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Performance of Evaporative cooler using Solar Energy

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Abstract— Evaporative coolers are required for cooling purpose in summer. Large amount of energy used for their operation. Solar operated evaporative cooler will save this electricity and also will be beneficial where there is shortage of electricity. The main objective is to compare operating cost for evaporative cooler operating on electricity and solar energy. Such coolers are extensively being used in hot and dry climate conditions in northern Maharashtra, MP, Gujarat, Rajasthan etc.

Keywords— *Evaporative cooler, solar energy, electricity, operating cost.*

I. INTRODUCTION

Solar Power is an economically and environmentally sound source of renewable energy. As a society, we are beginning to understand that it is important to open up to new concepts of energy production. Solar Power plants convert the sun's energy into solar electricity. The sun is the largest source of energy in the form of heat and light energy. Solar Power has a huge potential to make a major impact on the electricity requirement in homes and industries. That the sun supplies as much energy onto the earth in a single day that equals the annual energy requirement is enough to judge the amount of solar energy that goes untapped.

An evaporative cooler produces effective cooling by combining a natural process - water evaporation - with a simple, reliable air-moving system. Fresh outside air is pulled through moist pads where it is cooled by evaporation and circulated through a house or building by a large blower.

II. LITERATURE REVIEW

The new emerging evaporative cooling options is one a series of technical briefs being prepared by the Southwest Energy Efficiency Project (SWEEP) in support of the U.S. Department of Energy's Building America Program. There's a world of difference between old-style swamp coolers and modern evaporative cooling systems. The latter can provide years of trouble-free service and cool, clean, comfortable, fresh air at a lower energy cost than conventional air conditioners—and initial costs are competitive as well. In addition, the latest evaporative cooler designs are a lot easier on the grid than compressor-based cooling systems.[1]

Evaporative coolers perform best when the humidity is low. On days when the humidity is really high, the house can feel muggy inside. For those who have another type of air conditioning system, that will be the time to use it. For the drier days the evaporative cooler can do quite well. If you can, place the cooler in a window that is shaded. The sun baking on the metal surface can reduce the effectiveness. I actually don't have mine shaded, but you should do what I say and not what I do. Evaporative coolers draw air from the outside and as it passes through the pads it is cooled and blown into the house. It is best to close all the windows in the house except for one that is farthest from the cooler. [2]

A swamp cooler is a simple device that produces cool air by evaporative cooling. This is achieved by blowing warm, dry air through a permeable pad that is soaked with water. As the water evaporates it cools the pad and the air that passes through it. This principle works well in hot dry climates, and is less expensive to install and operate than conventional air-conditioning units. Swamp coolers run on regular 115-volt electricity, but they can be low-cost if they are solar powered. [3]

Evaporative cooling, also known as adiabatic saturation of air is a thermodynamic process. When hot and dry air passes over a wet surface, the water evaporates and air loses its sensible heat and gains equal amount of latent heat of water vapor, thereby reducing its temperature. More the amount of evaporation, greater is the cooling effect. Thus the system is more efficient in hot and dry climates i.e. when it is most needed.[4]

Performance of evaporative cooler with rectangular pads of materials like rigid cellulose, corrugated paper, high density polythene and aspen is theoretically analyzed. The variation of saturation efficiency and cooling capacity with air mass flow rate is shown. The saturation efficiency decreases and outlet temperature of air increases with mass flow rate of air for all the materials. [5]

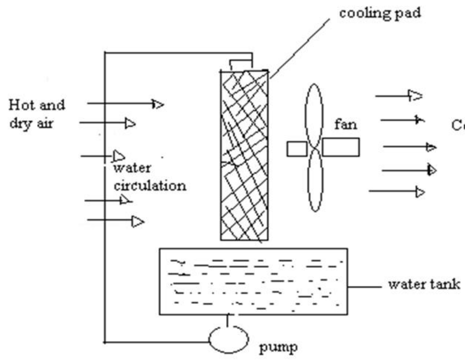
III. PROBLEM DEFINATION

Evaporative coolers are required for cooling purpose in summer. Large amount of energy used for their operation. Solar operated evaporative cooler will save this electricity and also will be beneficial where there is shortage of electricity.

IV. OBJECTIVE

The main objective is to compare operating cost for evaporative cooler operating on electricity and solar energy.

V. WORKING PRINCIPLE



The present evaporative coolers use a cooling media made wet by water flow. Hot and dry air is made to flow over this media with the help of a fan or blower. The water in the cooling media gets evaporated due to heat of air. Thus the temp of air reduces and water vapour formed, mixes with air. The relative humidity of air increases. Normally 5-10ºc reduction in the temp of air is possible.

VI. EXPERIMENTAL SET-UP

Cooler operated on solar system:-.

1. Solar panel is mounted on top floor of building for getting proper sunlight.
2. Battery is connected to solar panel for charging within 2 days battery get fully charged.
3. Battery is connected to inverter to convert DC to AC.
4. Inverter is connected to energy meter to measure energy consumption & outlet of energy meter is connected to evaporative cooler.
5. Duct is made on inlet & outlet side for the accurate measurement of velocity.
6. Thermocouples are placed at inlet & outlets side of cooler. Two at inlet & two at outlet side. Out of two, one for DBT measurement & one for WBT measurement.
7. For energy consumption measurement, energy meter is connected to the cooler.
8. Now cooler is running on first speed. At this time, velocity is measure at each side by using anemometer. On each side four readings are taken at four corners for reliability purpose.
9. Different temperature readings are taken at inlet & outlet directly by using temperature indicator.
10. For energy consumption measurement, time was measure for pulses of energy meter. Then by using energy meter constant energy consumption is calculated.
11. Similarly procedure is carry out for second & third speed.

VII. OBSERVATION TABLE FOR EVAPORATIVE COOLER RUNNING ON SOLAR SYSTEM

Time		Inlet		Outlet			Time (10p)
	Flow	DBT	Flow	DBT	Flow	DBT	
9 am	I	33.4	22.6	27.4	22.0	3.4523	75.76
	II	31.8	22.8	27.5	22.2	3.6850	80.71
	III	32.1	22.9	27.5	21.8	3.0350	92.96
12 pm	I	33.3	23.6	26.5	21.0	3.0925	74.19
	II	33.9	23.8	26.8	21.7	3.3900	83.43
	III	33.5	23.5	26.7	21.5	3.6650	96.44
3 pm	I	37.5	23.4	29.3	22.8	3.4650	72.14
	II	37.7	23.5	29.5	22.5	3.6246	80.50
	III	37.5	23.7	28.7	22.1	3.9430	100

VIII. RESULT TABLE FOR EVAPORATIVE COOLER RUNNING ON SOLAR SYSTEM

T		RH					
	FLOW	Inlet %	Outlet %	Sat. Eff. %	Ma Kg/hr	Cooling capacity KJ/hr	Energy consumption KW-hr
9 am	I	48	62	45.4	1199.97	4895.88	0.148
	II	48	64	47.7	1280.85	5617.83	0.139
	III	49	64	50.0	1402.10	6580.57	0.121
12 pm	I	45	62	70.1	1081.12	7498.67	0.151
	II	42	66	70.2	1178.31	8533.37	0.134
	III	44	65	68.0	1266.95	8787.57	0.116
3 pm	I	32	58	58.1	1197.5	10015.9	0.155
	II	31	58	57.7	1211.18	10130.3	0.139
	III	32	59	63.7	1370.56	12309.2	0.112

IX. PAYBACK PERIOD

Payback period in capital budgeting refers to the period of time required for the return on an investment to "repay" the sum of the original investment. The time value of money is not taken into account. Payback period intuitively measures how long something takes to "pay for itself." All else being equal, shorter payback periods are preferable to longer payback periods. Payback period is widely used because of its ease of use despite the recognized limitations described below.

The payback period is considered a method of analysis with serious limitations and qualifications for its use, because it does not account for the time value of money, risk, financing or other important considerations, such as the opportunity cost. Whilst the time value of money can be rectified by applying a weighted average cost of capital discount, it is generally agreed that this tool for investment decisions should not be used in isolation. Alternative measures of "return" preferred by economists are net present value and internal rate of return. An implicit assumption in the use of payback period is that returns to the investment continue after the payback period. Payback period does not specify any required comparison to other investments or even to not making an investment.

X. COST BENEFIT ANALYASIS

1) Operating cost = C = 1000 * A *Cost/unit Rs/season
=184.4 * 5.53
= 1019.73 Rs/season
2) Cost of solar panel, Battery, Inverter = S = 15000 Rs
3) Payback period = S/C season
= 15000/1019.73
= 14.70season
= 15 Seasons = 15 Years

In such application the operation will be continuous and payback period may be calculated as
Assuming 18 h operation per day,
Units per day =0 .184 *18
= 3.312 kWh = 3.3 units
Cost per day = 3.3 *5
= 17 Rs per day
Pay back = 15000/17
= 882 days
= 2.5 years approx.

If power consumption is higher this may be further reduced.

XI. CONCLUSION

There are many regions in India as part of Rajasthan, part of Bihar, M.P., Vidarbha and north Maharashtra and some hot spots in north where evaporative cooling will produce a condition well within the summer comfort zone. There is increasing demand of evaporative coolers in these regions as they are quite inexpensive compared with refrigerated air conditioning system. So in this region solar energy available abundantly. This energy can be stored in battery by using solar panel. It can be used to run the evaporative coolers.

If we used evaporative coolers three month in year (season) i.e.1000 hr operation then payback period is 15 years. This payback is more. So by optimizing cost of solar panel, battery and inverter payback period can be reduced. After payback period we will get upto 10-15 year free of cost evaporative cooling.

REFERENCES

[1] Midwest Research Institute National Renewable Energy Laboratory Division, "New Evaporative Cooling Systems: Modest Cooling Loads", November 2007.

[2] R.K.Kulkarni & S.P.S. Rajput "Comparative performance of evaporative cooling pads of alternative material", International journal of advanced engineering sciences and technologies vol no. 10, pp 239 - 244, October 2008.

[3] Camrago JR, Ebinuma CD and Siveria JL, 5. "Experimental performance of a direct evaporative cooler operating during summer in Brazilian city", International journal of Refrigeration; 28(7), pp.1124-1132. (2004).

[4] Durach, C. F., Kurpjuweit, S., & Wagner, S. M. (2017). "Artificial Intelligence in Logistics and Supply Chain Management: A Comprehensive Review." International Journal of Logistics Management, 28(3), 875-905. doi:10.1108/IJLM-04-2016-0062

[5] Yu, H., Sun, W., & Liu, H. (2020). Human-Robot Collaboration in Industrial Automation: A Comprehensive Review. IEEE Transactions on Industrial Informatics, 16(6), 4184-4200. doi:10.1109/TII.2020.2969415

[6] Li, M., & Cheng, G. (2017). Industry 4.0: A Survey on Technologies, Applications, and Open Research Issues. Journal of Industrial Information Integration, 6, 1-10. doi:10.1016/j.jii.2017.04.005

[7] Chen, C., Wu, N., & Chen, S. (2019). Machine Learning for Production Scheduling in Industry 4.0: A Review. Journal of Intelligent Manufacturing, 30(6), 2445-2461. doi:10.1007/s10845-017-1410-0

[8] Subasi, A. (2020), "A Review of Machine Learning Approaches for Fault Detection and Diagnosis in Manufacturing Processes" Journal of Manufacturing Systems,56,499-512.

[9] Sabattini, L., Secchi, C., & Fantuzzi, C. (2020). Vision Systems for Robotic Applications in Industry 4.0: Challenges and Opportunities. Annual Reviews in Control, 50, 13-25. doi:10.1016/j.arcontrol.2020.07.009

[10] Kocabasoglu-Hillmer, C., & Gavirneni, S. (2020). Artificial Intelligence in Supply Chain Management: Applications, Challenges, and Research Perspectives. Production and Operations Management, 29(4), 925-947.

[11] Li, X., Tao, F., Zhang, M., Cheng, Y., & Luo, Y. (2020). Intelligent Quality Control in Cyber-Physical Systems: Current State and Opportunities. Journal of Manufacturing Systems, 54, 202-213. doi:10.1016/j.jmsy.2019.10.004

[12] Dietz, T., Singh, J., & Lim, C. P. (2021). Human-Centric AI in Manufacturing: A Review. Journal of Intelligent Manufacturing, 32(4), 939-958. doi:10.1007/s10845-019-01531-