International Engineering Journal For Research & Development
Vol.4
Issue 7

E-ISSN NO:-2349-0721
Impact factor : 6.03

DESIGN AND TESTING OF SOLAR POWERED EVAPORATIVE AIR COOLER.

Naynakumar S. Ambagade
Department of Mechanical Engineering
PRM Institute of Technology and Research
Amravati(M.S.), India
nsa7668@gmail.com

Abstract:

Energy saving mechanism is the reason behind this research project that led us to design and test a new evaporative air cooler. The conventional energy source i.e. Electrical energy which is produced in thermal power plant, is ultimately responsible for hot and humid conditions, has lots of adverse impact on environment like global warming , air pollution, water pollution and waste generation etc. also these energy generation required huge amount of coal that's why the people are more fascinating towards solar energy. In hot and humid conditions the need to feel relaxed and comfortable has become one of few needs and for this purpose utilization of systems like air-conditioning and refrigeration has increased rapidly. Air cooler are one of the major consumer of electrical energy. In future the demand can be expected to increase because of changing working time, increasing global warming and increase comfort expectations. In this project, design cooler is powered by solar energy instead of conventional energy source. We are also testing the efficiency of cooler motor and pumping system by giving different voltage and current input. The system is consists of solar panel, motor, pump, blades, water tank, wood wool and honeycomb. The conventional air cooling system is most of the time not suitable for villages due to longer power cut durations and high cost of products. This model is designed by considering the need of offices, schools and small commercial consumers.

Keyword: ***Energy saving, evaporative air cooler, solar energy.***

I. INTRODUCTION

The human body is a heat engine with 20% thermal efficiency, remaining 80% of heat must be disposed of in surrounding in order to maintain thermal balance in body otherwise accumulation of heat caused discomfort to a person. The human body works best at the particular body temperature like any other machine.

Day by day, the in energy consumption is increasing very rapidly as energy is a crucial input in the process of economic, social and industrial development as the demand for electricity is increasing the supply is decreasing which results in shortage of energy. This is called as the energy crisis. According to the law of conservation of energy, energy can neither be created nor be destroyed but can be transferred from one form to another form. Therefore, we are transforming solar energy into electricity by using solar panel. This is used to run motor and pump of evaporative air cooler.

Need for air cooler:

Humans are heat engine. We know that normal human body temperature is around 31˚C and that of environment is usually 25˚C. Hence we can say that there is some resemblance between heat engine, in which body is a heat source and environment is a sink. Heat engine can't operate when the source and the sink are at the same temperature and also if the temperature of sink is higher than source. Body temperature can vary according to the surrounding temperature and relative humidity. To maintain body temperature there is a steady flow of heat from body to environment. If the environment is very cool this flow rate of heat increased. Which lowers the body temperature and we feel cold. On the other hand if the surrounding temperature is more than body temperature there cannot be flow of heat from body to environment hence person feel hot. In such condition water from the body evaporates from through steam surface dissipating the heat due to metabolism. But if the surrounding air is hot and highly humid, very little evaporation can takes place through steam surface and hence person feel hot and uncomfortable so, we need cooler in hot summer to reduce surrounding air temperature.

Need for renewable energy:

The growing consumption of energy has resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. The increasing cost of energy over the past few years has made the energy saving concept as one of the most important research area in industry. Increasing use of fossil fuels also causes serious environmental problems. The above-mentioned problems have increased the motivation to use renewable

energy. Solar energy is one form of renewable energy and is available in many areas on the earth and can be used in different devices. In recent years, solar energy has been used as a cost-effective solution everywhere; it is clean, silent, renewable, and climate-friendly. Solar systems provide a groundbreaking vision of a sun-powered world.
The evaporative cooling is a simple, least energy intensive and environmentally benign technique of air conditioning. With the advancement of technology, different aspects of evaporative coolers have been studied and a lot of research articles are available which cover a number of significant features of these coolers. In this paper, the process of design, manufacturing, and performance analysis of a simple solar powered evaporative cooler is described. This cooler is proposed with the underlying aim of being solar compatible and environmentally friendly. The cooler can be used for air cooling of a small room in a house or an office. The cooler was tested in a specified room in order to evaluate its performance. The air temperatures at different locations in the room was measured and compared during sequential days in the summer. The results showed that performance of the cooler is relatively reasonable during the summer.

II. EXPERIMENTAL SETUP

A. Block diagram:

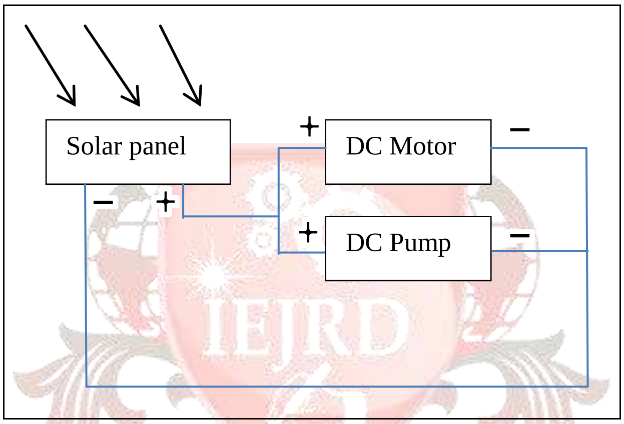


Fig 1: Block diagram of cooler

Why we choose dc supply instead of ac supply?
Solar panel can generate electricity in DC form. If we convert it into AC then, we need inverter which increase the cost of production. Conventionally AC supply is used for our home appliances. But, as we are providing supply to only one appliance which consists of DC motor and DC pump so, there is no need to convert DC into AC.

B. Cooler body:

Different types of cooler bodies are available in market, generally in metal and fiber material. We have chosen fiber body of 2.5ft*1.5ft*1.5ft dimension. As fiber bodies are shock free, non-corrosive, and light in weight, have long life, easily movable and looks good. Nowadays people are more fascinating towards compact body which is available in fiber material.

Fig 2: Fiber cooler body

C. DC Motor:

DC motors are used in applications that the connected load has to have its speed controlled. Motors generally convert electrical energy into mechanical energy. In coolers motors are used to rotate fan or blower which is implemented on their shaft. As we are using solar power which is in dc form so we are using brushless dc motor having voltage ratings of 12V in this model. Brushless dc motors are maintenance free and have longer life span.

Fig 3: 12V DC Motor

D. Fan:

The airflow also depends on a blower or a fan use by the evaporative cooler. The fan is typically powered with an electric motor. Fans are often attached directly to the motor's output, with no need for gears or belts. Smaller fans are often powered by shaded pole AC motors or brushed or brushless DC motors. In this model it is powered by brushless dc motor having three blades with 12” blade sweep.

E. DC Pump:

We are testing a performance of cooler by using two different DC brushless pumps. One of them is High pressure pump i.e. non-submersible pump, use for forming mist. Another one is High discharge pump i.e. submersible pump, use for evaporative cooling. As we are using solar power which is in dc form so we are using brushless dc pump having voltage ratings of 12V in this model. Brushless dc pump are maintenance free and have longer life span.

F. Solar panel:

A solar panel is a device that collects and converts solar energy into electricity or heat. It is also known as Photovoltaic panels. A solar power technology uses solar cells or solar photovoltaic arrays to convert light from the sun directly into electricity. In photovoltaic solar panel the photons from sunlight knock electrons into a higher state of energy, creating electricity. Solar cells produce direct current electricity from light, which can be used to power equipment or to recharge a battery.

Solar panels are available in two types that are: Monocrystalline and Polycrystalline. We have chosen Monocrystalline solar panel because it is more efficient than Polycrystalline solar panel. Also it required less space per watt and tend to perform better than rated polycrystalline solar panel at a low light condition.

G. Cooling pads:

Different evaporative cooling pads have a different water retention capacity which is attributable to the different structural features of the pad. Therefore, the performance of evaporative coolers to a reasonable degree is hinged on the saturation effectiveness of the evaporative cooling pad material. We are using two types of cooling pads that are honeycomb and wood wool type. The dimension and material of cooling pad affect the efficiency of cooler.

III. WORKING PRINCIPLE

Evaporative coolers lower the temperature of air using the principle of evaporative cooling, unlike typical air conditioning systems which use vapor-compression refrigeration or absorption refrigeration. Evaporative cooling is the conversion of liquid water into vapor using the thermal energy in the air, resulting in a lower air temperature. The energy needed to evaporate the water is taken from the air in the form of sensible heat, which affects the temperature of the air, and converted into latent heat, the energy present in the water vapor component of the air, while the air remains at a constant enthalpy value. This conversion of sensible heat to latent heat is known as an isenthalpic process because it occurs at a constant enthalpy value. Evaporative cooling therefore causes a drop in the temperature of air proportional to the sensible heat drop and an increase in humidity proportional to the latent heat gain. Evaporative cooling can be visualized using a psychometric chart by finding the initial air condition and moving along a line of constant enthalpy toward a state of higher humidity.

IV. OBSERVATION TABLE AND CALCULATION

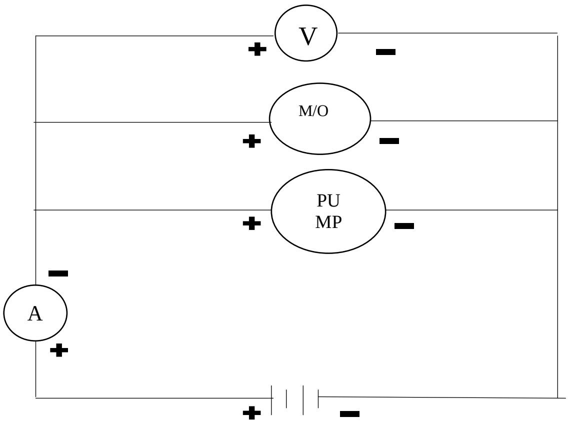


Fig 4: Circuit diagram for observation of motor and pump rating.

1. The reading taken by using battery for the selection of solar panel

Room Temperature : 36 ˚C

Room Humidity: 20%

Sr. No.	Voltmeter (V)	Ammeter (A)	Tachometer (RPM)	Anemometer (m/s)	Humidity (%)	Temperature (˚C)	W=V*I (w)	Q=A*V (m3/s)
1	12	6.1	2150	5.61	52%	27	73.2	0.4093
2	11	5.96	2020	5.1	60%	25	65.56	0.3721
3	10	5.3	1926	5.05	57%	26	53	0.3684
4	9	4.9	1850	4.89	57%	26	44.1	0.3568
5	8	4.4	1740	4.68	57%	26	35.2	0.3414
6	7	4.04	1649	4.42	58%	26	28.28	0.3225

Table 1: Selection of solar panel rating

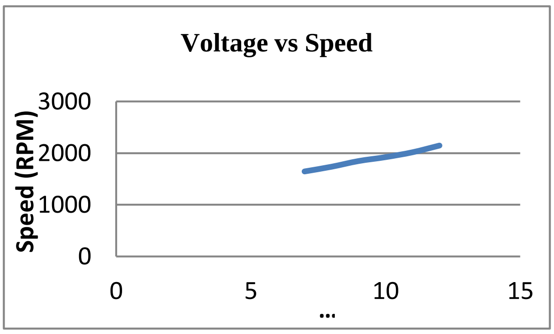


Fig 5: Voltage Vs Speed graph

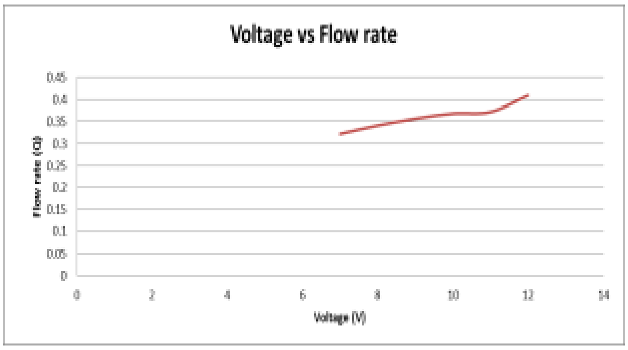


Fig 6: Voltage Vs Flow rate graph

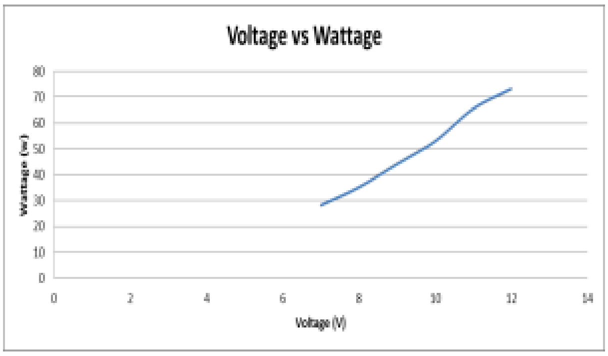


Fig 7: Voltage Vs Wattage graph

2. Observation table of comparison between power consumption of high pressure pump and high discharge pump by using battery.

High discharge pump(Evaporative pump)				High Pressure pump (for Mist)		
Sr. No.	**Volt meter (V)**	**Am-meter (I)**	**W= V×I (Watt)**	**Volt Meter (V)**	**Am-meter (I)**	**W= V×I (Watt)**
1	12	3.69	44.28	12	6.11	73.21
2	11	3.32	36.52	11	5.96	65.56
3	10	3.21	32.01	10	5.31	53.01
4	9	2.82	25.38	9	4.91	44.01
5	8	2.43	19.44	8	4.41	35.21
6	7	1.95	13.65	7	4.04	28.28

Table 2: Selection of Pump

3. Effect of solar inclination on power generation per various inclination for the GPS.

20.51.18N

77.45.08E

Sr. No.	Solar Inclination (in ˚)	Voltmeter (V)	Ammeter (I)	Tachometer (RPM)	W=V×I (Watt)
1	0 ˚	14	4.39	2455	61.46
2	10 ˚	14	4.3	2432	60.21
3	20 ˚	14	4.25	2409	59.51
4	30 ˚	13.8	4.16	2397	57.41
5	40 ˚	13.6	4.12	2393	56.03
6	50 ˚	12.8	3.92	2312	50.18
7	60 ˚	12.2	3.79	2256	46.23
8	70 ˚	11.4	3.49	2163	39.78
9	80 ˚	10.2	3.11	2005	31.72

Table 3: Effect of Solar Panel Inclination

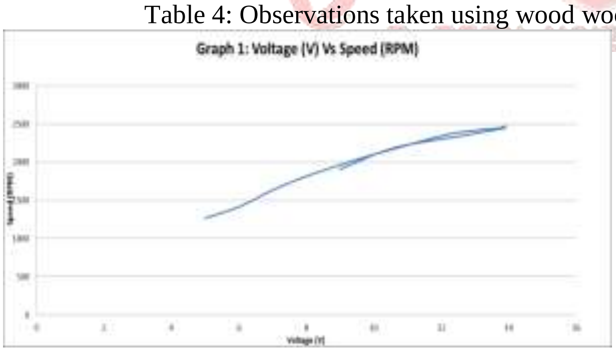
4. Observation table (by interval of 30 min from 7.30am to 4pm) with solar panel fixed on south direction inclined by 25^0.

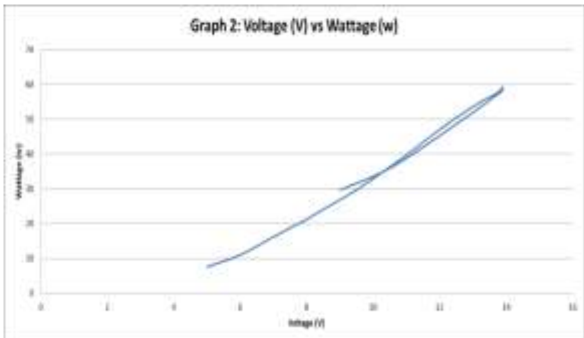
Cooling pad : Wood Wool

Pump: High discharge pump (Evaporative pump)

Sr No.	Time (in hrs)	Voltmeter (V)	Ammeter (I)	Tacho-meter (RPM)	Anamo-meter (m/s)	Temperature (˚C)		Humidity (%)	W=V×I (Watt)	Q=A×v (m3/sec)
						Inlet	Outlet			
1	7:30 AM	5	1.51	1270	3.34	33	32	27	7.56	0.2487
2	8:00 AM	6	1.83	1415	3.86	33.6	32	29	10.98	0.2816
3	8:15 AM	7	2.31	1636	4.42	33.9	27	52	16.17	0.3225
4	8:30 AM	8	2.66	1815	4.85	33.9	26	56	21.28	0.3538
5	8:45 AM	8.4	2.81	1876	5.07	34.2	26	52	23.52	0.3699
6	9:00 AM	9.6	3.16	2048	5.27	35.4	26	51	30.33	0.3845
7	9:30 AM	11	3.61	2224	5.91	36.9	27	48	39.71	0.4312
8	10:00 AM	12.2	3.97	2364	6.45	37.6	28	46	48.43	0.4706
9	10:30 AM	13.2	4.15	2426	6.56	39.9	28	46	54.78	0.4786
10	11:00 AM	13.7	4.19	2444	6.61	40.6	29	42	57.4	0.4815
11	11:30 AM	13.9	4.26	2472	6.81	41.4	29	41	59.21	0.4961
12	12:00 PM	13.9	4.27	2480	6.82	42.6	30	40	59.35	0.4976
13	12:30 PM	13.9	4.27	2472	6.72	42.7	30	40	59.35	0.4903
14	1:00 PM	13.9	4.24	2464	6.78	42.8	30	39	58.93	0.4947
15	1:30 PM	13.9	4.21	2442	6.82	44.3	30	40	58.38	0.4961
16	2:00 PM	13.9	4.21	2452	6.69	44.3	30	39	58.38	0.4881
17	2:30 PM	13.8	4.17	2440	6.82	43.3	30	39	57.54	0.4961
18	3:00 PM	12.6	3.91	2345	6.47	43.4	30	38	49.26	0.472
19	3:30 PM	10.6	3.44	2186	5.71	42.4	29	39	36.46	0.4166
20	4:00 PM	9	3.29	1911	5.14	42.3	29	39	29.61	0.3751

Table 4: Observations taken using wood wool cooling pad and high discharge pump





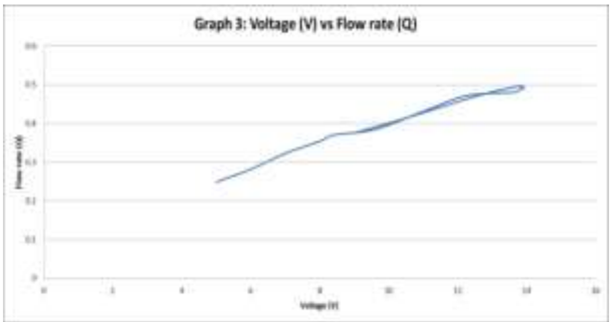


Fig 8 : Voltage Vs Speed graph

Fig 9: Voltage Vs Wattage graph

Fig 10: Voltage Vs Flow Rate graph

5. Observation table (by interval of 30 min from 7.30am to 4Pm) with solar panel fixed on south direction inclined by 25^0.

Cooling pad: Honey Comb
Pump: High Pressure pump

Sr. No.	Time (t) (in hrs)	Voltmeter (V)	Ammeter (I)	Tacho-meter (RPM)	Anamo-Meter (m/s)	Temperature ˚C		Humidity (%)	W=V×I (watt)	Q=A×V (m3/sec)
						Inlet	Outlet			
1	8:00 AM	4.4	1.786	1056	2.98	35	33	30	7.85	0.2174
2	8:30 AM	5.6	2.57	1293	3.75	36	29	53	14.39	0.2736
3	9:00 AM	6.4	3.16	1493	4.15	37	29	54	20.23	0.3028
4	9:30 AM	7.2	3.56	1637	4.76	37.5	29	53	25.63	0.3473
5	10:00 AM	8	4.08	1772	5.08	39	30	50	32.64	0.3707
6	10:30 AM	8.8	4.51	1947	5.4	41	30	48	39.69	0.394
7	11:00 AM	9.4	4.8	2046	5.83	42	31	46	45.12	0.4253
8	11:30 AM	9.4	4.82	2040	5.8	42	31	45	45.3	0.4232
9	12:00 PM	9.8	4.95	2075	5.91	43	31	44	48.51	0.4312
10	12:30 PM	9.8	4.96	2076	5.9	44	32	42	48.61	0.4304
11	1:00 PM	9.4	4.88	2038	5.7	45	32	41	45.87	0.4159
12	1:30 PM	9.2	4.72	1980	5.6	45	32	41	43.42	0.4086
13	2:00 PM	9	4.55	1960	5.52	45	32	40	40.95	0.4027
14	2:30 PM	8.1	4.22	1840	5.2	45	32	40	34.18	0.3794
15	3:00 PM	7.5	3.8	1720	4.91	45	32	40	28.5	0.3582
16	3:30 PM	7.1	3.57	1640	4.6	44.5	32	40	25.34	0.3356
17	4:00 PM	6.6	3.19	1525	4.33	44	31	41	21.054	0.3459

Table 5: Observations taken using honey comb cooling pad and high pressure pump

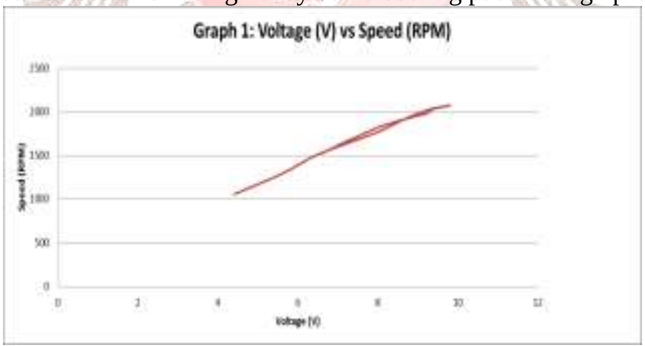


Fig 11: Voltage Vs Speed graph

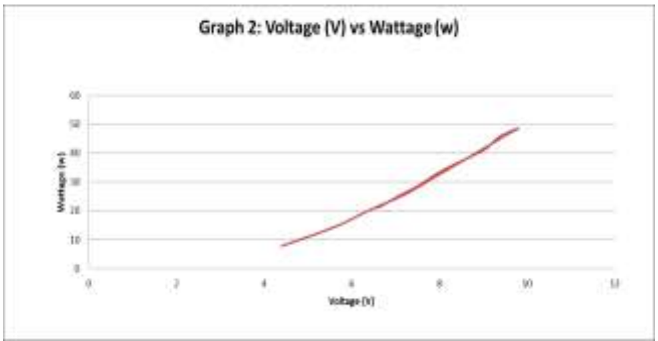


Fig 12: Voltage Vs Wattage graph

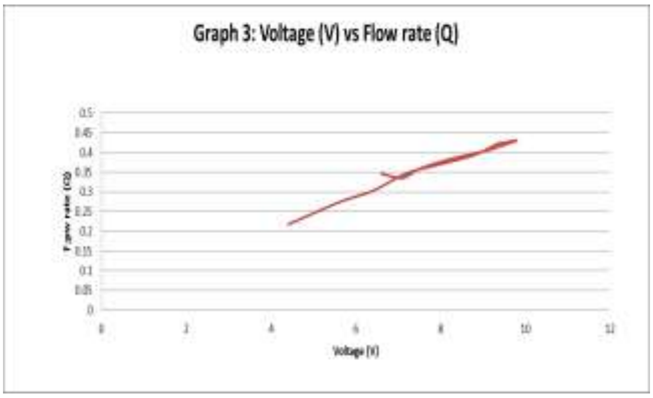


Fig 12: Voltage Vs Flow rate graph

V. RESULT

By comparing high discharge pump and high pressure pump along with DC motor, the power consume by high discharge pump is very less (from observation table no. 2). The comfort thermal condition achieved in the room i.e. temperature up to 25^0C and relative humidity upto 58%.

VI. CONCLUSION

The designed system is ecofriendly in operation as it uses non-conventional source of energy. This solar product perfectly suits for schools, offices and villages and thus an alternate to the power cut problem. The designed solar cooler gives maximum efficiency during summer season for working hours from 10am to 5pm.

VII. REFERENCES

1. A.E. Kabeela, Mohamed Abdelgaieda and M'Barek Feddaouib; “Hybrid system of an indirect evaporative air cooler and HDH desalination system assisted by solar energy for remote areas”.
2. M. Eslamia, F. Tajeddinib, N. Etaatia; “Thermal analysis and optimization of a system for water harvesting from humid air using thermoelectric coolers”.
3. A.E. Kabeel, Mohamed Abdelgaied, Ravishankar Sathyamurthy, T. Arunkumar; “Performance improvement of a hybrid air conditioning system using the indirect evaporative cooler with internal baffles as a pre-cooling unit”.
4. Vijaykumar Kalwa, R. Prakash “Design and Development of Solar Powered Air Cooler”
5. S. Magibalan, B. Raman, M. Ramar, S Ramesharvind, R. Ranganathan “FABRICATION OF MODERN SOLAR AIR COOLER” 2018 JETIR march, volume 5, issue 3.
6. Vipin Das, Nidhin Mj, Midhun Unnikrishanan, Nygin Jose, Rishikesh P., Suneeth Sukumaran . “Fabrication and Analysis of Solar Powered Air Cooler” IJES 2016, volume 5, issue 1.
7. Hamed Sadighi Dizaji, Samad Jafarmadar, Shahram Khalilarya, Samira Pourhedayat; “A comprehensive energy analysis of a prototype Peltier air-cooler; experimental investigation”.
8. Vijaykumar Kalwa, R. Prakash “MODELLING AND FABRICATION OF SOLAR POWERED AIR COOLER WITH COOLING CABIN FOR HOUSEHOLD FOOD ITEMS” 2014 IJMERR, vol 3, no 3, july 2014.
9. A Textbook of Refrigeration and Air Conditioning by the authors R. S. Khurmi and J. K. Gupta.