ABSTRACT

A Solar thermal collector with computer aided design have been studied, with emphasis on cost reduction. Cost is the major factor governing applications of concentrated solar power (CSP) system. There is a need for reliable and simplified manufacturing process to limit the system costs. Cost reduction is the key issue which needs to be tackled in order to bring CSP technology into the market. Parabolic reflector profile programming with Auto LISP is developed for construction of compound parabolic concentrator (CPC) having a flat, one-sided absorber for various CPC configurations by adding aperture width and half-acceptance angle. The study shows that the geometry of the reflectors could be improved and thus reduced losses due to geometrical imperfections in the optical compound parabolic concentrate system and incident more heat flux in the absorber area to increase the collector efficiency. It also indicated that profile generated in Auto LISP could be used for modeling of multiple channelled concentrators (MCC) which may be used for photovoltaic cell, as to obtain as much as possible uniform density of concentration on the it, the analysis of the CPC ray-tracing and to gauge the distribution of the absorbed solar radiation on the absorber surface.

A low cost solar air heater with CPC is fabricated and experimentally tested in Patan, North Gujarat (23.8˚N, 72˚E) and operating performances is determined. The solar device has an aperture area of 0.96 m$^2$, a real concentration ratio of two, an acceptance half angle of 30°, and a galvanized iron flat receiver coated with a matt black paint. The profile of an air heater with a truncated is generated through programming with Auto LISP developed for construction of compound parabolic concentrator (CPC) having a flat one-sided absorber. CPSAH have a large acceptance angle for collection more portion of diffuse and beam solar radiation focusing all over the day without need to employ a tracking system. The thermal performance of a compound parabolic solar air heater (CPSAH) for a single pass is investigated experimentally. The effect of mass flow rate of air on the outlet temperature, thermal efficiency is studied. Experiments are performed for two air mass flow rates of 0.012 kg/s/m$^2$ and 0.016 kg/s/m$^2$. The presented results can be considered important for the design and the operation of solar air heaters used for drying agricultural products, space heating and, industrial purposes.

The thermal efficiency is found to be varied between 25.32% and 45.46% with daily solar radiation varied between 418 W/m$^2$ and 965 W/m$^2$ for air flow rate 0.012 kg/s/m$^2$ and 30.32% and 53.46% with daily solar radiation varied between 371 W/m$^2$ and 918 W/m$^2$ for air flow rate 0.016 kg/s/m$^2$. Experimental results show the highest air outlet temperature of the absorber is 75°C at 13:00 hr with highest solar radiation of 965 W/m$^2$ at an air flow rate 0.012 kg/s/m$^2$ and the
A pragmatic mathematical model or representation of the CPSAH system is developed and validated with measured field test data to predict the energy output from the CPSAH system under various different weather conditions in order to assess its long-term performance. The validated thermal model is used to predict the annual energy output from the CPSAH system in order to carry out a techno-economic analysis using the energy output, system characteristics, costs, fuel emission factors. The techno-economic analysis evaluates the thermal, economic and environmental performance of the CPSAH system. The estimated indicative cost of the new system is Rs.12000/m$^2$. The designed stationary system has the operational and economic advantages of no moving components. Incorporating a galvanized iron flat receiver coated with a matt black paint reduced overall life cycle cost significantly.

The annual CO$_2$ emission reduced by the CPSAH system is calculated as 344 kg/m$^2$ for flow rate 0.012 kg/s/m$^2$ and 385 kg/m$^2$ for flow rate 0.016 kg/s/m$^2$ against an electric heater which makes it an attractive air heating system for the drying of agricultural products and residential sector.

Developing efficient and cost effective CPSAH solar system for continuous drying of agricultural food products at moderate temperature (40°C–75°C) has become potentially a viable substitute for fossil fuel in much of the developing world like India.

The fabricated solar collector can be immerse and wide spread use for urban, rural such as water heating, steam cooking and sterilization, micro turbines and concentrating photovoltaic. This system can be efficient and cost effective solar concentrating system for SWHS/Air Heating System, power generation and Industrial / Agricultural drying applications.