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Comparison Between Traditional Air Conditioning System and Wearable Cooling/Heating Devices

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***Abstract*— Heat is always generated in human body due to metabolism and because of this heat generation human body feels discomfort during cold or hot weather, and this is the reason of the development of a system through which temperature can be set within the range of human comfort. Till now this requirement was fulfilled by Traditional Air Conditioning System which majorly uses Vapour Compression Refrigeration System (V.C.R.S), but with the development in technology new devices are coming in the market which are able to provide cooling and heating to our body only and are wearable. In this paper we will discuss about some of the wearable devices and a detailed comparison on the basis of many different points between these wearable devices with traditional Vapour Compression Refrigeration System based space air conditioning system. We will also check capabilities and possible future developments in these new age wearable devices.**

Keywords*— *Traditional Air Conditioning Syastem; Wristify; Therfmoelectric Cooling/Heating Jaclet; Vortex Coolong Jaclet

I. INTRODUCTION

Human body needs to be maintained at specific temperature limit. This temperature control is done by a proper cooling/heating system. Till now majorly used cooling/heating system is Vapour Compression refrigeration system (V.C.R.S) based devices. These devices use a Vapour Compression refrigeration cycle in which a refrigerant flows and carries heat from low temperature region and rejects heat at high temperature region or vice-versa.

A recent study shows that traditional air conditioning system is one of the basic necessities of living. Air conditioning consumes a lot of power to operate and also cause harm to the environment, lacks portability and unable to operate at extreme conditions where proper supply of electricity is not possible. Due to all these limitations of traditional air conditioning system, new devices has been developed which have potential of eliminating these limitations of traditional air conditioning systems.

These new devices will be further explained and compared with the traditional air conditioning systems in later parts of this paper.

II. LITERATURE REVIEW

Wearable cooling/heating devices have ability to control human body temperature when they are worn. These devices are thermoelectric bracelet [1], a thermoelectric cooling jacket [2], a vortex tube cooling jacket and many other devices which are at development stage that's why only these three devices will be discussed in this paper.

2.1 Thermoelectric bracelet:

A thermoelectric bracelet is a device that regulates wearer's body temperature. The main component of thermoelectric bracelet is a peltier device [4] which liberates heat from one side and cools the other side when an EMF is given to it. It is made from heat sink of copper alloy, a heat exchanger to transfer heat. The heat sink absorbs dispense heat away from hot side of the peltier device to lower down device temperature. An automated control system with certain algorithms is used to manage intensity and duration of thermal pulses.

A device is developed by students of MIT Sam Shames, David Cohen-Tanugim and Matt Smith in 2013 known as *wristify* [5]. Wristify works on the principle of thermoelectric bracelet [1]. In wristify a peltier device [4] which is in shape of plate with two sides, one cold side and one hot. The hot side is attached to a heat sink of copper alloy which will dissipate heat and cold side will be in contact with wrist to cool down blood which will ultimately cool whole body, a sheet can also be provided between wrist and cold side of peltier.

2.2 Thermoelectric cooling/heating jacket:

The jacket is designed in such a way that thermoelectric device [4] and heat sink are housed in a pocket at the back side of jacket. An insulation layer provided between cold side and hot side [2]. There is separate pocket for keeping battery. Interconnections are made internally and a control switch is connected. The cooling side will cool all the air present between jacket and body.

2.3 Vortex Tube cooling jacket:

This jacket is based on use of vortex tube [3] and compressed air for cooling. A vortex tube [3] is a new type of energy separation equipment which consists of nozzle, vortex chamber, orifice plate for separation, hot side control valve and hot end tube.

This jacket is in the shape of vest which has holes at its back, chest and face side which supplies cooled air coming from the cool side of vortex tube. Paper presented by Xiaojie Zhai [3] use this jacket specifically in coal mines. The high pressure air enters the vortex chamber and eddy current is generated because of rotational movement of gas which will lead to separation of air into two different temperatures, hot air will be directed to the atmosphere through hot end tube and control valve whereas cold air will be fed to vest for cooling of body.

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III. COMPARISON

Now we will compare traditional air conditioning system with wearable cooling/heating devices on the basis of space of application, performance, comfort ability, operating conditions, life, environment, cost and production.

3.1 Space of application:

Traditional air conditioning systems are used for air conditioning of a definite space like a room, a cabin or a box. While in case of wearable devices cooling/heating is personalised. Wristify will cool the body of human, thermoelectric jacket will cool/heat only the upper half of the human body and vortex tube jacket will only cool the upper half of the human body by supplying cool air through vents.

3.2 Performance:

Performance is the ability of device to give required output on giving definite input.

We will compare wearable devices with traditional air conditioning unit of 1.5 TR capacity as done by *Prof. S.H.Shaikh, Prof. A.M.Patil and Prof. A.M.Vibhute in their research paper Performance Investigation of Window Air Conditioner* [6].

Coefficient of performance (COP) = Refrigeration effect/work done by compressor

Actual COP of 1.5 TR Window Air Conditioner = 2.172 [6].

Performance of vortex tube is calculated by Jeliazko Polihronov and Anthony G. Straatman in their paper The Maximum COP of Vortex Tube (April 2015) [7].

According to them COP = $1/(\gamma \pm 1)$

Where $\gamma = 1.4$

Negative sign is used when harvested work from the cold gas in reinvested whereas positive sign is used when harvested work from the cold gas is not reinvested.

Therefore, maximum COP = 0.42 or 2.5 [7].

For performance of thermoelectric device (Peltier device) that is used in wristify and thermoelectric jacket a paper was published by *Jatin patel, Matik patel, Jigar patel, Himanshu modi [8]*.

According to them COP of thermoelectric cooler = 0.564432.

Whereas in the same paper they achieved COP = 1.2151 by using multistage thermoelectric cooler.

3.3 Comfort ability:

Human comfort is the condition of mind that expresses satisfaction with thermal environment.

This human comfort depends upon factors such as temperature, air velocity, humidity but in case of wearable devices weight and positioning of device will also add into the comfort factors.

All these factors are discussed in this paper.

3.3.1 Temperature:

All these wearable devices and traditional air conditioning systems are capable of maintaining comfort effective temperature which is in range of 21°- 29° Celsius as stated in ASHRAE [9].

3.3.2 Humidity:

As the traditional Air Conditioning system is capable of maintaining comfort relative humidity which is 60-70% for 90% of people as stated by ASHRAE [9] but wearable devices are not capable of maintain humidity.

3.3.3 Air Velocity:

Air velocity is considered in the case of space air conditioning which is controlled by fan fitted with evaporator. But in case of wearable devices air velocity is not considerable.

3.3.4 Weight and Positioning:

In case of traditional air conditioning system weight is not considered as it is not in physical contact with human body. But in case of wearable devices weight should be considered.

No specific data is given regarding weight of these devices but it can be assumed that whatever the weight may be, it will lead to discomfort to some extent.

3.4. Operating Conditions:

At a place where supply of electricity is hardly or not available at all, in these conditions traditional air conditioning system can't be used whereas wristify and thermoelectric jacket can be operated at very less amount of electricity stored in battery and vortex tube jacket will not need any electricity, it only need a compressed air source.

Traditional air conditioning system needs a proper installation before there usage whereas wearable devices can be operated without any such need.

3.5 Life:

Life of traditional air conditioning system is 15-20 years as described by USDOE [10].

Life of vortex tube jacket is more than 5 years [3].

Life of thermoelectric module used in wristify and thermoelectric jacket is 2,00,000 hours or 23 years approximately [10].

3.6 Environment:

A thermoelectric device (Wristify and thermoelectric jacket) does not emit any harmful emission.

Vortex tube rejects only air at very high temperature into the atmosphere but that does not harm atmosphere in any way.

In case of traditional air conditioning system compounds used as refrigerants are harmful for nature if leaked.

3.7 Cost:

Cost for Air Conditioner of 1 TR is on average 25,000 INR (for window type) and there are installation charges according to the type of Air Conditioner (window, split and centre).

Operation and maintenance cost is also very high in the case of traditional air conditioning system and maintenance is needed annually.

Vortex tube jacket costs around 3200 INR (300 Yuan) as on 09/09/2018 [3]. And according to the paper by Xiaojie Zhai vortex tube needs only $1/16^{th}$ amount for operation in comparison to traditional air conditioning system and needs only $1/25^{th}$ amount for maintenance in comparison to traditional air conditioning system.

Wristify is now a product manufactured by Embr Labs and the selling price is $299.00 which is roughly 21,500 INR on 9/09/2018. Maintenance and operation cost is not defined but it is comparatively lower than traditional air conditioning system.

Thermoelectric jacket is not launched as a product therefore costing is not done.

3.8 Production:

As we all can see around us that Air conditioners are available everywhere and there is no problem in mass production.

Mass production of Wristify is also started by Embr Labs and is available in markets.

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Thermoelectric jacket and vortex tube jackets both are in development stage and production is not yet started.

IV. RESULT

Result in shown in figure 1.

DEVICES		TRADITIONAL AIR CONDITIONING SYSTEM	WRISTIFY	THERMOELECTRIC JACKET	VORTEX TUBE JACKET
S.no	BASIS				
1	Space of Application	Large Room	Body	Upper Body	Upper Body
2	COP	2.172	0.56	0.56	0.42-2.5
3	Comfort				
3.1	Temperature	Yes	Yes	Yes	Yes
3.2	Humidity control	Yes	No	No	No
3.3	Air Velocity	Yes	Not Considered	Not Considered	Not Considered
3.4	Weight of device	Not Considered	Very light	Light	Light
4	Operating Conditions	Needs proper operating conditions	Can be used at remote places	Can be used at remote places	Can be used at remote places even without electricity
5	Life	15-23 Years	23 years	23 Years	5 Years
6	Environment	Harmful when refrigerant leaked	Not harmful	Not harmful	Not harmful
7	Cost	25,000 INR for 1.5 TR unit (window)	21,500 INR for 1 person	Not available	3200 INR for 1 piece
8	Production	Mass production	Mass production	Prototype	Development stage

Fig.1. Figure of result table.

V. CONCLUSION

So in this paper we compared our traditional air conditioning system with the new age wearable cooling/heating devices. We found that these devices are still in development phase and are currently not is position to completely eradicate traditional air conditioning systems. Also these wearable devices are not capable to control other comfort factors like relative humidity and air velocity. But these devices carry a huge potential in portable and small cooling capacity, maintenance, operating and installation of these devices is very cheap as compared to traditional air conditioning systems.

For large space cooling traditional air conditioning systems are still best option and cannot be replaced in near future.

VI. FUTURE SCOPE

COP of thermoelectric based devices can be increased in upcoming researches.

Some mechanisms can also be found out to control other comfort factors.

Smart systems can also be integrated to increase the user friendliness of the wearable devices.

REFERENCES

[1] https://patents.google.com/patent/US9456529B2/en
[2] Ahammed, K. N. (2013). Thermoelectric Cooling Prototype Jacket. MES J. Technol. Manage., 5, 85-94.
[3] Zhai, X. (2017, August). Research on the application of vortex tube type of cooling jacket in coal mine. In AIP Conference Proceedings (Vol. 1864, No. 1, p. 020220). AIP Publishing.
[4] https://www.marlow.com/how-do-thermoelectric-coolers-tecs-work
[5] https://spinoff.com/wristify
[6] Performance Investigation of Window Air Conditioner by Prof. S.M.Shaikh, Prof. A.M.Patil2, Prof. A. M. Vibhute published in IOSR Journal of Civil and Mechanical Engineering (IOSR-JMCE) ISSN: 2278-1684, PP: 32-37
[7] Polihronov, J. G., & Straatman, A. G. (2015). The Maximum COP of Vortex Tubes. Can. J. Phys, 99, 1-4.
[8] Patel, J., Patel, M., Patel, J., & Modi, H. (2016). Improvement In the COP Of thermoelectric cooler. International Journal of Scientific & Technology Research, 5(05), 73-76.
[9] ANSI/ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy.
[10] https://www.energy.gov/energysaver/central-air-conditioning
[11] http://www.beercooler.com/thermoelectric.html