DESIGN AND PROTOTYPING A PERISTALTIC PUMP

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ABSTRACT

The main objective for this research is to design and develop a rotary peristaltic pump. This type of pump is hard to find on the market and also very rare. However, this pump has a wide application in medical sector. In order to prototype a peristaltic pump, its basic concept and function must be understand. The scope of this research are to design the pump for fabrication and determining the component that will be apply on the pump.Then engineering analysis and testing is done on the prototype to test its functionality.This prototype was successfully prototype with all the systematics plans and procedures.This prototype weight is 4 kiliograms, long 25 cm, height 22.5 cm and width 18 cm.This project basically use mild steel angle bar and aluminium and powered by an electric motor. Improvement to the part of the pump like housing and motor are recommended for further stage of the study.

ABSTRAK

Objektif utama dalam kajian ini adalah untuk merekabentuk dan meghasilkan satu jenis sesaran positif pum iaitu Pum Peristaltic. Pum ini adalah sejenis pum yang sukar untuk diperolehi kerana kekurangan pembekal yang sanggup menghasilkan pum jenis ini. Fungsi lain pum ini adalah digunakan di hospital dan di bahagian perubatan Di dalam menghasilkan pum ni, konsep asal dan fungsinya mesti la dipahami sepenuhnya. Skop dari kajian ini ialah untuk menghasilkan pum ini dan mengenalpasti komponen yang terdapat dalam pum jenis sesaran positif. Analisis kejuruteraan dan ujian telah dijalankan untuk memastikan agar pum berfungsi dengan lancar. Pum ini telah berjaya dihasilkan dengan perancangan yg sistematik dan teratur. Pum ini mempunyai berat 4 kg ,panjang 25 cm,tinggi 22.5 cm dan kelebaran 18 cm. Projek ini meggunakan mild steel angle bar dan aluminium dan menggunakan elektrik sebagai sumber tenaga. Terdapat beberape pembaharuan yang perlu di lakukan kepada bahagian pum iaitu perumah pum dan motor untuk pembelajaran yang lebih tinggi.

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ω	Natural frequency
Q_t	Flowrate (theory)
P_{hydr}	Power
η	Efficiency
T	Torque
H_f	Head Loss

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

A lot of equipment around us uses the mechanisms of pump, from the smallest pump used in the house to the biggest scales and specification pump used in industries. A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A rotor with a number of 'rollers', 'shoes' or 'wipers' attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to be pumped to move through the tube. Additionally, as the tube opens to its natural state after the passing of the cam ('restitution') fluid flow is induced to the pump. This process is called peristalsis and is used in many natural biological systems such as the gastrointestinal tract. Peristaltic pumps are typically used to pump clean or sterile fluids because the pump cannot contaminate the fluid, or to pump aggressive fluids because the fluid cannot contaminate the pump. Some common applications include pumping aggressive chemicals, high solids slurries and other materials where isolation of the product from the environment, and the environment from the product, are critical. Suitable with the widely used of pump application, this research is currently focusing on designing and developing small scale of rotary peristaltic pump that will be used by small food industries and house use. The objective of this project is to understand the concept of peristaltic pump and its function in order to develop a prototype of this pump. The scale prototype would be built. Solidworks should be use in the process of designing

this pump. The following are the basic components that will be installed in the pump: All the important part of peristaltic pump is housing of the pump, rotor and shoe of the pump, tube pump and frame of the pump. This frame used to support the pump from bending which can affect the operation of the pump.

1.2 PROBLEM STATEMENT

The peristaltic pump is an equipment that requires many part where each part has different purpose. The important parts are the rotor, shoe, tube, pump housing and base plate. Each part of the design must have their own function. This type of peristaltic pump is easily obtain at developed country rather than local market. This is due to the lack of Original Equipment Manufacturer (OEM) that are capable of manufacture such a product. Peristaltic pump has many domestic usages such as in medical sector and handling of critical fluid. Thus, a study is needed to systematically be conducted in order design and analyzed the principle operation of such device.

1.3 OBJECTIVE

The objectives of this project are:

1. Design and develop a prototype of a rotary peristaltic pump.
2. To understand the concept of peristaltic pump and its function in order to prototyping a prototype of this pump.

1.4 SCOPE

The study is started by determine appropriate specification of the peristaltic pump. The specification of the pump is rotary peristaltic pump. Then followed by concept design. Basically there are four type of concept design for peristaltic pump but this project only concentate on the concept 2 as final design. The chosen design needed to be draw using Solidwork software. The design have been analyzed by using manual calculation. The material used to fabricate the peristaltic pump is iron and aluminium. After all the selection have been decided, fabrication process are started. The last scope is to test the functionality of the peristaltic pump.

CHAPTER 2

LITERITURE REVIEW

2.1 INTRODUCTION

This chapter presents an overview of the peristaltic pump principle embracing overview of peristaltic pump, classification peristaltic pump, application and advantage, major drawback in existing design, and critical part of peristaltic pump. In this chapter also include basic operation of the pump which to explain how this pump operate.

2.2 OVERVIEW OF PERISTALTIC PUMP

Over the years, applications for the peristaltic pump have continued to grow because of its resistance to abrasion and corrosion. Peristaltic pumps are now used worldwide in chemical and food processing, waste and water treatment, and paper manufacturing and mining industries.

2.2.1 Basic Idea of Peristaltic Pump

Basic structure. of peristaltic pump composed of a composite hose enclosed in a casing with a flange at both ends. The flanges are connected to the suction and discharge lines of the system. The casing also contains a rotor that is mounted on a shaft that is supported on its own bearings. Two or more regularly ‘pressing shoes’ are fixed to the rotor. The principle of operation is relatively simple. As the rotor turns the hose is totally compressed by the shoes and the liquid is pushed forward through the hose. Behind the

shoe, the recovering hose creates a vacuum that enables the pump to suck in a new batch of products. Higher pressure peristaltic pumps, which can typically operate against up to 16 bar, typically use shoes and have casings filled with lubricant to prevent abrasion of the exterior of the pump tube and to aid in the dissipation of heat, and use reinforced tubes'.

This class of pump is often called a 'hose pump'. Lower pressure peristaltic pumps, typically have dry casings and use rollers, use non-reinforced tubing. This class of pump is sometimes called a 'tube pump' or 'tubing pump'. Because the only part of the pump in contact with the fluid being pumped is the interior of the tube, it is easy to sterilize and clean the inside surfaces of the pump. Furthermore, since there are no moving parts in contact with the fluid, peristaltic pumps are inexpensive to manufacture. Their lack of valves, seals and glands makes them comparatively inexpensive to maintain, and the use of a hose or tube makes for a relatively low-cost maintenance item compared to other pump types.

2.2.2 Rotary Peristaltic Pump

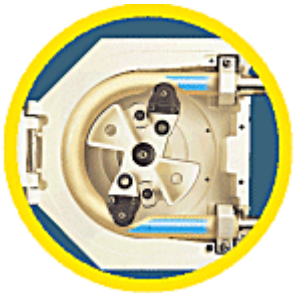

Figure 2.2: Basic Shape for rotary peristaltic pump (World Pumps, 2005)

Rotary peristaltic pump have pump case, hose, rotor, shoe, chasis, and motor. The Pump case has rotor that lay down at shaft that support by it bearing. Normally two shoes will put at rotor.

Rotary peristaltic pump have two flange. This flange will be connecting input fluid and output. Hose are pump element that be found at peristaltic pump, which rotor and shoe is use to pressed hose and will be have vacuum to pulling fluid to enter the hose.

Rotary peristaltic pump is different from the linear type where the rotary type used motor to rotate the shaft linear type used cam to control the motion of shaft. The rotor is attached to the shaft that connected to the motor. End of strip rotor was pressed the hose and the vacuum is form to produce attraction force. (World pumps, 2005)

2.2.3 Basic Operation Of Peristaltic Pump

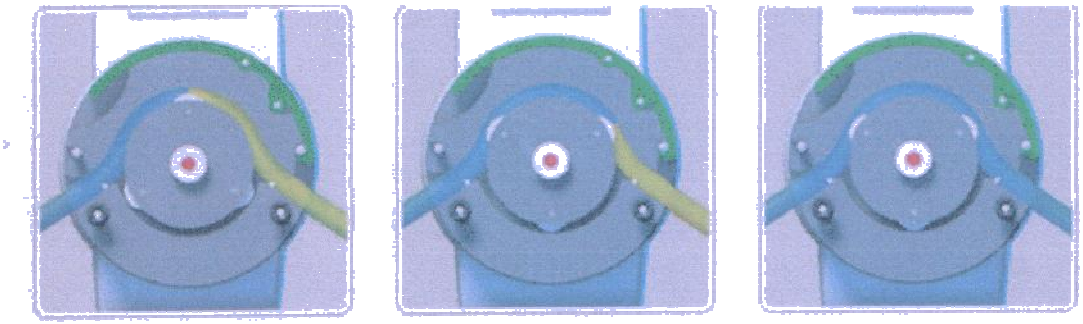

Figure 2.3: Principle of peristaltic pump (Verder, 2006).

Figure 2.5 above shown that basic operation for rotary peristaltic pump.Principle of operating are very easy.Figure 2.5 (i), shown that when rotor is rotate,fluid is enter the hose because of attraction force from vacuum produce after hose push by rotor. Figure 2.5 (ii) shown that hose are fully pressed by rotor along the the hose and then fluid is push and flow to the ouput. Figure 2.5 (iii) shown that fluid is shift to ouput and the other place which operator wish. Part of shoe were form vacuum and attract the fluid that want to pump.This operation stay repeatedly untill the power of motor are off.

2.3 CLASSIFICATION PERISTALTIC PUMP

A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. This pump did use for a long time ago. For easy way, peristaltic describe one motion for displace material through tube. Peristaltic pumps are now used worldwide in chemical and food processing, waste and water treatment, and paper manufacturing and mining industries.

The fluid is contained within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A rotor with a number of 'rollers', 'shoes' or 'wipers' attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to be pumped to move through the tube. Additionally, as the tube opens to its natural state after the passing of the cam ('restitution') fluid flow is induced to the pump.

A housing of the pump which contained cylinder oil is use to avoid high friction at the surface with rotor when rotor or shoes rotate and reduce heat among the tube. Because only surface area of the tube touching with the fluid, so it easy to organize and clean. (Bredel, 2005).

Peristaltic pump have big component that consist of various kinds shape and size.This pump is classification a vacum pump ,which type of positive displacement pump. Figure 2.2 show that classification of the variety pump.

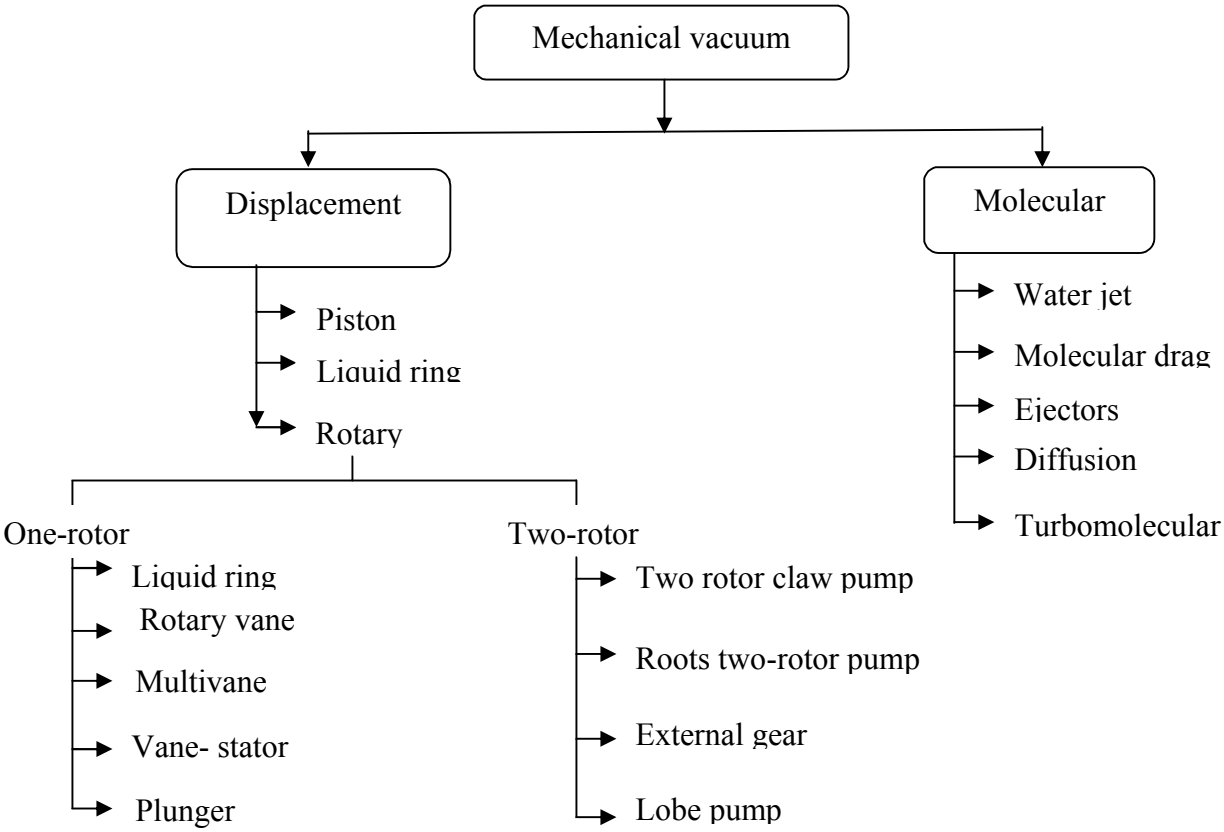

Figure 2.4: Classification Peristaltic Pump (Rozanov, 2002)

2.4 APPLICATION AND ADVANTAGE

2.4.1 Application

This peristaltic pump has many usages. Peristaltic pump now used in biotechnology to aspiration of culture tissue medium, dosing of feed activities and spraying of insecticide. This pump also used in chemical industry that to circulated coolant in low temperature baths and for flow injection analysis. For the food, this pump used in pizza sauce dispensing and inject vitamin A&D. Because this type of pump is isolate from environment, so it can used in medical to moved the blood and dispensing of sterilized fluids.

2.4.2 Advantage

This type of pump is high solid produt which it can produse vacuum during pump process. This pump can drain the fluid consisten ,not like piston type pump. The hose snout also in static condition and stable at the fixed place. The only part of the pump in contact with the fluid being pumped is the interior of the tube, it is easy to sterilize and clean the inside surfaces of the pump. Furthermore, since there are no moving parts in contact with the fluid, peristaltic pumps are inexpensive to manufacture. Their lack of valves, seals and glands makes them comparatively inexpensive to maintain, and the use of a hose or tube makes for a relatively low-cost maintenance item compared to other pump types. Peristaltic pumps also minimize shear forces experienced by the fluid, which may help to keep colloids and slurry fluids from separating. For other word, the replace hose cannot disturb the pump system (Bredel,2005)

2.5 MAJOR DRAWBACK IN EXISTING DESIGN

The spacing between the occlusion bed and the rotor assembly is critical for proper pump operation, and known prior art pumps have a number of disadvantages that limit the ability to provide consistent spacing. For example, the linkage used to open and close the occlusion bed with respect to the pump body is very complicated, requiring numerous components to create the linkage. Moreover, the tolerances of each of the components results in additional complications. However, the spacing between an occlusion bed and a rotor assembly is unforgiving from a tolerance standpoint since it is used both to provide a compressive force between the rotor assembly and occlusion bed pump and to locate the occlusion bed with respect to the rotor assembly.

Further, installation of the tube is complicated in known pumps. For instance, jaws that grip the tube must be manually separated with select tube diameters not automatically fully opened such that the tube can be removed without touching the jaws when the peristaltic pump is opened. Moreover, it is desirable to be able to stretch the installed tube to prolong its useful life. Known peristaltic pumps lack the ability to

provide a constant stretching independent of tube size. In addition, pumps are typically preferred that have tube entry and exit on the same side of the pump, to minimize the possibility of interfering with other equipment.

Thus a pump is desired that provides at least one or more of the following advantages, very accurate positioning of the occlusion bed with respect to the rotor assembly to properly occlude the tubing; retaining automatically a wide range of tubing; is simple to operate, provides consistent tube tensioning independent of the type of tube used and is installed from a single side or single end of the pump.

2.6 CRITICAL PART

2.6.1 Peristaltic Pump Hose

Hose peristaltic is most important components in the design of peristaltic pump and it's because why this pump still use in the development until today. Function of this hose is to shed the fluid and protect the fluid from distinct thing from inner pump.

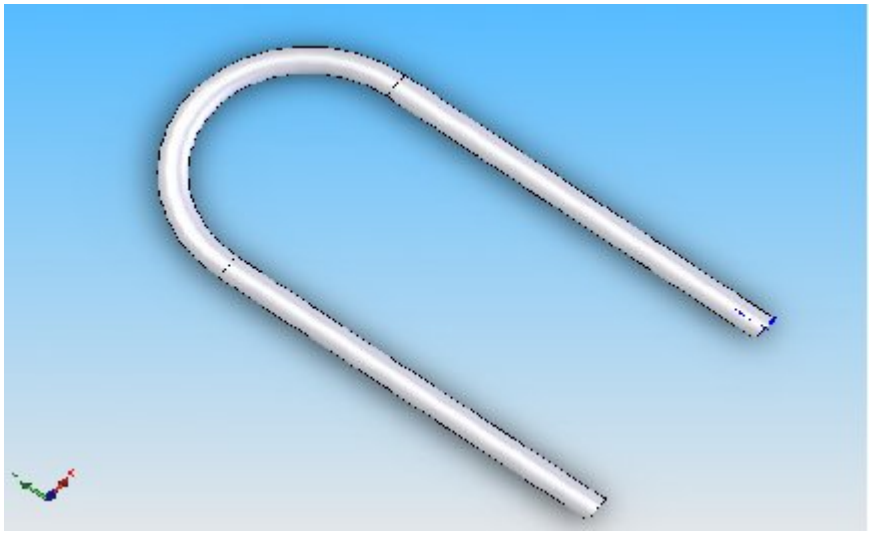

Figure 2.5: Tube peristaltic pump

New design of peristaltic is resultant with material like open-cell polyurethane,type thing which use in many application now like polyurethane springs for scissors.One part reference company that produce this pump say that this kind of hose can stand 5 time more long from the hose produce from steel spring.

After long time use,it's will undergo elastic shape because from pressure that produce from grinder and fluid. This type of hose still can afford for change back to normal shape that shape is circle and the important is when hose return to normal shape, it can produce vacum for pull fluid from stagnant and fill hose by itself. . (Monolithic, 2006).

2.7 SUMMARY

This chapter has shown all information about peristaltic pump which neede to protoype this type of pump. In the first part of the contents, (1) overview of operation which present principel of operation and basic operation of peristaltic pump, (2) classification of the pump, (3) application and advantage of the pump, (4) major drawback in existing design for describe about the design concept. The last part of the chapter is described about critical part of the peristaltic pump like the hose peristaltic. All descriptions include picture of peristaltic pump, chart of classification pump and the hose of peristaltic pump.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter represents the methodology to prototyping the peristaltic pump. It include about the design concept and selection design. All the design is shown in this chapter.

3.2 DESIGN METHODOLOGY

Designing is process where there are an exact answer like the answers to question in exercises. There are four major stages in applying design process of peristaltic pump.

1. First step to apply the process design is identified the Product Design Specification (PDS) [8]. Product Design Specification (PDS) is the product function, design requirement and design criteria will identified to solve the problem and because the applications can give one of a good solution to get a new design. Some of the criteria that were considered for the pump are performance, material selection, size and maintenance.

2. The second stage is the conceptual design. Conceptual design is the important step in design process. This process indicates a sketch of design idea that is suitable with the PDS. Two processes in this step are concept generation and concept evaluation.

There are 4 sketching of pump from the methodology chart and after completed the concept evaluation, concept generation 1 has been choose. Please refer to the appendix for the morphology chart and concept evaluation. All of these processes were done to get more ideas and to choose the best ideas to proceed for the next step.

3. The third stage is preliminary design. Preliminary design is propose to detail the chosen design from the evaluation that was done in conceptual design. At this level, the dimension has been made to get a dimensional modeling. There are two processes in this steps that is material selection and design analysis.

4. The final stage is final design. In the final design process, all the detail drawings and final specifications including the type of material for the components have been finished. Besides that, fabricating processes to build the prototype has also been determined.

3.3 CONCEPTUAL DESIGN

This conceptual sketch is produce after have good ideal to identify and analyzes all the pros and cons that think logical. The best design is choosen using matric method. All the design process is begins from ideal which best ideal was choosen to select the best design. First sketch are important thing of sketch because it is represent a suitable procedure and can settle all the problem that come when design the peristaltic pump. There is 4 difference design that come from first ideal and internet. Every design have pros and cons and lastly only one of the design were choosen .