ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ENERGY CONSERVATION ANALYSIS BY APPLICATION OF HEAT PUMP SYSTEM- A CASE STUDY

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ABSTRACT

Heat pump application delivers an efficient way to replace the electrical energy for heating application in an industry, specifically for large-scale installations. This technology is very cost effective, Eco friendly source for water heating application which significantly reduces the use of electrical energy consumption. An analysis of heat pump system for water heating application at the process industry established a new option for water heater. This paper presents key issues that will define how well, and to what extent, this technology will fit into process industry. The paper also shows the results of a life-cycle cost analysis of heat pump water heating system. The commercial analysis was carried out for 7500 liter hot water per day. The results show that system COP can reach up to 3.12A extremely substantial factor of cost saving is about 66.67 % with heat pump system. Electricity consumption of 480 units as per day is saved by using heat pump water heating system.

KEYWORDS: heat pump, COP, energy consumption, energy conservation.

INTRODUCTION

In a process industry heat pump water heater system (HPWH) is an economically effective and environmentally efficient way to provide hot water for industrial process applications like washing of various components and also for cleaning of various machineries. In the heat pump system to move heat from a cool reservoir such as air and transfer this heat into the water. The system contains a compressor, condenser, expansion valve, evaporator, hot and cold water circulating pump and controls to reach this task. High capacity water storage tank aids the heat pump to operate more commonly than the heating elements. An insulated water storage tank is installed alongside with the Heat pump water heating system, so that the system can complete the regular hot water requirement. in the Heat pump the water heating is by circulating heat rather than by producing the heat, so heat pump is efficient than an electric water heater. HPWHs are a developed technology, and it can be very powerful when applying for replacement of regular electrical heaters.

With the maximum demands for hot water which can gives advantage of the inherent efficiency of by HPWH. With the help of heat pump technology in a process industry it has various advantages like improvement in indoor environmental quality and cooling effect carried out by evaporator can help in the other processes like in Refrigeration or for air handling unit for ventilation Depending on the position and the application of the water heater, its operation may significantly decrease the cooling load in the Cooling season.

HEAT PUMP TECHNOLOGY AND ITS OPERATIONAL VIEW

A heat pump is a device that is able to transfer heat from one fluid at a lower temperature to another at a higher temperature for process heating. Heat pumps work on vapour compression system with the refrigerant R134a. The shell and tube type cooled heat exchanger is used as a condenser. The heat rejected by the condenser into the water in present in the condenser is consisting of heat absorbed by the evaporator side from atmospheric air and heat added during compression.

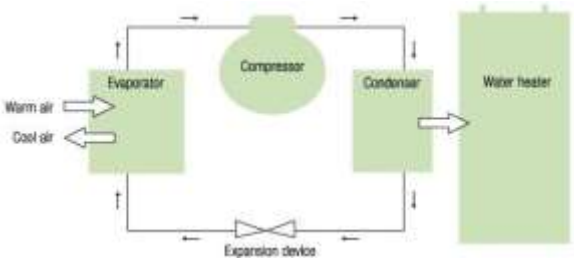

Fig.1 Heat pumps water heater System

PRELIMINARY ECONOMIC ANALYSIS

A preliminary economic analysis was carried out on regular coil electrical heaters. In the initial stage in process industry electrical heaters was installed to supply the hot water of 7500 LPD. The electricity consumption during this period was near about 720 units per day. In the modification stage heat pump system was installed to reduce electricity consumption. In development and installation stage to fulfill the requirement of hot water throughout the year heat pump system was designed & installed. Heat pump system saves around rs.27/component. In this paper the energy efficiency improvement of installed heat pump is quantified and potential economic and environmental benefits are discussed.

The Heat pump technology is energy efficient and eco-friendly, used to reduce the consumption of electrical energy and save operating cost for the same requirement. It indirectly reduce pollution and it improves IQE(Indoor Environmental Quality). This is a practical case study heat pump (HP) system installed in process industry for hot water application.

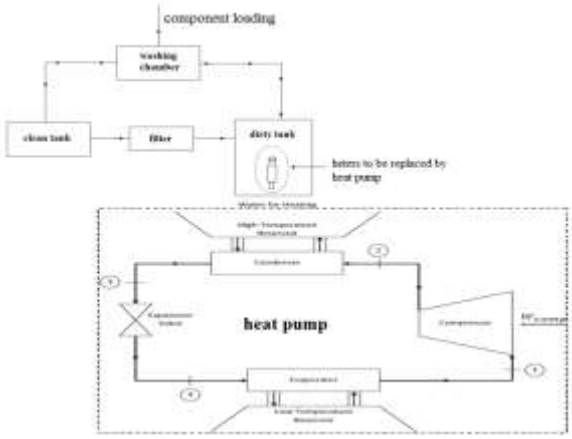

Fig.2 Schematic overview of Heat pump System

EXPERIMENTATION AND ACTUAL PERFORMANCE

The analysis of thermodynamic performance of the electric heater and heat pump were investigated by using life cycle cost analysis for water heating application for load of 15000 LPD. Calculations were performed in the application discussed above (4°C evaporation temperature and heating water from 27°C to 55°C). Table no. 2 and 3 list the performance evalution taken through the study.

Operating Limits	Unit	Range
Water heating system	^{0}C	Max.55/27 min
Heating capacity	Kw	45
COP	-	3 to 3.5
Rated Power	Kw	17
Refrigerant		R134a

Table1-Parameters of Heat Pump System

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Operating Limits	Unit	Range
Avg. Water consumption per component	LPD	50
No. of components washed per day		150
Capacity	LPD	7500
Specific Heat	kJ/kg k	4.187
Temperature Diff.	°C	28
Heat Load	kJ/hr	162000
Heat Loss	2%	3240
Heater Efficiency		95%
Operating hours	Hrs	16
Heater Rating	kW	45
Electricity Consumption per day	kWhr	720
Electricity Rate	Rs./kWhr	8
Electricity Cost	Rs./day	5,760
	Rs./month(25 days)	1,44,000
	Rs./year(300 days)	17,28,000
Energy Consumption per component	kWh	4.8
Cost of Energy Consumption per component	Rs.	38.4

Table 2-Electrical Heater System

Operating Limits	Unit	Range
Avg. Water consumption per component	LPD	50
No. of components washed per day		150
Capacity	LPD	7500
Specific Heat	kJ/kg k	4.187
Temperature Diff.	°C	28
Heat Load	kJ/hr	162000
Heat Loss	2%	3240
Heater Efficiency		95%
Operating hours	hrs	16
Heat pump Rating	kW	15
Electricity Consumption per day	kWhr	240
Electricity Rate	Rs./kWhr	8
Electricity Cost	Rs./day	1,920
	Rs./month(25 days)	48,000
	Rs./year(300 days)	5,76,000
Energy Consumption per component	kWh	1.6
Cost of Energy Consumption per component	Rs.	12.8

Table.3 Heat Pump System

ECONOMICAL ANALYSIS

Analysis of heat pump system for water heating application for washing application is based on the theoretical and practical basis; here Savings in money related with annual electricity reductions are good and beneficial. Below table shows the total

Sr. No.	heat source	Power	Electricity consumption	All Cost (Rs/annum)
heat pump unit	Electrical energy	15 kW	72,000 kw hr/year	Rs. 5,76,000
Electric heater unit	Electrical energy	45 kW	216000 kw hr/year	Rs.17,28,000
Annual Saving per year with heat pump				Rs.11,52,000

Table 4. Economic analysis of heat pump systems.

Economic analysis of heat pump. The 45 kW electric heater run for the water consumption of 7500 liters per day and the electricity consumption is 2,16,000 kWhr/year. Using heat pump in process line gives maximum output i.e. 45 kW with taken of 1/3 electrical input as compared to that of electrical heaters. For heat pump, energy consumption is 72,000 kWhr/year which gives saving around 1, 44,000 kWhr/year. Considering the economic annual life cycle costs of heat pump were Rs. 5.76 Lakh/annum & electric heater is around Rs. 17.28 Lakh/annum.so here saving of around Rs.11.522 Lakh/annum is achieved. An additional annual cost by considering maintenance of heat pump. The majority of savings in money as well as energy is associated with the electricity consumption.

REDUCTION IN EMISSION

One of the most important advantages of heat pump system is the reduction in that integrally comes with the reductions in energy consumption. When 1 kWh of energy is consumes then it can reflect about 0.00052 tons of CO2. It gives approximately 76 tons of CO2 emission is reduced per annum by using a heat pump for hot water application.

RESULT AND DISCUSSION

Energy assessment and energy conservation by application of heat pump shows that the operating cost increases with temperature differences. Cost saving with heat pump technology as compared to solar and electric heater is reported as 66.67%.

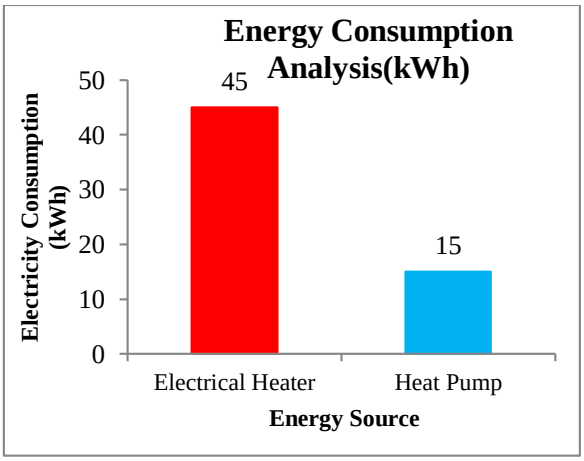

Fig. 6 Energy consumption analysis of different energy sources

Electricity consumption for the heat pump system is almost 1/3 as that of compared with electric heater for the same capacity output of heat.

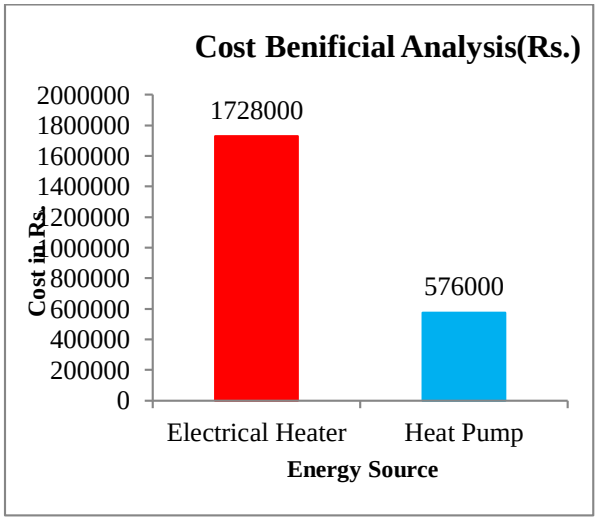

Fig.7 cost beneficial analysis of heat pump system w.r.t electrical heaters.

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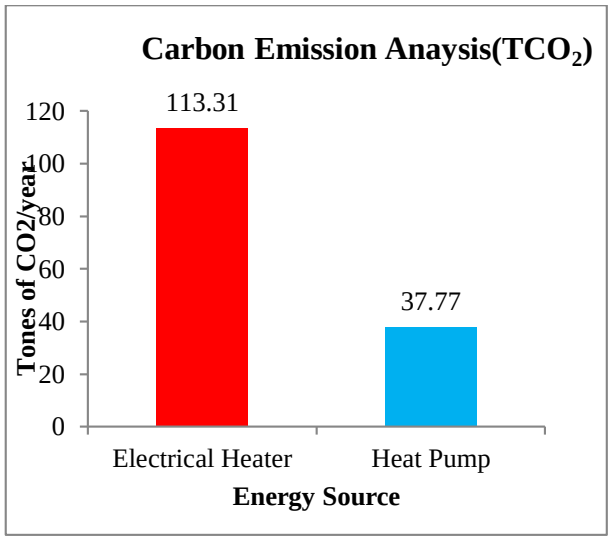

Fig.8 Carbon Emission Analysis

CONCLUSION

The analysis of installed heat pump to meet the demand of supplying hot water to the component washing machine in a process industry having capacity of 7500LPD is carried out. The results shows that saving electrical energy units of the order of 1, 44,000 kWhr/year, which tends to annual saving of an electrical energy to about 67%. This also gives an advantage of reduction in CO2 emissions to the atmosphere by 76 tons per annum.

ACKNOWLEDGMENT

We express our sincere thanks to the Director and Head of Energy Technology Department, Department of Technology, Shivaji University for their valuable guidance and support.

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