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INVESTIGATE OF MANUEL COOLING SYSTEM USED VORTEX TUBE

Ayşe DANIŞ*, Kerim ÇETİNKAYA*
* Karabük University, Technical Education Faculty, Karabük, TURKEY

Abstract

In this study, a functional vest which can be worked by manuel without any starting system was designed and a prototype was produced for peoples cooling requirement. This system was made of a vortex tube, knee pad, linear motion mechanism with 3 members and vest.

While walking, depending on knee's movement, a piston at linear motion mechanism was moved front and backward. This front and back movement was used obtain pressured air and this air was sent to vortex tube with pneumatic pipes.

In the experiments, one piston on one leg were used. Using one piston, the air was pressured and sent to the system during 1 minute. Thus, the temperature of air out coming vortex tube was decreased about 1,9ºC.

Occured cold air in the vortex tube was carried on vest surface with placed pipes periodically. Thus, it will be cooled in summer. Also, this system can be used any working environment, because of its lightweight and wearable. Using this system, efficiency and performance of employees were increased. In this way, product quality and economic can be affected positively direct or indirect.

Keywords: Vortex tube, cooling

1. Introduction

People always use cooling and warming technologies for keep their daily lifes. So, cooling, warming and climate of peoples living environment are indispensable for much comfortable. Nowadays, cooling and warming systems are developed more smaller and portable. Also these systems can be operated quickly.

There are many studies at literature about cooling using vortex tube. Especially these studies were based on how its work. Saidi et al. [1] were performed experiments to understand of vortex tube principle. They focused on categorize parameters of effeecting vortex tube performance. They were classified parameters as geometrical and thermophysical. Yılmaz et al.[2] were studied on design and classified of vortex tubes, fluid medias, vortex tubes at industry, and production of vortex tubes at first part of article. At second part, they were investigated research and examine methods of vortex tubes, energy separation in vortex tubes, parameters effecting of vortex tubes performance, and vortex tubes preformance. Usta et al. [3] were performed experiments about cooling behaviour of air and oxygen in vortex tubes. And they were compared different fluid media at experiments.

Vortex tubes were invented form Rangue (Ranque 1933) and then improved from Hilsch (Hilsch 1947). These tubes are called Rangue Vortex Tube (RVT), Hilsch Vortex Tube (HVT) and Rangue-Hilsch Vortex Tube (RHVT) for these scientists.

Vortex tube is a simple device which can be worked only pressured gasses, but have no moving parts except for control valve. High pressure gas enters to tube tangentially, and this simple mechanical tube can be

Corresponded Author;adanis@karabuk.edu.tr

divided entering gas to hotter and colder gasses. The principle of vortex tube and its geometrical model are showed in Figure 1.

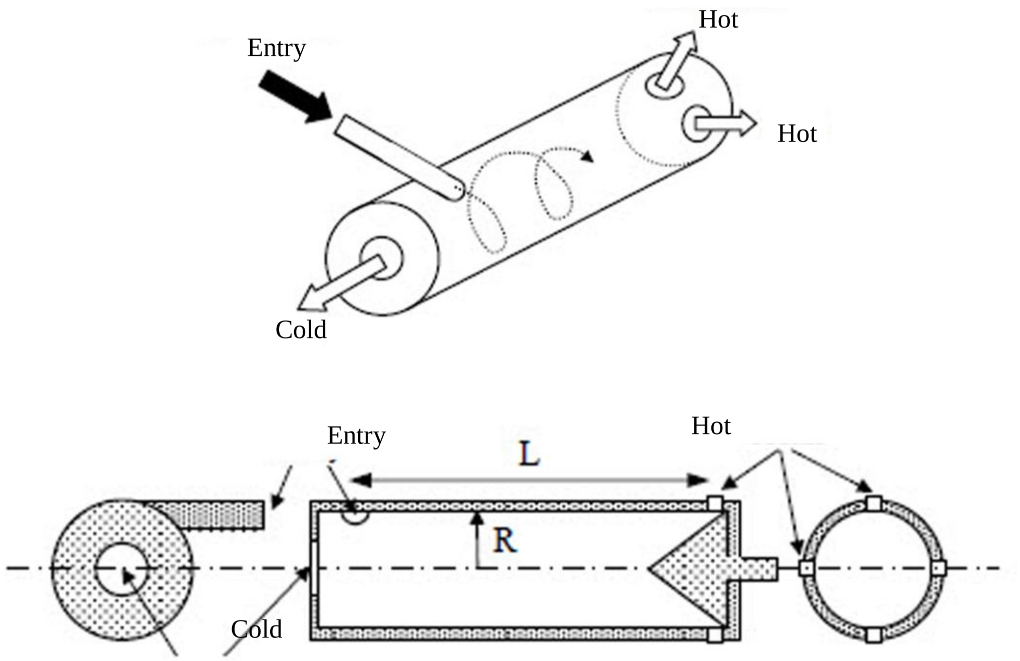

Figure 1. Vortex tube, (a) The principle and definition of parameters, (b) tube geometry [2].

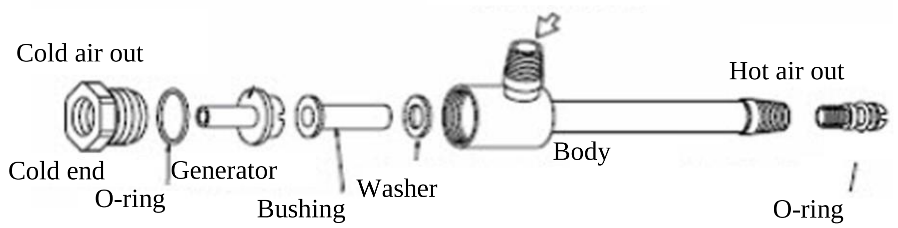

Figure 2. Vortex tube with counter flow generator [4].

Vortex tubes are applied to areas of requirement of portable, reliability, and low cost production. Vortex tubes have many advantages than traditional cooling devices [2,5,6]. They have simple geometry. Because of this, they can produce easily. Size of vortex tube is small and also lightweight. They don’t have any moving parts, so minimum wearing occurs. They can be used safely and portable. On the other hand, in addition to these advantages, they have a few disadvantages [2,5,6]. They operate loudly and need to pressured gas resource.

2. Material and Method

Experimental system has counter flow vortex tube, installed three members piston mechanism on knee, air pipes and planted couplings on vest between specific spaces. Model of this system is showed in Fig. 3.

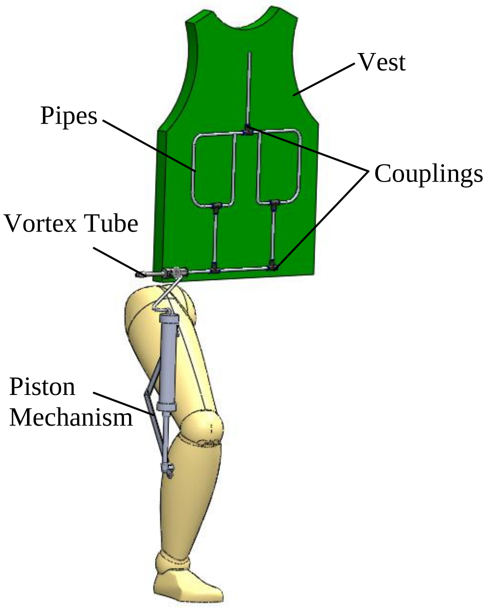

Figure 3. Experimental system model.

Inner diameter of vortex tube is 9 mm and length is 102 mm. The piston was pomped air to vortex tube and piston has 100 mm length, 35 mm outer diameter, 1 mm thickness. Piston material is high strength plastic and it was choosed because of ligthweight. Air was pumped throught front cover when piston moved forward and sent using couplings. These couplings set on front cover. Three piston members was made of St 37 low carbon steel and lengths are 215 mm and thicknesses are 1 mm. The piston was installed on members using pipe clamp, axial rotation fitting parts, M4 screws and nuts. Open and close position of piston mechanism is showed in Fig. 4. Four T couplings were used in system. T couplings were planted specific spaces on undercoat of vest for installation of air pipes. Pipe and coupling with 6 mm diameter were fixed at input of vortex tube. For distribute air in vest, pipes and couplings with 4 mm diameter were used, too. For this decreased of diameter, air velocity was increased and ligthweight design was achieved.

Figure 4. Open and close postion of piston mechanism

Distributed pipes and couplings are showed in Fig. 5.

Figure 5. Set pipes and couplings on vest.

Due to matching knee ergonomic, medical knee pad with hinge was choosed. Mechanism movement was simplified using hinge system. System can be put off without break down.

2.1. Technical properties of system

In installed system, members of piston mechanism were started to pump air in system using muscle power.

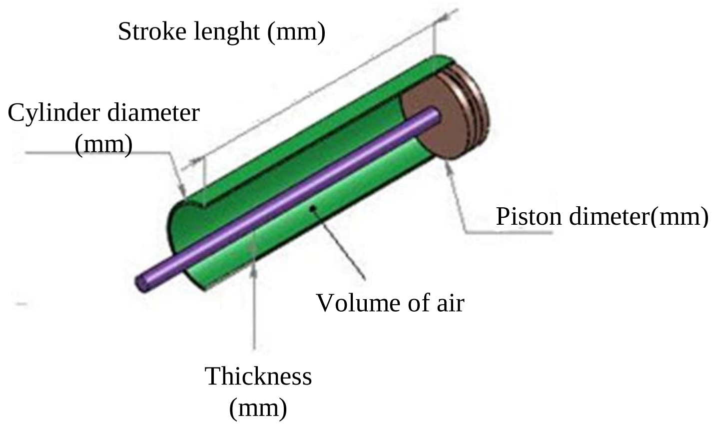

Figure 6. Section of piston

Stroke length of piston is 100 mm. Outter diameter of cyclinder is 35 mm. These values are showed in Fig. 6.

Volume of air (VH)

In system, total volume of sent air can be obtained using stroke length value and diameter of piston as showed in equation 3.1.

$$VH = \frac{\pi D^2}{4} x H \rightarrow VH = \frac{\pi (\frac{35}{1000})^2}{4} x 0.1 \rightarrow VH = 9,621127x10\text{-}5 \text{ m } 3 \quad (3.1)$$

Transporting this air was actualized in 1 second, so this value can be determined as flow.

Flow of air (Q) was calculated 9,621127. 10-5 m 3/s. Pressurized air was forwarded to vortex tube with 6 mm diameter pipe. Using obtained flow value, velocity of air entering vortex tube can be calculated in equation 3.2.

Velocity of air

Flow=Area x Velocity

(3.2)

Q=(π x r2) x V
9,621127x10-5 = (3,14 x 0,0032) x V
In here, velocity of air (V) entering vortex tube was calculated (V) 0,009075 m/s.

2.2. Design and analysis of members and piston.

Used the piston mechanism for sending air is showed in Fig. 7. in operation of system, the members can be opened maximum 119 degree. at this degree, distance of piston from cylinder cover was 59,390 mm. when members degree was 119, the auxiliary members degree was 169,63.

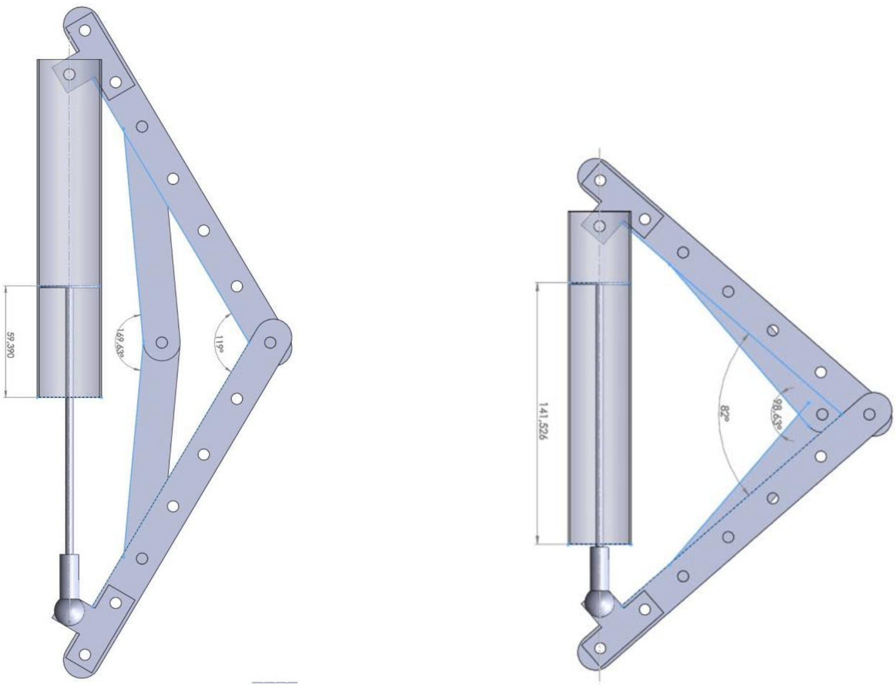

Figure 7. Piston mechanism

The members totally closed or the dead point of members was 82 degree. at this degree, degree of auxiliary members was 98,63. and the distance of piston from cylinder cover was 141,526 mm. with these values, stroke length of piston could be calculated 82,136 mm.

Graphic of stroke length depending on degree between members is showed in Fig. 6. minimum stroke length was obtained at 82 degree. and maximum stroke length was obtained 119 degree.

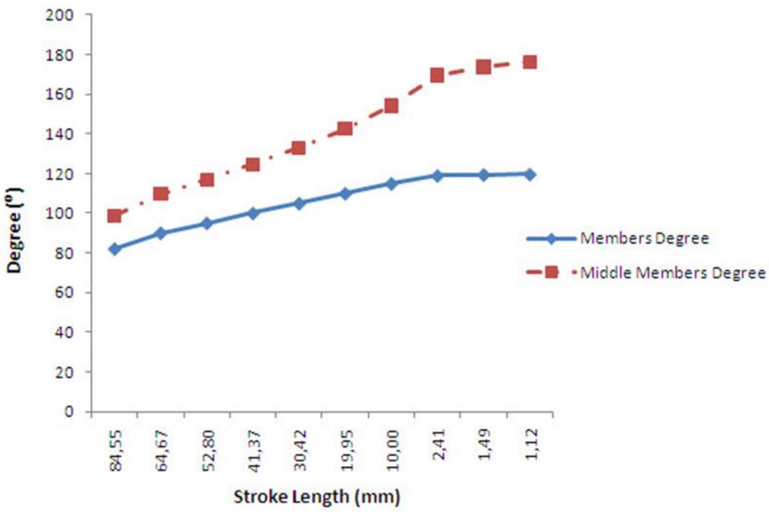

Figure 8. Relation between members degree and stroke length

3. Results and Discussion

3.1. Cooling experiment

%1 precision manometer was used for measuring input pressurized air. And digital thermocouple ±1°C precision was used for measuring temperature of output hot and cold air, too. Thermocouple probs were set 1 cm distance from hot and cold output ends.

3.2. Results of cooling experiment

In the system, air was sent regularly about 0,5 bar pressure using piston mechanism. Begining of sending air, the temperature was 25,4°C. it was achieved that 25,4°C temperature was decreased about 23,5°C. thus, the gap between begining and end of experiment was 1,9 °C. Temperature graphic of sending 0,5 bar pressure air during 1 minute is showed in Fig. 8.

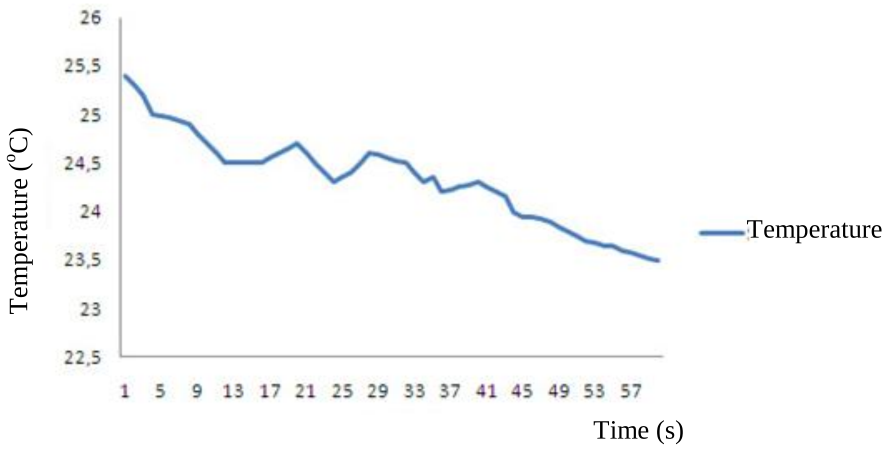

Figure 8. Sending constant 0,5 bar pressure air during 1 minute

4. Conclusion

It was realized that the prototype of portable cooling vest with vortex tube was designed and produced. Pressurized air was sent to system using one piston. in experiments, the air was constant 0,5 bar pressure and sent regularly finally, sending this air, decreasing of temperetaure was obtained about 1,9 °C.

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