Experimental Study of Solar Heat Pipe Performance in Peradeniya

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Solar heat pipes are unique devices in the sense, that with absolutely no external power input or moving parts, they can transfer large quantities of heat obtained from solar energy over a long distance at a constant temperature. The objective of this study was to evaluate the thermal performance of solar heat pipes fabricated at the laboratory, working under different conditions to heat batches of water in Peradeniya. This is the first reported work carried out with heat pipes in Sri Lanka.

Two solar heat pipes of 1 m total length were made up of sealed copper tubes of 0.019 outer diameter and 0.002 m thickness. Inner surfaces were lined with a porous capillary wick made up of stainless steel of 50 mesh size. Methanol having a boiling point of 64.7°C was used as the working fluid, with 40 ml trapped inside each sealed tube. Methanol was vapourized by absorbing solar energy in the evaporator end of the pipe (0.75 m in length) which was exposed to sun light. The vapour moved through the core of the pipe to the condenser end of the pipe, which was immersed in a batch of 0.1 kg water to be heated. At the condenser end, working fluid ejected the latent heat to water and became liquid. The liquid was absorbed by the porous capillary wick lining and it moved back to the evaporator end.

On the day of experiments, solar radiation measured at the location was in the range of 800 to 900 W/m^2 for about 50 min starting from 12.40 pm, and it dropped to about 450 W/m^2 in the next 30 min. Atmospheric temperature varied in a narrow range of 28.1 to 29.2°C. The batches of water being heated were at an initial temperature of 28.1°C. Temperatures of the same, measured at fixed time intervals, showed that in both cases studied, water temperatures were raised to 45°C in about 40 min. After that, the temperatures remained at a steady value of 45°C. Absence of further increase of water temperature in the latter part of the experiments may be explained by the solar radiation data which experienced a sharp drop during this period of time as reported above.

Cumulative thermal efficiency of the system, estimated as the ratio between the cumulative heat gain by water and cumulative solar energy input to the respective heat pipe, was as low as 8%. Even at this low efficiency, water could be heated from 28 to 45°C in about 40 minutes and the temperature could be maintained at that level despite the solar radiation dropping sharply to very low values. Both heat pipes, with and without a vacuum, prior to administrating methanol, exhibited similar results. When the experiments were repeated without a vacuum on a day in which the atmospheric temperature varied in the range of 29.2°C to 29.8°C and solar radiation varied in the range of 700 to 1000 W/m^2, water was heated from 29.2°C to 49.6°C in about 55 minutes at an efficiency of 7%.

Considering the simple construction of the heat pipes used in this experiment and the fact that no moving parts were involved, they could be recommended for water heating usage at homes in Peradeniya with appropriate modifications required to further enhance the efficiency.