INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : **Ph.D.**

Thesis Title : ***Development and Performance Investigation of Parabolic Trough Solar Collector and Latent Heat Storage Units for Indoor Cooking Application***

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Thesis Submitted to the Department/ Center : **Center for Energy**

Date of completion of Thesis Viva-Voce Exam : **May 14 2021**

Key words for description of Thesis Work : Parabolic trough solar collector, latent heat storage, hybrid, PCM, HTF, Erythritol, nano-particles.

SHORT ABSTRACT

The main objective of the present study is to design, develop and investigate the thermal performance of a suitable indoor solar hybrid cooking system using thermal energy storage materials. For this reason, a parabolic trough solar collector (PTSC) and latent heat storage (LHS) units are designed and fabricated. The thermal performances of both systems are investigated experimentally and numerically. Furthermore, a hybrid PTSC and LHS system is proposed for solar cooking application and lab-scale experimental setup are coupled to test the performance of the hybrid system. The performance of the fabricated PTSC system is investigated experimentally, analytically and numerically. The important parameters for all the methods are inlet temperature, beam radiation, mass flow rate. The result indicates that the efficiency and useful heat decrease while inlet temperature increases keeping other parameters constant. On the other hand, the thermal efficiency is increased along with mass flow rate and solar radiations. Besides, the effect of the nanofluids on the thermal performance of PTSC is investigated numerically. However, addition of nano-particles into the base fluid brought insignificant difference. The experimental results indicate that the thermal performances of PTSC are better in the month of June as compare to October in the north east region of India. The maximum HTF outlet temperature recorded are 110.7 ^{0}C and 108 ^{0}C on June 15 and 22, respectively. Similarly, the maximum HTF outlet temperature recorded on October 13 and 18 are 89.9

^{0}C and 86.8 ^{0}C, respectively. It is to mention that the analytical, numerical and experimental results are found in the good agreement.

Similarly, an experimental and numerical study of the lab-scale LHS unit is conducted. Erythritol ($C_4H_{10}O_4$) and cooking waste oil are employed as PCM and HTF, respectively. The performance of the LHS unit is tested experimentally during the charging process, whereas, both charging and discharging characteristics of the storage unit are studied during the numerical study. The performance of LHS is investigated with the help of charging time, liquid fraction, average transient temperature and stored energy parameters. During the charging process, both numerical as well as experimental tests are conducted at HTF volume flow rate of 75 LPM at 138 ^{0}C. For the discharging process, HTF inlet temperature is chosen to be at 87 ^{0}C keeping the volume flow rate same as that of the charging process. The optimal number of tubes and fins are decided after multiple investigations of different LHS models.

The effect of operating parameters on the performance of the storage unit is examined using both experimental and numerical analyses. It is observed that an increase in the flow rate of HTF and inlet temperature enhances the heat transferring rate of PCM and minimizes the charging time of the LHS unit. The experimental outcome of the storage unit is validated along with numerical results. The numerical analysis results exhibit very good similarity with the experimental data exhibiting a maximum deviation of 6.0%. The total time consumed in the complete melting and solidification of PCM inside LHS is estimated to be 175 min and 156 min, respectively. During the melting of PCM, the sensible heat, latent heat and total energy stored in LHS are found to be 9.3 MJ, 17.74 MJ and 27.03 MJ, respectively. Similarly, the sensible heat, latent heat and total energy released during the solidification process are 4 MJ 17.6MJ and 21.6 MJ, respectively.

A hybrid lab-scale PTSC and auxiliary source of energy are proposed to power LHS developed for indoor cooking purposes. The experimental investigations of the coupled PTSC and LHS units, and the numerical investigation of the proposed LHS unit powered by PTSC and auxiliary energy source are evaluated. First, the performance of the LHS unit is examined using PTSC as a heat source, where the energy from the sun is generated in the receiver tube. The experimental test is conducted on a sunny day starting from 9:30 PM local time and at 14:00, the average temperature of the LHS is 88 ^{0}C. Although the experimental test is conducted for more than five hours, the PTSC does not collect enough solar radiance for the complete charging of LHS. Therefore, an auxiliary energy source is required for the complete melting of PCM.