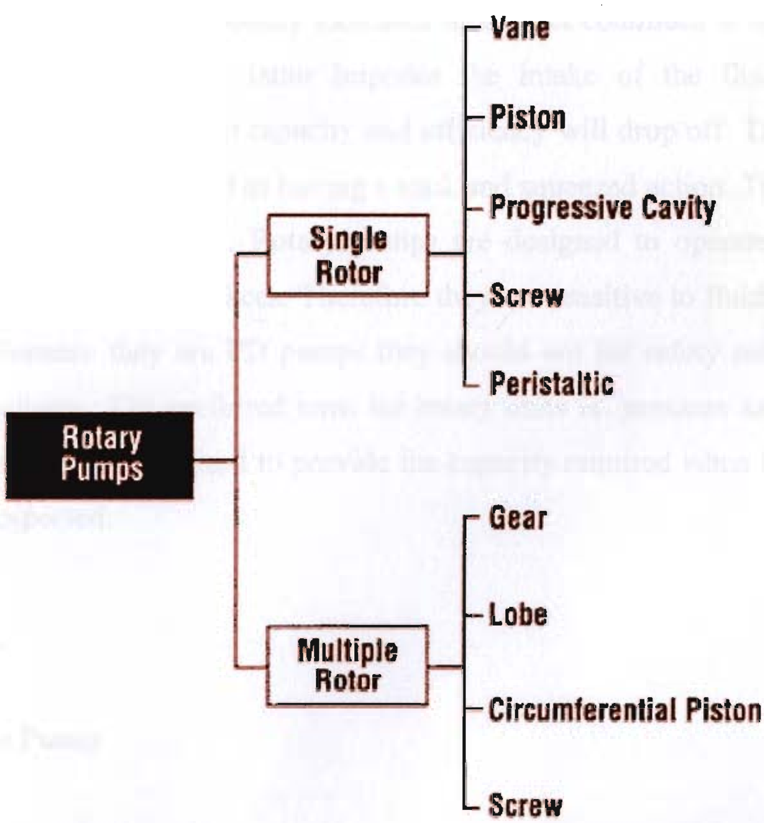


Chart 2.1 : Types of rotary pumps

(Source : Evans, 2006)

Rotary pumps make up the second largest group of pumps in terms of numbers. They also represent the second most economical selection, next to centrifugals. Most rotary pumps are self priming and along with that have the ability to handle fluids consisiting of liquids with entrained gas or vapour. Compared with the high pulsations and definitive batched flow of the reciprocating types, the rotary has a more continuous flow with lower pulsation levels. They are available in types that can handle fluids of extremely high viscosity. However, the most efficient speed drops as viscosity increases above a certain point. This is a function of clearance and the shear action. With high viscosity fluids the clearance is generally opened up by the manufacturer to reduce the power consumption and maintain the low shear effects on the product. Their capacity varies with speed but is affected by pressure to some extent due to its effect on slip in the low viscosity ranges but as viscosity increases this effect continues to diminish to a point. If, at some viscosity, the latter impedes the intake of the fluids into the displacement compartment then the capacity and efficiency will drop off. The operation of rotary pumps has been described as having a suck and squeezed action. They suck the fluid in and then squeezed it out. Rotary pumps are designed to operate with close clearances and wetted internal surfaces. Therefore they are sensitive to fluids containing abrasive solids. Because they are PD pumps they should not for safety sake to be run with a closed discharge. The preferred term for rotary units is pressure as opposed to head. Rotary pumps should be sized to provide the capacity required when handling the lowest viscosity expected.

2.3 Peristaltic Pump

It is very easy to buy pumps based on price to reduce material costs, but the smart money takes a more longterm view. Although not always the least expensive option, the peristaltic pump has several operational advantages over traditional PD pump designs. The biggest of these is that the pumped media remains contained within the pump tube from source to delivery. The peristaltic pump is a special kind of leak-free rotary displacement pump. Its construction and operating principle are two completely different from the other pumps dealt with. The name peristaltic is derived from peristaltis which means a wave of muscle motion used in animals to move liquids and solids along internal passage. Peristaltic pumps are PD pumps incorporating a flexible hose. It has a wide range of applications from medicine to clarification tasks, with delivery flows from mililitre range per day up to 85 m³/h. The maximum achievable delivery pressure is 15 bar. They are able to deliver liquids with a wide variety of consistencies including those containing constituents which are abrasive or consist of long fibres. The liquid is transported in a tube so that no other part of the pump comes in contact with the product and there is complete separation of the working chamber from the drive part. Here is the figure for the common peristaltic pump in figure 2.3.

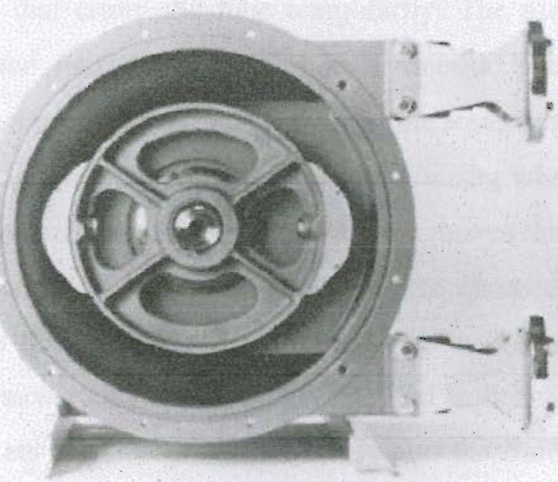


Figure 2.3 : Peristaltic pump
(Source: Treutel, 2005)

Peristaltic pumps are low shear, need no valves or seals, self priming and dry running. As the fluid is contained within a tube, the pumps mechanical part does not contaminate the fluid. These are fundamental attributes to develop a reliable, repeatable, accurate fluid movement system in any type of equipment. Peristaltic pumps are able to pump fluids that many other types struggle to handle. Peristaltic pump can perform better than any other type of pump which is diaphragm, piston, lobe and progressive cavity pump.

Typically, peristaltic pumps are used in sampling, metering, dispensing and transfer applications and do not demand complex commissioning programs, additional check valves or hardware. Pump maintenance typically involves a simple tube changeover which takes just a few minutes and can be carried out by unskilled operatives. This low maintenance requirement enables a very low whole life pump cost, making peristaltic pumps far more economical than other PD pump types.

2.31 Peristaltic principle

The peristaltic pump is a flexible tube that is made to give a pumping action by the use of shoes or rollers that crimp the tube temporarily. The number of shoes or rollers can be two, three and four rollers maximum. Peristaltic pumps operate on a simple principle. A pump head consists of only two parts, the rotor and the housing. The tubing is placed in the tubing bed between the rotor and housing where it is occluded. The alternating pattern of squeezing and releasing the tubing moves the fluid through the pump. As a roller passes over the tubing, it first occluded then released. The progression of this squeezed area forces fluid to move in front of the roller. The tubing behind the rollers recover it shape, creates a vacuum and drawing fluid in behind it. As the roller moves faster, vacuum pockets are created more quickly and the fluid moving through the system picks up speed. The roller act as check valves to prevent siphoning or loss of prime. The distance between the rollers create a pillow of fluid as shown in figure 2.31 below. This volume is specific to the characteristics of the tubing and the geometry of the rotor. Flow rate is determined by multiplying pump head speed by the size of the pillow by the number of pillows per revolution. This pillow volume stays very constant except with highly viscous fluids. Among pumps with the same diameter of rotor, pumps with large pillow will deliver higher volumes of fluid per revolution. A greater degree of pulsation exists with this higher flow rates, not unlike the pumping profile of a diaphragm pump. Pumps with small pillows deliver small volumes of fluid per revolution. With many of these small pillows developing in rapid succession, the motion of the fluid appears smoother, similar to that seen in gear pump.

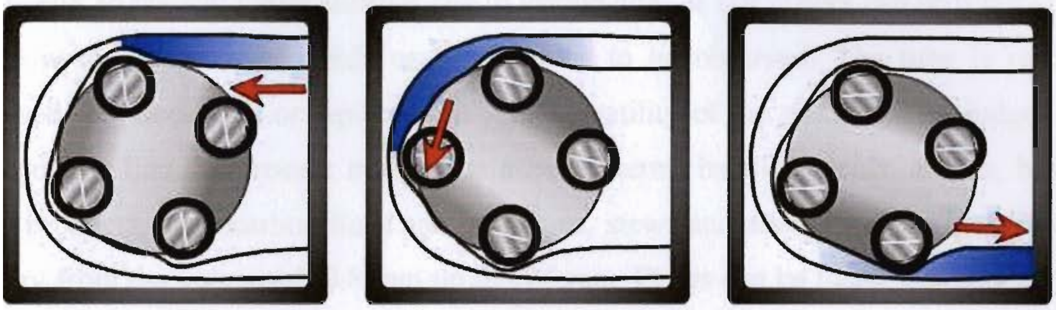


Figure 2.4 : The pillow is created between the rollers

(Source: Nessbitt, 2006)

2.32 Advantages of Peristaltic Pump

Because the peristaltic pump design is radically different to other pump designs there is no requirement for a dynamic process seal which is no soft packing and no mechanical seal. Pump manufacturers may describe their pumps as sealless. The pump shaft is supported by rolling contact bearings in a lubricated bearing housing. Rotating parts are not lubricated by the process liquid. The pump can operate at very low speeds without lubrication problems. The pump has the ability to self-prime when dry (although the moisture can improves priming), and to run continuously when dry. The pump can accommodate process conditions when the liquid supply is intermittent. Pumping will resume when liquid becomes available. Self priming performance, wet or dry, will be influenced by the pump discharge conditions. Priming on a low pressure bypass will be much faster than with a pressurized discharge system. Some pump designs submerge the tube in the glycol or glycerine to provide external lubrication and remove heat when running dry. The nature of the design allows pumping in either direction simply by changing the direction of rotation. The shoes or rollers act as valves that prevent reverse flow and siphoning. As with all pumps, peristaltic pumps can be operated in parallel to increase flow. As with other PD pumps, and unlike rotodynamic pumps, the pumps don't have to be matched to work together successfully. Peristaltic pumps are very versatile because of the incredibly wide range of tube compounds available. Tubes can be opaque, to prevent liquid changes due to visible light or UV. Tubes can be transparent to allow the progress of solids or gas bubbles to be observed. The tube is readily removed to autoclaving or replacement. The versatility of the pump can be judged by some of the liquids (process medium is a better term) handled: acids, alkalis, blood, dairy products, hydrocarbon fuels and lubricants, stews and sewage. The tube bore can be vary from the very small 0.8 mm up to 125 mm. Flows can be incredibly small from 0.001 l/h up to 3000 m³/h. Small bore pumps can be assembled to operate several tubes in parallel.

2.33 Applications in using peristaltic pump

There are many major markets that are using peristaltic pump which is dialysis machine, sewage sludge and here are the others applications;

- Laboratorary Research and Development

  Tubing pump offer excellent repeatability in low volume dispensing and metering applications. The valveless design eliminates clogging and siphoning of fluid under most conditions. The design of the system allows one pump drive to be used for many applications. Common laboratory research and development applications include cell tissue transfer, destaining, perfusion, liquid chromatography and transfer of acid and base solutions.

- Pharmaceutical Manufacturing

  The non-contaminating and non invasive design of tubing pumps makes them very popular. A wide variety of drive options fit the pump into many different applications. Pumping nutrients or pH adjusters for fermentation, filtration of