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Solar Industrial Process Heating Associated with Thermal Energy Storage for Feed Water Heating

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Abstract: With the rise in fuel cost and scarcity now, there is a significant research, development and application in solar industrial process heating. A massive deployment of solar thermal technology in those industries which use large quantities of lowtemperature hot water is also required for the economic operation. Due to the unavailability of solar energy during non sunny days and diurnal changes throughout the day, storage of thermal energy is inevitable. Recent developments nationally and internationally may rekindle new applications of solar thermal energy use by industry. This paper reviews the application of solar industrial process heating in paper industry.

Key words: Process heating % Feed water % Thermal Energy Storage % Phase change materials

INTRODUCTION

Solar Energy: The sun is a sphere of intensely hot gaseous matter witha diameter of 1.39 x 10^9 m. The solar energy strikes ourplanet a mere 8 min and 20 s after leaving the giantfurnace, the sun which is 1.5 x 10^{11} m away. The sun has an effective blackbody temperature of 5762 K [1]. The temperature in the central region is much higher and it is estimated at 8 x 10^6 to 40 x 10^6 K. In effect the sun is continuous fusion reactor in which hydrogen is turned into helium. The sun's total [2]. energy output is 3.8 x 1020 Which is equal to 63 MW/m^2 of the sun's surface [3]. This energy radiates outwards in all directions [4]. Only a tiny fraction, 1.7 x 10^{14} kW, of the total radiation emitted is intercepted by the earth [1]. However, even with this small fraction it is estimated that 30 min of solar radiation falling on earth is equal to the world energy demand for one year.

Thermal Energy Storage (TES): Thermal energy can be stored in three methods: sensible, latent and thermo-chemical heat storages. Although the sensible heat storage (SHS) system is simple and a well-developed technology, this type of storage is the least efficient method for energy storage because of low heat storage capacity per unit volume of the storage medium. The heat transfer which occurs when a substance changes from one phase to another is called the latent heat. Latent heat storage (LHS) systems using phase change material (PCM) as storage medium offer advantages such as high heat storage capacity, small unit sizes and isothermal behavior during charging and discharging processes [5].

Implementation of Solar Tes System for Feed Water Heating: From a number of studies on industrial heat demand, several industrial sectors have been identified with favorable conditions for the application of solar energy [6]. In this work implementation of TES system for feed water heating in the paper industry with production capacity of 65 Tons per day of Kraft paper is analyzed [7]. The process involves grinding the wet pulp, pressing and drying with the help of steam. After grinding the pulp it is passed through rollers, where the excess water is squeezed out and it is passed through heating rollers and drying drums, where the paper is dried to final stage [8].

Process Details: The steam used for drying is saturated steam which is fed to the set of rollers and to the drying drums of 4 numbers. The condensate collected is used as feed water along with makeup water [9].

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- Feed water initial temp before mixing with condensate will be around 30-34 ° C.
- Feed water temp after mixing with condensate will be around 60-75 ° C.
- Flow rate of feed water around 5000 L/Hr
- Capacity of feed water tank will be around $20m^3$.
- Quality of condensate: Condensate mixed with Flash steam.
- Temp of condensate: around 98 ° C.
- Steam temp at boiler: 165 ° C, at process 150° C (Saturated steam)
- Capacity of boiler: 5000 Kg/Hr (operating) and [10] Design: 6000 kg/Hr.
- Steam Pressure: 9 Kg/ cm2 and Design: 10 kg/cm^2
- Flow rate of steam: 4 - 5 T/Hr
- Usage of steam: 4-5 T/Hr with 3-4 kg/ $cm^2$of pressure.
- Fire wood consumption: Average - 1.5 T/ Hr.
- Cost of fire wood: Rs. 3.00/- per kg
- Make up water required @ 30% = 1500 L/Hr

System Designed: The system is designed for heating the makeup feed water of 1500 L/Hr. Energy available from solar flat plate collector is 400 J/s. The solar energy available for 6 hours is 8640 kJ [11]. From the above process details the total solar collector area required is 523 m^2.Total solar number of panels (Area of $2m^2$) required is 262 panels. Solar energy is to be used for heating the makeup water quantity of 1500 L/Hr, to a temperature around 60 ° C. The Makeup water required for 24 Hours is 36 Tons. Energy requirement for heating 36 Tons of water is 5266 MJ [12].

The TES system is designed in such a way that 75% of energy is stored in PCM and 25% is stored in SHS (water). From the calculations the mass of PCM required is 13500 kg and mass of water (SHS) is 9000 kg.

Fig 1: Boiler plant

Fig 2: Feed water tank

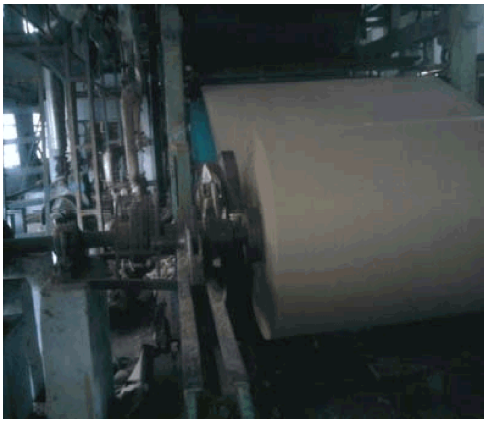

Fig 3: Paper rolling and drying process

Fig 4: Solar collectors

RESULTS AND DISCUSSION

The cost involved in operating the boiler plant with conventional heating is around Rs. 4500/- per hour. With the application of the solar industrial process heating system associated with thermal energy storage for heating the makeup water, the cost is reduced by 30 %. This also reduces the carbon emission generated by firing the boiler with wood [13].

CONCLUSION

The implementation of industrial process heating associated with solar thermal energy storage system in a paper industry with production capacity of 65 Tons per day of Kraft paper is analyzed. The system is designed to heat the makeup feed water of 1500 L/Hr. Heat collected by solar flat plate collectors is used for heating the makeup feed water and also stored in the TES tank for usage during non-sun shine hours. From the design calculations, the number of solar panels, quantity of PCM and SHS material ware decided. It is obvious that the operating cost and thus the production cost of the Kraft paper unit is reduced [14].

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REFERENCES

1. International Energy Agency Technology, Solar Heating and Cooling, http:// www.iea.org/ techno/ iaresults.asp
2. Vannoni, C., R. Battisti and S. Drigo, 2008. Potential for solar heat in industrial process. IEA Solar Heating and Cooling, Task33/IV. Madrid: CIEMAT.
3. Nallusamy, N., S. Sampath and R. Velraj, 2003. 'Effective utilization of solar energy for water heating applications using combined sensible and Latent heat storage system', Proceedings of the International Conference on New Millennium Alternate Energy Solutions for sustainable development", Coimbatore, pp: 103-108.
4. Nallusamy, N. and R. Velraj, 2009. 'Numerical and experimental investigation on a combined sensible and latent heat storage unit integrated with solar water heating system'-Journal of solar energy engineering, pp: 13.
5. Reddy, K.S., P. Avanti and N.D. Kaushika, 1999. 'Finite time thermal analysis of ground integrated-collector-storage solar water heater with transparent insulation cover, International Journal of Energy Research, 23: 925-940.
6. Sari, A. and K. Kaygusuz, 2001. 'Thermal energy storage system using stearic acid as a phase change material', Solar Energy, 71(6): 365-376.
7. Sodha, M.S., A.K. Sharma, R.L. Sawhney and A. Kumar, 1997. Experimental performance of built-in-storage solar water heating systems in laboratory and field conditions, International Journal of Energy Research, 21: 275-287.
8. Saitoh, T. and K. Hirose, 1986. 'High performance phase- change thermal energy storage using spherical capsules, Chemical Eng. Commun., 41: 39-58.
9. Velraj, R. and R.V. Seeniraj, 1999. Heat transfer studies during solidification of PCM inside an internally finned tube, Journal of Heat Transfer, 121: 493-497.
10. Velraj, R., R.V. Seeniraj, B. Hafner, C. Faber and K. Schwarzer, 1999. Heat transfer enhancement in a latent heat storage system', Solar Energy, 65(3): 171-180.
11. Vijay Padmaraju, S.A., M. Viginesh and N. Nallusamy, 2008. Comparative study of sensible and latent heat storage systems integrated with solar water heating unit, Proceedings of ICREPQ'08, ICREPQ 08-218, Santander, Spain.
12. Vikram, D., S. Kaushik, V. Prashanth and N. Nallusamy, 2006. An Improvement in the solar water heating systems by thermal energy storage using phase change materials Proceedings of ASME international solar energy conference, Irvine, CA.
13. Wang, J., Y. Ouyang and G. Chen, 2001. Experimental study on charging processes of a cylindrical heat storage capsule employing multiple-phase-change materials, International Journal of Energy Research, 25: 439-447.
14. Watanabe, T., H. Kikuchi and A. Kanzawa, 1993. Enhancement of charging and discharging rates in a latent heat storage system by use of PCM with different melting temperatures, Heat Recovery Systems and CHP, 13(3): 57-66.