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DESIGN AND CONSTRUCTION OF AN AUTOMATED PERISTALTIC PUMP

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Abstract – 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. 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 the tube under compression closes (or "occludes") 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. In this paper, basic principle of working and pump design specification has been discussed. The advantages and critical applications have been presented. We considered three concepts for brainstorming and selected one out of three based on the advantages and disadvantages. The theoretical calculations carried out for the flow rate of pump are presented. This prototype consists of Peristaltic pump, coupling and geared car wiper motor and a spring-loaded sensor to automatically turn of the pump (via the motor). It pumps 1.3 cm^3 volume of water per second.

Keywords:– Peristaltic pump, electric, fluids, volume**.**

I. INTRODUCTION

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 (Suripa, 2008). 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, (Mansor, 2008). 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 paper is currently focusing on designing and developing small scale of an automated rotary peristaltic pump that will be used for pumping distilled water. 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 scaled prototype would be built. Solidworks will be used in the process of designing this pump. The following are the basic components that will be installed in the pump: the housing of the pump, rotor, and roller of the pump, tube pump, and frame of the pump. This frame is used to support the pump from bending which can affect the operation of the pump.

The peristaltic pump is equipment that requires many parts and each part has a different purpose. The important parts are the rotor, rollers, tube, pump housing, and base plate. Each part of the design must have its own function. This type of peristaltic pump is easily obtained in developed countries rather than in the local market. This is due to the lack of Original Equipment Manufacturers (OEM) that are capable of manufacturing such a product. Peristaltic pump has many domestic usages such as in the medical sector and handling of critical fluid. The characteristic nature of the pump which isolates the transported fluid from the environment makes it ideal to be used in hospitals to transfer blood and dispense sterilized fluids, (Thananchai, 2008).

Thus, a study is needed to systematically be conducted in order to design and analyze the principle of operation of such a device and, also design a mechanism to automatically shut off the pump when the desired volume(s) is reached.

The objective of this study is to develop an automated prototype of a rotary peristaltic pump capable of pumping 10 cm^3 of water per minute.

II. METHODOLOGY

To effectively design the pump, the Product Design Specification (SPD) was developed. Product Design Specification (PDS) is the product function, design requirement and design criteria identified to solve the problem. Some of the criteria that are considered for the pump are; performance, material selection, size and maintenance.

The second stage is the conceptual design which is an important step in the design process. This process indicates a detailed sketch of a design idea that is suitable with the design. Two processes in this step are concept generation and concept evaluation. As such three concepts were formulated and after evaluation based on the specified criteria (Table 1), the best concept was selected and further developed.

Table 1. Concept screening matrix

Selection Criteria	Conceptual design		
	Design 1	Design 2	Design 3
Low friction	-	-	+
High motor torque	-	-	+
Less Complexity	-	-	-
Ease of Tube replacement	+	+	+
Low Vibration / Noise	-	-	+
Low Unbalance	-	0	+
Less Floor space	-	-	+
Ease maintenance	+	+	+
No Axial thrust	-	-	0
Less pulsating flow	-	-	0
Durability	-	-	+
Sum +’s	2	2	8
Sum 0’s	0	1	2
Sum -’s	9	8	1
Net Score	-7	-6	+7
Rank	#3	#2	#1
Develop?	NO	NO	YES

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

The final design process involved the preparation of detailed drawings and final specifications including the type of material for the components before the final fabrication of the prototype. The prototype was evaluated to determine its performance.

2.1 EXPERIMENTAL SET-UP

Two different experiments were conducted, first to measure the volume (cm^3) of fluid flow against time (s) and second, volume against the height of the sensor screw. Various volumes of water are measured using a calibrated beaker and their corresponding times are recorded using a stopwatch.

A volume range of 50 cm^3 to 300 cm^3 at intervals of 50 was recorded and timed in seconds. Readings from the stopwatch were started immediately after flow began from the output and stopped when the volume required was reached. The experiment was repeated three times for each volume to determine the average time for each volume.

The various volumes measured were used to calibrate the height of the sensor screw for each recorded volume required to shut off the pump by touching the metal plate. The adjustment of the sensor screw was done using a screwdriver. The experiment was repeated three times for each volume to determine the average height for each volume.

III. RESULTS AND DISCUSSION

This project presents the design, construction, and performance of a spring-loaded sensor to automate the peristaltic pump. A calibrated beaker was placed on the sensor to measure the required volume of water flowing through the pump. The results obtained during the experiments revealed that the pump is running faster than our expectation. However, we can read from the table below that more than 10 cm^3 of water is delivered from the pump per min. Two different experiments were conducted, the results for each experiment are shown in the tables below. Therefore, the variation in flow rate is represented from the graphs for each experiment.

Table 2. Result of Volume (cm^3) against Time (s) experiments

Volume (Cm^3)	Time (S)		
	First	Second	Third
50	38	36	37
100	80	78	78
150	120	120	118
200	150	150	148
250	187	186	186
300	224	224	224

Table 3. Average result of Volume (cm^3) against Time (s) experiments

Volume (cm^3)	Time (s)
50	37
100	78.66
150	119.33
200	149.33
250	186.33
300	224

Table 4. The average result of the height of the sensor screw head against the volume of water.

h (cm)	V (cm)
0.1	50
0.3	100
0.5	150
0.7	200
0.9	250
1.2	300

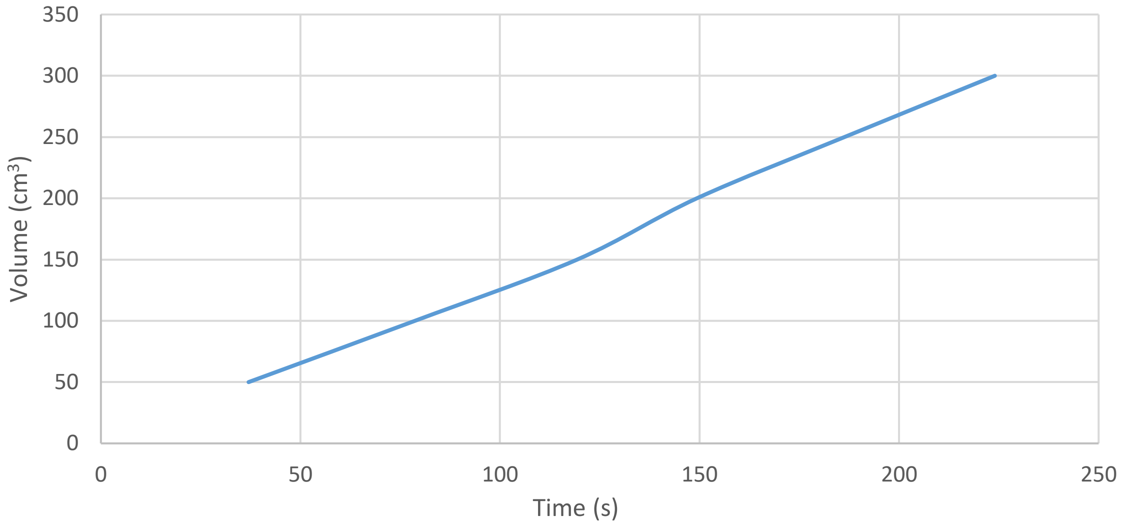

Figure 1. Variation of the flow rate per second

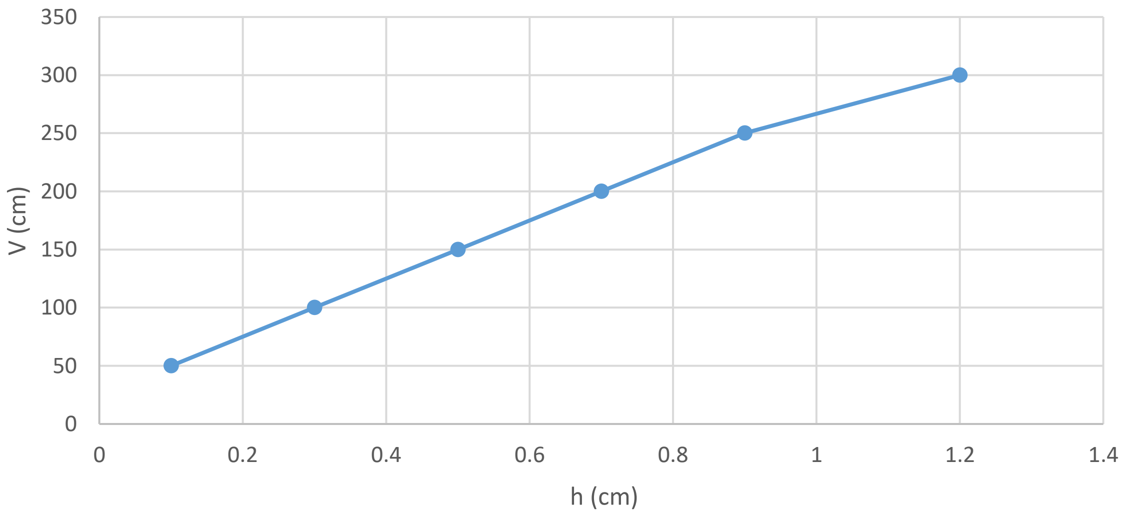

Figure 2. Variation of volume against the height of sensor screw head.

IV. CONCLUSION

This paper set out to develop an automated prototype of a rotary peristaltic pump capable of pumping 10 cm^3 of water per minute. The design process involved a literature survey to obtain an idea of the present status of work and challenges in the design and development of peristaltic pumps. Concept generation and selection criteria with the challenges in the design and development of peristaltic pumps. The selected concept design has been designed to handle water per our calculations and has a working efficiency of 98.8 %.

As a part of future studies, several tests on the pump shall be carried out to know its flow characteristics by using different Viscosity fluids, and different diameter rollers keeping the tube diameter and other parts of the pump unchanged.

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