Design of water generating device using peltier effect for access of affordable and clean water

[1]Nikhil Nandkumar Kulkarni

[1]Research Scholar, Dept. of Mechanical Engineering,JSPM'S Rajashri Shahu College of Engg., Pune, Maharashtra, India

Abstract : This device is able to generate a clean and palatable drinking water by absorbing the water vapor present in humid air. This device uses the process of dehumidification of surrounding air and generates consumable drinking water. This device might have several applications in defense and during natural calamities. It also has a self sustaining future scope where it can use the solar energy for its necessary power generation and also storage for further usage. It can also be designed to distill the impure water using filtration and sanitization of muddy water, which can also be added further in design.

IndexTerms **– water generation, clean water, peltiereffect, dehumidification, filtration, condensation, solar energy, condenser.**

I. INTRODUCTION

After a detail analysis and study of the systematically recorded data of last few decades on the occurrence of natural calamities due to man made changes in the environment or naturally occurring calamities it has been observed that the survival of the being in such critical situation needs some basic amenities, and the basic amenity of water ranks high in such situation so the idea or need for undertaking such project was important. Also in military and survival in inhospitable condition requires basic edible water that led us to developing this device.

There have been numerous endeavors to provide clean drinkable water in the situation of some natural calamities such as earthquakes and flood naming the few. The physical connection is cut off and the distribution of basic amenities such as food, power and water is disturbed, the main issue arises of distributing of water and storing the water in large containers for its further consumption. Thus the delay in such tedious and costly process partly due to collapse of roads and connectivity may prove to be curse to humanity. So to tackle such situation with lack of standard infrastructure the emergency water generation device need to be developed which can be safe, easy to use and independent to operate. This was the primary purpose to develop a water generating device.

II. MOTIVATION

It's a fact that more than 75 percent of the human body is composed of water and unfortunately it's also a fact that 1.2 billion people lack the access to clean drinkable water (as in 2017), the reason being water pollution and less sources of drinking water, and its not just those 1.2 billion people, if we look at our daily lives, whenever we go out, what we prefer to drink is bottled water. So this being our basic problem statement we preferred to develop a project for the community that would solve the drinking water issue to some extent. The atmosphere holds some amount of water as humidity, and India is one among those countries that is blessed with an average humidity of more than 45 percent. In order to make use of humid conditions we came up with an idea to develop a bottle that can extract water on its own by absorbing humidity from the environment.

III. MARKET SURVEY

Before developing the initial designs we did a survey for understanding the prevailing problems, know the requirements, know the cost expectations and also to get an overview of the design of life bottle.

A Google form was created and individuals including our colleagues, friends, family members, etc were requested to fill the same. We got an overwhelming 121 responses, the results of the survey are as stated below:

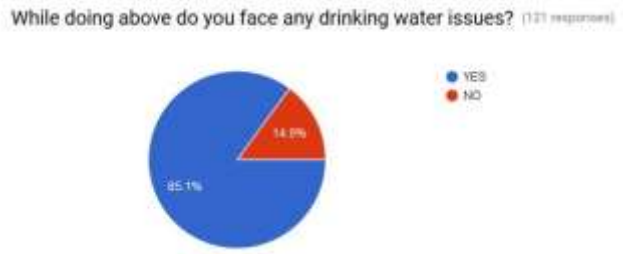

Figure 1 Pie chart 1

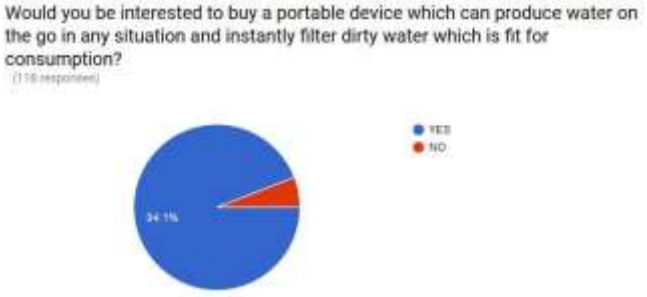

Figure 2 Pie chart 2

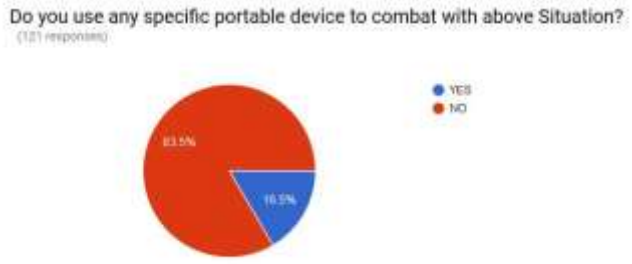

Figure 3 Pie chart 3

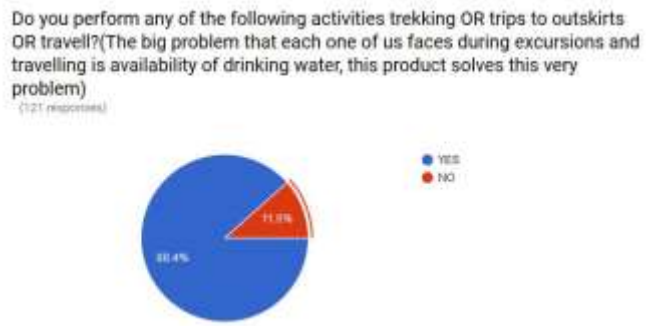

Figure 4 Pie chart 4

IV. CONSTRUCTION

Until this point of time we are able to come up with two designs, the first being the very initial draft for the product. While the second model was created after intense research and an in depth study of the processes involved in the production of clean drinking water. The initial design has undergone various optimizations in order to achieve greater ergonomics as well as the ease of machining in order to keep the machining costs low as possible. The existing model consists of:

1. Heat sink
2. Peltier module array
3. Condenser
4. Storage container
5. Cooling fan
6. Intake fan and Exhaust fan

V. EARLIER DESIGN

This design was based on the first design but has undergone various changes as well as many parameters were either eliminated or defined in order to eliminate any ambiguity in the design of the bottle. The dehumidifier unit was redesigned. This was done after calculations were carried to decide the amount of air flow, the no of thermoelectric tiles, the configuration of these tiles, placement of the fan on the top from its earlier place inside the cap. The requirement of the heat sink in order to cool the heated side of the thermoelectric tiles. As well as accommodation of cooling fans for the unit and the exit of air flow from the unit. Also a condenser coil is being introduced in the hollow space to accelerate the cooling process by increasing the exposed surface area to air. Also the design for air outlet has been reworked such as that the cool exiting air would help to cool down the heat sink.

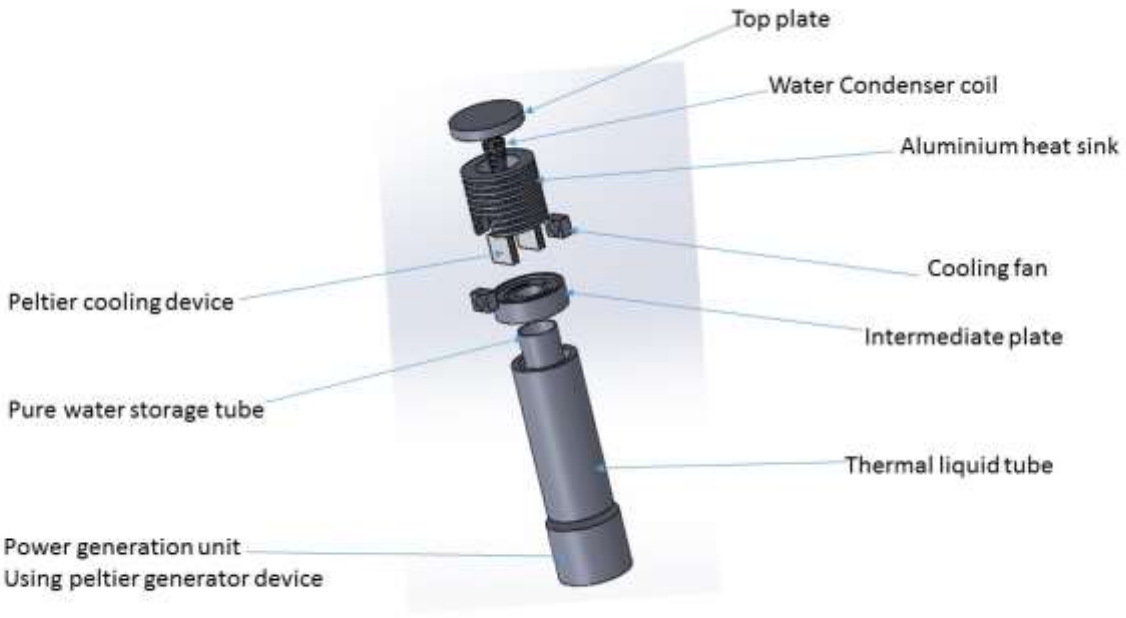

Figure 5 Earlier concept

A lid structure is introduced between the dehumidifier and storage compartment. It would have conical cross section on the lower side, this side would act as a condenser for the solar distill. The storage compartment has been divided in four parts now : The innermost being for the storage of dehumidifier condensate. The next to it will store dirty water and will contain a nano filter with activated carbon filter which will be in form of a straw. This compartment will also collect the distill water from the solar distillation process. The third compartment will be used for storing the thermal fluids, as earlier no changes have been made to this part. The outer most part will now work for two processes, that is for solar distillation and forward osmosis. It will store saline or dirty water, which could be then filtered by either process. Also at the lower end of the bottle space for the electronics and an independent power unit for the bottle will be provided. This will help us secure the electronics from any damage and also increase the portability range of the bottle. Also the This part being a little heavy will provide balance to the entire bottle and will resist tipping on any kind of surface. Also the dimensions of the bottle were decided to be 300mm in height and 100mm in diameter. These dimensions were decided considering the process requirements, ergonomics and portability.

VI. CALCULATIONS

Radius of fin (r_2) = 60mm =0.06 m
Outer radius of fin (r_1)=40mm=0.04 m
Length of fin (L) = r_2-r_1 = 60-40 = 20mm = 0.02 m
Fin thickness = 3mm = 0.03m

$$L_c = L + (t/2) = 0.02 + (0.003/2) = 0.0215m$$

$$A_p = L_c \text{ x } t = 0.0215 \text{ x } 0.003 = 6.45 \text{ x } 10^{-5}\, m^2$$

$$R_{2c} = r_2 + (t/2) = 0.06 + (0.003/2) = 0.0615\ m$$

v = 4.83 m/s

$$h = 10.45 - v + 10\,(v)^{\frac{1}{2}}$$

h = 27.6 W/m^2K

$$Lc^{\frac{3}{2}} \text{ x } \left(\frac{h}{kA_p}\right)^{\frac{1}{2}} = 0.0215^{\frac{3}{2}} \text{ x } \left[\frac{27.16}{(210)x(6.45x10^{-5})}^{\frac{1}{2}}\right] = 0.14$$

Radius ratio = $\frac{0.0615}{0.04}$ = 1.53

Since the ratio is not a whole number we consider the graph for radius ratio of 2. hence from the graph we get value of fin efficiency, ne f f = 97%

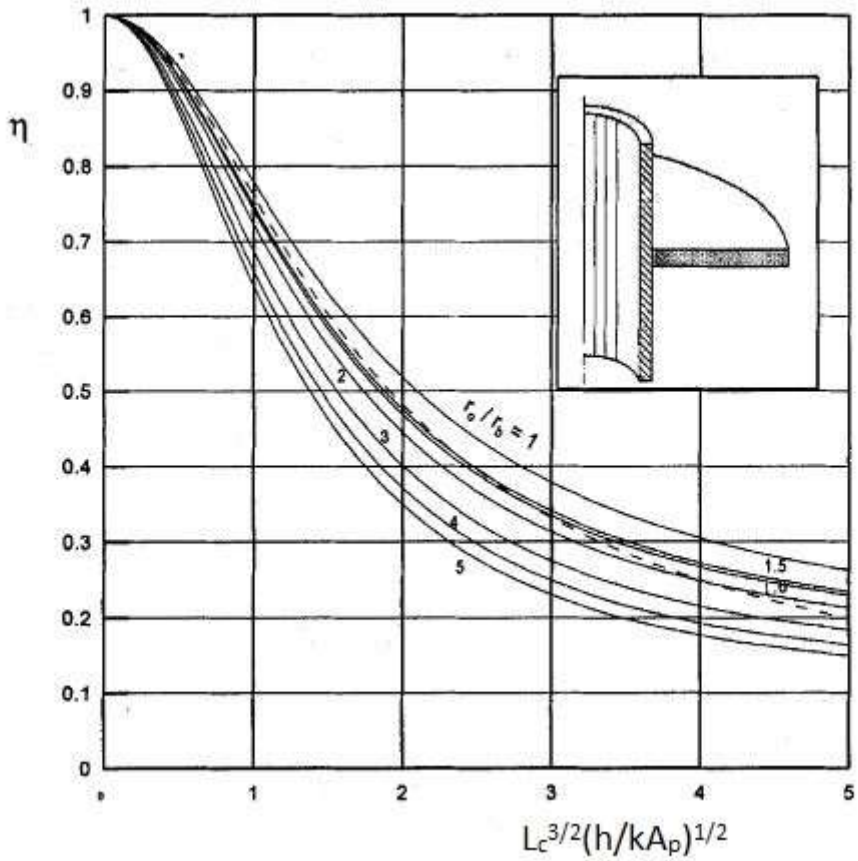

Figure 6 graph of fin efficiency

VII. CONSTRUCTION AND WORKING

A. Heat sink

There are two options available for manufacturing the heat sink i.e by casting and by conventional material removal processes, since closer tolerances as well as smooth surface finish required for the efficient operation of peltier tiles couldn't be achieved using casting, we opted for material removal processes,Also the Machining or material removal processes is less costly and much easier to design because casting require more attention todetailsand involves after casting machining process which was costly and time consuming . The manufacturing sequence is as stated below: As the Aluminium is ductile and malleable the CNC operations needed to be more precise and accurate.

1. Purchase of raw material (Al 6063 bar 200mm dia.)
2. Turning on lathe.
3. Grooving on lathe
4. Machining on VMC (Vertical Milling Center)

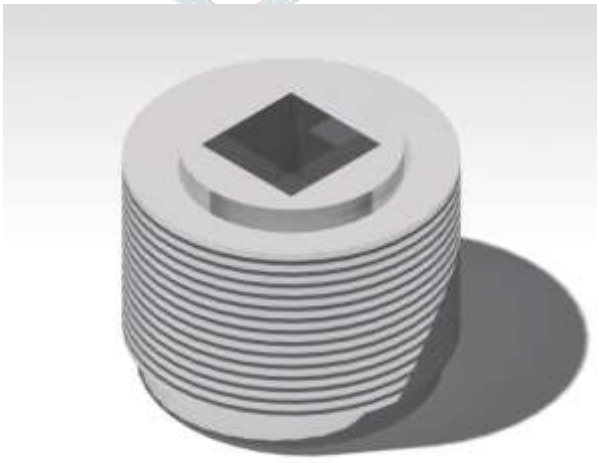

Figure 7 Actual heat sink design

B. Condenser

For manufacturing the condenser a strip slab of straight fin was purchased which are used as heat sink in workstations/pc and other cooling devices and then it was fabricated in college workshop as per design requirements.We made it as per design requirements in cubical shape where a thin Aluminium plate was cut and the attached to the fins to take the shape of the desired fin specification.

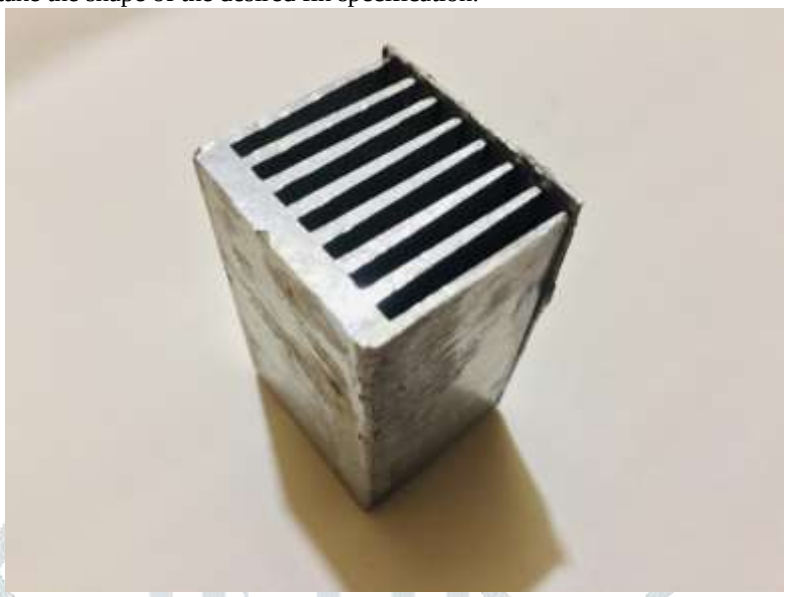

Figure 8Actual condenser

VIII. ANALYSIS AND RESULTS

A. Steady state thermal

Steady state thermal analysis of Heat sink: We have performed steady state thermal analysis of heat sink to calculate the temperature of fins at the tip, as well as heat flux of the heat sink. To obtain the result the model was imported and meshed using mesh on curvature tool to obtain the required quality of mesh. Then the model were given the boundary condition which we calculated earlier the heat flux was given on the surface on which Peltier tile is mounted and the convection of 27.6W/m 2 k was given as per the calculation of convective heat transfer coefficient. The heat flow given was about 180W. We obtained results of heat flux as well as Temperature distribution of the Heat sink. The temperature and heat flux obtained was about 49.163 degree Celsius and 30823W/m^2 respectively.

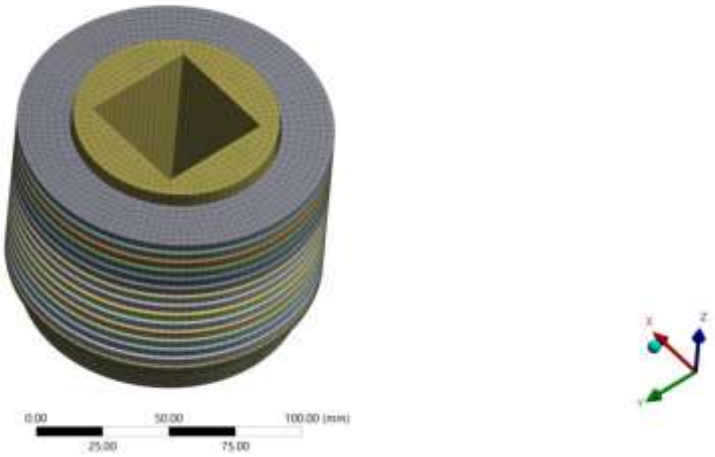

Figure 9 Sink mesh

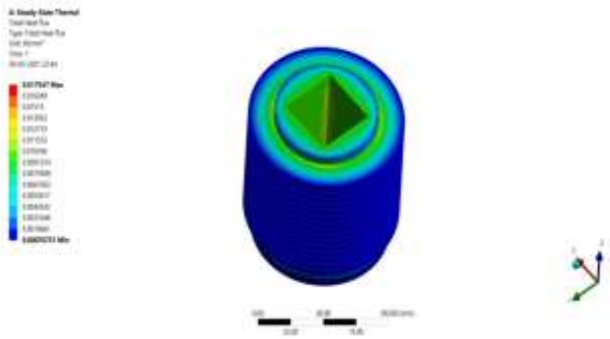

Figure 10 Heat flux of stedy state thermal

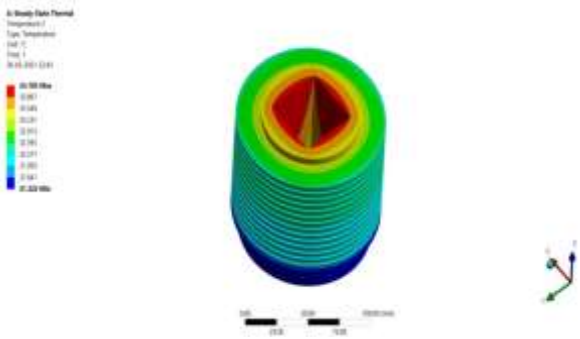

Figure 11 Temperature of steady state thermal

IX. Circuit of Arduino and Sensor

Arduino and Sensor (dht11-Temperature Sensor Module) circuit can be developed for temperature and humidity measurements the circuit diagram is as shown below.This Temperature Sensor module along with the the arduino circuit will help us to determine the temperature and humidity of fin's and surrounding air/atmosphere for validation purpose.The program will help us to retrieve the data into the laptop for further data analytics.

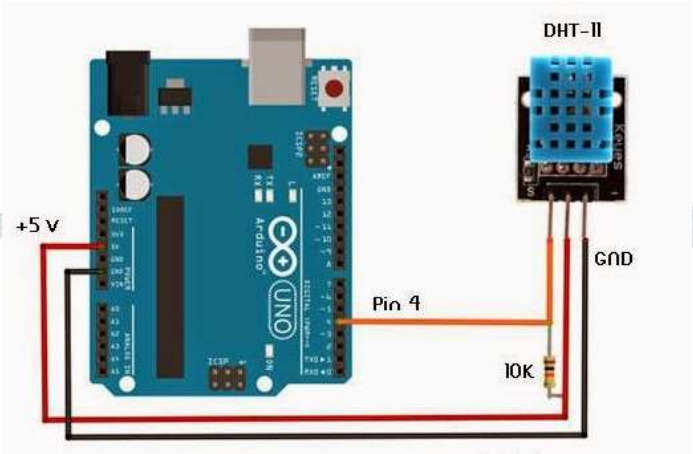

Figure12 Arduino circuit

X. Final Product

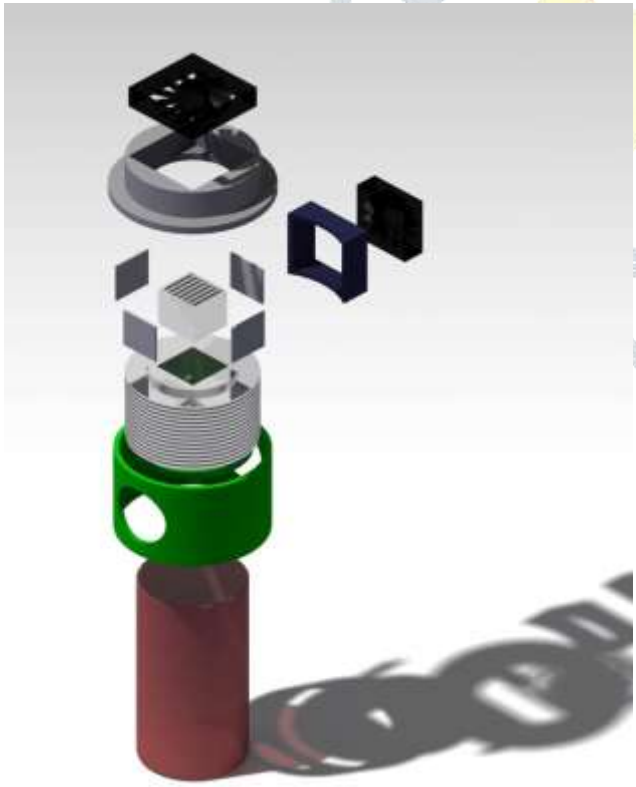

Figure13 Disassembled view

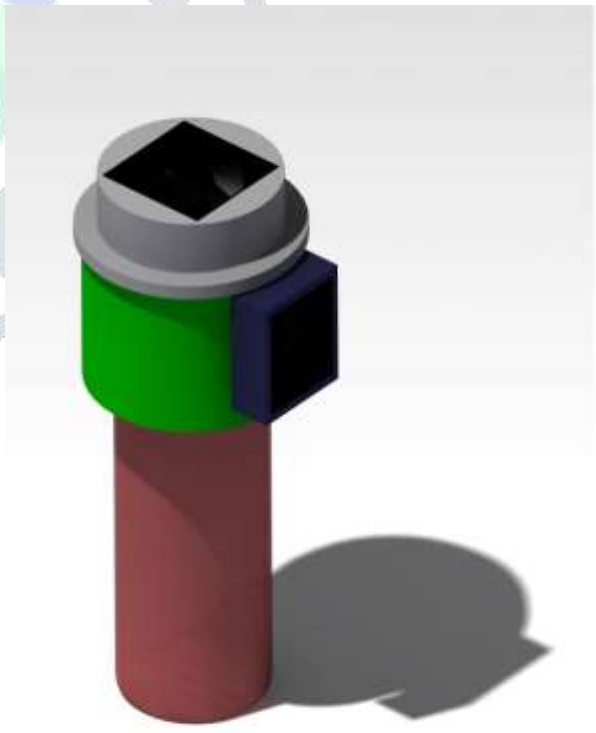

Figure 14 Assembled view

XI. Acknowledgment

We are profoundly grateful to Prof. Dr.A.M.BADADHE for his expert guidance and continuous encouragement throughout to see that this project right its target since its commencement to its completion

We would like to express deepest appreciation towards Dr. R.K.JAIN, Principal, JSPM'S Rajarshi Shahu College of Engineering, and Prof. SUBIM N. KHAN, Project Coordinator whose invaluable guidance supported us.

REFERENCES

[1] Dia Milani, Abdul Qadir, Anthony Vassallo, Matteo Chiesa, Ali Abbas- "Experimentally validated model for atmospheric water generation using a solar assisted desiccant dehumidification system.".

[2] School of Chemical and Biomolecular Engineering, The University of Sydney, NSW 2006, Australia Institute Center for Energy (iEnergy), Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates. Published by Elsevier journal. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] Aditya Nandy, Sharmi Saha, Souradeep Ganguly, Sharmistha Chattopadhyay. "A Project on Atmospheric Water Generator with the Concept of Peltier Effect". International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970) Volume 4 Number-2 Issue-15 June-2014.

[4] S. C. Kaushik, Ranjana Hans, and S. Manikandan –" Theoretical and Experimental Investigations on Solar Photovoltaic Driven Thermoelectric Cooler System for Cold Storage Application". International Journal of Environmental Science and Development, Vol. 7, No. 8, August 2016.

[5] Chhatrasal Gayner, Kamal K. Kar- ("Recent advances in thermoelectric materials") Advanced Nano engineering Materials Laboratory, Materials Science Programme, Indian Institute of Technology Kanpur, Kanpur 208016, India, Advanced Nano engineering Materials Laboratory, Department of Mechanical Engineering, Indian Institute of TechnologyKanpur, Kanpur 208016, India. Published by Elsevier journal.

[6] Inger Lise Alsvik and May-Britt Hägg, "Pressure Retarded Osmosis and Forward Osmosis Membranes:Materials and Methods", Department of Chemical Engineering, Norwegian University of Science and Technology.

[7] Hitesh N. Panchal- "Use of thermal energy storage materials for enhancement in distillate output of solar still: A review". Department of Mechanical Engineering, Gujarat Power Engineering & Research Institute, Mevad, Mehsana, Gujarat, India. Published by Elsevier journal.

[8] Ahmed Z. Al-Garni, "Productivity Enhancement of Solar Still Using Water Heater and Cooling Fan", Solar Energy Division of ASME for publication in the journal of solar energy engineering, august 2012, Vol. 134.

[9] Diana Enescu, Elena Otilia Virjoghe."A review on thermoelectric cooling parameters and performance". Department of Electronics, Telecommunications and Energy, Valahia University of Targoviste, Unirii Avenue 18-20,130082 Targoviste, Dambovita, Romania. Department of Automatics, Informatics and Electrical Engineering, Valahia University of Targoviste,130082 Targoviste, Dambovita, Romania. Published by Elsevier journal

[10] YusakHartanto, MasoumehZargar, XiaolinCui, YinghuaShen, BoJin, ShengDai.;"Thermoresponsive cationic copolymer microgels as high performance draw agents in forward osmosis desalination". School of Chemical Engineering, The University of Adelaide, SA5005, Australia College of Chemistry Chemical Engineering, Taiyuan University of Technology, Taiyuan 030024, China.

[11] Chambre Andre;"Effects of Carbon Filtration Type on Filter Efficiency and Efficacy: Granular Loose-Fill vs. Bonded Filters", CEO, Air Science, LLC March 2014.