Design of Peristaltic Pump with Mechanical Drive of Static Bike as Multi-Function Equipment

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Abstract. Multi-function tool is one of the solutions offered to solve the recent problems of human beings, especially in health and water supply problem. A static bike was one of the fitness equipment resulting in wasted power. In this work, the power of static bike was proposed to drive peristaltic pump which complies water supply for human beings. The peristaltic pump was chosen due to its simple construction and its low torsion requirement to transport water with the height of five meters. The proposed equipment was constructed by the components which were easy to find. It was examined by comparing the time whether hand and static bike driver. The experimental results showed that the proposed equipment which integrating the function of the peristaltic pump and static bike produced multi-function tool which was versatile to do the daily sport of human beings.

1. Introduction
Life demand makes people had to arrange their time in smart way. This makes the utilization of multi-function tools has interested especially people with less of spare time. On this condition, performing exercise in daily life becomes one big problem. This is caused by problem in area and time to do it. One of proposed solution that can solve this problem is using Fitness equipment such as static bike. Moreover, this equipment is more attractive whenever it provides other advantages for the user specially to overcome their other problems. Analysing this kind of bike, there was something engaging in this equipment. The static bike generated wasted power which actually can be harnessed. Considering the other problem faces by the people, water supply is still becoming a big problem. This could be solved by exploiting the wasted power of static bike as the option. However, torsion resulted by static bike is not too high, so it should be used to operate low torsion equipment. peristaltic pump is one of the pumps that works with a fairly low torque [1,2]. Based on this situation, this work purposes to design multi-function tool to solve this existing problem. Furthermore, this multi-function tool can be used as emergency option when the electrical power is not available to supply clean water for individual need like taking bath and washing. This can be helpful in Indonesia since many people use wells as a water resource. They commonly rely on electrical pump to prepare clean water.

Peristaltic pump is categorized as positive displacement pump which working with rotary concept [2]. It operates by allowing the liquid into the hose. This fluid then flows into the pump casing through the hose. Once there, the propellers with a number of hose hook compresses force the liquid on through the pump and direct it to the final destination. This technique is known as peristalsis. This process actually mimicked the activities in stomach [2]. Thus, this tool is called peristaltic pump. In this process, the fluids do not get touch with the component of the pump [3]. This process occurred
due to the fluid flow in the hose and the pump give the pressure to the water from out of the hose. This becomes the advantages of peristaltic pump namely the fluids will be more sterile [4]. Thus, this kind of pump is commonly used in pharmacy industries. The separation between fluid and component in the peristaltic pump is also toward that its component will always dry or no water contained. This will avoid the components of the pump from the corrosion. That means that the component is more durable. The other benefit of this pump is its simplicity. This kind of pump can be developed by using the materials which are available around the people.

This paper presents a system design that integrates static bike as a sports equipment that is used as a driving source for a peristaltic pump. The results of this design are expected to provide multiple advantages, namely being healthy and more cost effective. And this tool is also expected as a solution during an emergency when there is a power outage whose function is to pump water from the surface of the water in the well to the bathroom. The remainder of the paper is structured as follows. Section 2 introduces design of mechanism concept. Section 3 presents prototype development. Section 4 describes theoretical and experimental methodology. Section 5 reports results and discussion. Finally, Section 6 conclude overall results of the study.

2. Design of Mechanism Concept
This research has aimed to proposed multi-function device which were built as simple as possible [5]. It was brought to the straight-forward design. One of them was the selecting of two wheel handlebars as discussed by Klepitz and Kovács[1]. In this scheme, the fluid was compressed between two wheels. This was intended to develop the minimum number of the part. Despite this kind of peristaltic pump would lead to the pulsation characteristic [6], it would not disrupt the orientation of the idea of this work.

In this proposed design, both wheels were located 180° each other. In this condition, the pump was expected to compress maximum volume of the fluid in both directions. The other superiority of this kind of pump was its ability to operate both direction of the rotation [1]. This would be advantages when the pump was drove by static bike. This brought to the simple adjustment and risk reducing of mis-operational. The proposed peristaltic pump was given as on Figure 1 and Figure 2.

Figure 1 described the schematic of the proposed peristaltic pump. In this picture, the direction of fluid flow is depended on the rotation of its bar. While Figure 2 showed the component of the proposed pump. Overall, the peristaltic pump was proposed to construct by ten components as given in Figure 2. This number are not too complicated to develop by any private-made or home industry.

3. Prototype Development
The prototypes of peristaltic pump in this experiment was constructed based on the component which are easy to be obtained in the market. Some of this component were also selected from recycling items. The components were plywood board, elbow iron, 2 mm plate iron which is made circular with a diameter of 400 mm, six bearings for the inside of the wheel and bearing housing, sprocket as a
connection to the tool fitness, two skate-board wheels, shaft, and hose. The components of the pump are shown on Figure 3(a) to Figure 3(j).

![Figure 3](image1)

**Figure 3.** Component of peristaltic pump, namely: (a). Wheel trajectory area, (b). wheel, (c). Hose, (d). Ball bearing, (e). Handlebars, (f). Shaft, (g). Pillow block, (h). Gear, (i). Frame of body, (j) Rolling process

Referring to Figure 4, wheel trajectory area was the area which the wheel pressed the hose to obtain higher pressure of the fluid inside of the hose.

![Figure 4](image2)

**Figure 4.** Front view of the peristaltic pump

![Figure 5](image3)

**Figure 5.** Back view of peristaltic pump.

Wheels was the component of the pump which had two functions, namely: 1. To press the hose between two sides in order to obtain clamping zone for the water and (2) To push the water inside of the hose by sliding in the trajectory area. Body and frame of body had a function to form the pump itself. Specification of the hose. The hose had been clamped in the wheel trajectory area. The wheel had designed to slide freely. This meant to reduce friction between the wheels and trajectory area. Friction in this area would increase loss of the pump. Figure 5 showed gear and chain of the peristaltic pump as the connection part of the pump with the power resource in order to rotate the pump.

4. Theoretical and Experimental Methodology

Theoretical and experimental methodology were discussed in this section. This exposure aimed to describe the real condition of the proposed prototype in this work.

4.1. Theoretical analytic of peristaltic pump Performance

Performance of the peristaltic pump was analysed by measuring the ability of the pump to transport the water. Consideration of its operating principles, the volume of the water of fluid which moved by the pump was determined by the quantity of the water or fluid that could be transported for each rotation of the pump. The maximum value of the water was assumed as much as a volume of the hose in the arc between two wheels. Both wheels were in handlebar which were stretched in a straight line which mean the wheel has 180° angle for each other. which mean arc of half circle. Thus, length of the
hose for this condition are given as follows:

\[
L_{\text{tube}} = \frac{\text{arc between the wheels}}{360} \times \Omega_{\text{pump}}
\]  

(1)

where \( \Omega_{\text{pump}} \) refers to circumference of the peristaltic pump circle.

\[
\frac{\text{Vol}}{\text{rotation}} = L_{\text{tube}} \times A_{\text{in}}
\]  

(2)

Peristaltic pump developed in this experiment had 200 mm radius where the hose that was selected for the prototype had 15.8 mm of inner diameter. So, the maximum volume for one rotation of peristaltic pump operated was expected around 123.19 mL.

In the emergency, people require around 20 L of water. This number was approximated for one standard pail. The quantity of this water was able to be theoretically fulfilled by the proposed peristaltic pump in the minimum of 163 rotation.

![Figure 6. Experimental set-up for the peristaltic pump for hand driver](image)

![Figure 7. Peristaltic pump in connection with static bike.](image)

4.2. Equipment testing methodology

Testing is carried out to find out whether the tool can work well to its designed function or not. The tool is said to be successful if it can transport fluid until to the height of at least 5 meters. There are two types of tests performed, namely testing with hand stroke and testing with a drive for Fitness equipment. A trial is conducted at least three times in different rpm and different heights. It is conducted to determine the performance of the pump. Analysis are done by testing the pump from a height of one to five meters.

In every head variation, the experiment was conducted in the hand driver as shown in Figure 6 and static bike as the energy source as shown in Figure 7.

5. Results and Discussion

Peristaltic pump was examined in two methods. The first experimental was conducted to operate the peristaltic pump with hand power as the driving source. The results were compared with results of peristaltic pump driving by the static bike.

5.1. Peristaltic pump results with hand operation

Theoretical calculation of the pump showed that obtaining 20 L of water would require 163 rotations. However, the actual volume would be less than this quantity. This was due to the flexibility of the hose and pressing of the wheel on the hose. Regarding of the losses measurement, the experiment was set up to operate the pump to transport the water in the height five metres with hand driver. Experimental results shown that the prototype of peristaltic pump was able to deliver 20 L of water for the height of five meters by using hand driver in 10.6 minutes.

5.2. Peristaltic pump results powered by static bike

The pump testing process that has been connected to the output of the fitness equipment is carried out using the same method by measuring the time needed to move water within the height of five meters. The measurement shown that the integration of both peristaltic pump and static bike was able to
delivery of the water for this height in 6.25 minutes or 375 seconds. This quantity described that the improvisation had been successfully increased the time to transport the water in the height of five meters for around 41%. The results of peristaltic pump testing with a mechanical drive system from a static bike are given in Figure 8.

![Figure 8](image)

**Figure 8.** Results comparison for the peristaltic pump which operated by hand and integrating with static-bike.

Figure 8 referred to the pump drove by hand power with rotation in the range of 50-55 RPM while the results for integrating tool of peristaltic pump operated by static bike as the energy source with rotation speed in the range 100-110 RPM was.

The results in Figure 8 also described that the characteristic of the pump enough constant for transporting variation of water volume. This was showed that the discharge of the pump is quite stable for fulfilling the 10 Litters and 20 Litters of water.

6. **Conclusion**

In this work, peristaltic pump was developed by using the material that was easy to obtain. Its simplicity in the construction made the components of the pump were able to be built in home industry scale even for the private. The results showed than this prototype was able to transport the water from the height of 5 metres in around 10.58 minutes to provide less and more of 20 L of water by using hand driver.

The combination of the peristaltic pump with the static bike had significantly shortened the time almost twice to move water for the same condition, namely height of 5 metres and 20 L of water. In this situation, static bike replace hand to operate the pump.

This research was also showed that light modification in order to combine between the peristaltic pump and static bike could improve the function of each equipment. These results brought to the reason that the proposed integrated equipment was able categorized as a versatile tool for daily use.

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