ABSTRACT

Solar radiation energy incident on a collector can be converted into electricity using PV cells or thermal energy by means of solar thermal collectors. Solar radiation intensity is sometimes lower than required for suitable applications, hence needs to be concentrated. Solar radiation concentration can be done by mirrors or lenses to obtain higher temperatures and thermal energy required for appropriate applications such as heating, drying, cooking and other industrial applications. This technique is known as concentrated solar power (CSP). To achieve this it is necessary to use devices such as compound parabolic concentrators (CPC) and parabolic trough concentrators (PTC). There is always a variation in solar radiation concentration along the concentrator axis producing temperature variation as a function of both aperture width and distance from the focal point, maximum concentration (temperature) being at the focal point. A lot of research has been done on the types of concentrators, but no information has been given on how the shape factor (curvature) affects temperature distributions within a PTC. The main objective of the study was therefore to determine how the shape factor affects temperature distribution within a solar parabolic trough concentrator. Other objectives were: to investigate the relationship between the parabolic equation coefficient, shape factor and focal length within a given range of parabolic equation coefficient, and also to determine the focal line temperature of a solar PTC from a given range of solar intensity. The shape factor was obtained by dividing the vertical distance from the collector axis to the reflecting surface by axial distance from the base of the collector. Thus different shape factors were determined for various aperture sizes. The temperature variation was determined by measuring steady state temperature of 1 cm^2 black aluminium plates placed at various points along the concentrator axis based on the shape factor. Corresponding temperature measurements at various points of the plates were simultaneously obtained by using thermocouples attached to multi channel data logger. Ambient temperatures were also recorded. Solar radiation falling on the concentrator was also measured using a solarimeter. From the experimental results it was found out that shape factors of 20 and 4 produced average focal point temperatures of 75^oC and 45^oC respectively at an average solar radiation intensity of 620 W/m^2 and average ambient temperature of 26.5^oC. This implies that the focal point temperature of a PTC depends on both the shape factor and ambient temperature, which is also affected by solar radiation intensity. Higher temperatures can be achieved if heat losses are minimized and sun tracking system installed for the solar concentrator. The research findings are useful in determining the focal line temperature of a solar PTC based on average ambient temperature, solar radiation intensity and the shape factor. This enables the PTC users at different locations to make appropriate choice of PTC design suitable for various temperature applications.