Solar Thermal Energy Harnessing Using a Parabolic Trough Concentrator

P D C Kumara [a, b, 1], M P S Viraj[b], S K K Suraweera[b], H H E Jayaweera[b], A M Muzathik[c], T R Ariyaratne[b]

[a]*Institute of Technology, University of Moratuwa, Katubedda, Sri Lanka*
[b]*Department of Physics, University of Colombo, Colombo*
[c]*Department of Mechanical Engineering, South Eastern University of Sri Lanka, Oluvil, Sri Lanka*

This paper reports the results of a study carried out in the development of a solar thermal energy harnessing plant using a parabolic trough concentrator. In the field of energy production one of the most concerned factors today is the air pollution, and it is linked with carbon and sulphur emissions from burning of fossil fuels. It is estimated that the global fossil fuel consumption will increase by 48% by 2040. In this context the Solar energy is still considered as the most prominent clean source of energy. Parabolic trough concentrator (PTC) is the most mature and commercially proven technology among the other solar thermal energy harnessing methods. The objective of this study is to design and develop a high efficiency PTC using locally available technologies and materials. The first Sri Lankan PTC thermal energy plant having dimensions of 4.5 m × 4.8 m and an aperture area of 22.3 m^2 has been successfully constructed under this project and are in operation at the University of Colombo. Solar mirror films (3M 1100) pasted on stainless steel sheets are used as parabolic reflectors and they are mounted on Unplasticized Polyvinyl Chloride profiles clamped on a Galvanized Iron structure. A heat transfer fluid (Mobil Therm-605) is used to transfer the harnessed energy from PTC to the secondary energy conversion modules such as steam generator. When designing the mechanical structure, effect of the wind load was taken in to account in order to achieve the maximum stability and precision-focusing. The maximum daytime wind speed of the location of interest is around 8.3 m s^{-1} and the calculated maximum wind load and torque were found to be 3.19 kN and 3.64 kNm respectively for a gust factor of 1.53. The structural design was optimized using a computer simulation to bring the maximum stress below the yield point, and when stress is 23.72 MPa the total deformation was found to be 1.12 mm which does not affect the focusing significantly. The concentration ratio of the plant is 1:66 and it lies well within the range of the corresponding parameter (1:30 and 1:80) available for commercial plants. The focusing efficiency of the system is 79% which is also on par with the values available for commercial plants. However, the overall efficiency of solar thermal utilization is found to be 28.7%, hence the thermal capacity of the power plant is 5 kW. Improvements are underway to reduce the heat loss from the receiver tube. It is estimated that the overall efficiency of the system can be increased up to 65% to 70% by using evacuated glass receiver tubes.

[1] Corresponding author. P D C Kumara ;Tel.: +94-71-156-2255
E-mail address: pdc_kumara@phys.cmb.ac.lk