HIGH TEMPERATURE SOLAR ENERGY RESEARCH

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Introduction

The high temperature solar energy research is an attempt to study the merits of the fixed aperture optics collector for the equatorial region using the concept of the fixed mirror distributed focus (Lodhi et al. 1991; Yusof Sulaiman et al. 1996). The general objective is to look for an alternative source of clean energy and a practical method of converting this energy into usable form for the projected industrialization program of the country. A fixed mirror distributed focus collector uses a stationary hemisphere bowl to capture the solar irradiance. The UPM bowl has a rim angle of 120° with a radius of curvature of 27.9m. This corresponds to an aperture diameter of 48m and therefore will be able to collect about 1 MW of solar irradiance. The captured solar radiation is reflected by mirrors laid on the bowl to a conical focus formed along the direction of the radius. The focus has its base formed adjacent to the mirror surface and vertex at half the radius of curvature. The conical focus represents region of high concentration since all the energy that is captured by the bowl is distributed in it. The energy at the conical focus can then be harnessed by different means. In the first part of this project, a receiver in the form of a boiler is utilised to extract thermal energy. Heating fluid from a storage tank is circulated through the receiver tubes that formed part of a closed loop. During operation, the axis of the receiver should at all times be pointing in the direction of the sun. The FMDF collector thus requires receiver tracking.

Materials and Methods

The project requires the construction of a concrete hemispherical bowl of 48m rim-diameter and submerge 5.1m in the ground. The bowl will later be tiled with 2446 square meters of mirrors. Alignment will be done with optical technique with accuracy limited to 6 minutes. The receiver support structure consists of massive steel structure of the bridge type suitable for the equatorial region. Two axes tracking in the direction of north south and east west is used for this type of receiver suspension. The tracking uses servo-motors with gears attached to the turning device shafts and boom. Active tracking by means of solar sensors is used when the irradiation is more than 300 W per square meter. Otherwise, it is switched to passive tracking (clock tracking). Two-sectional cone-receiver wound with 10 pieces of parallel tubes is attached to the boom and counterweight. The tubes are then connected to the inlet and outlet manifolds for thermal oil distribution. The oil is stored in a storage tank attached to an expansion tank. The storage tank is joined to the receiver through appropriate piping in a closed loop. Initial operation requires the oil to be circulated through the lower section of the receiver where the concentration is lower. When the temperature reaches 80°C, the oil is allowed to circulate through the upper section of the receiver by controlling appropriate valves and flow rates. The outlet temperature of the oil is then maintained at 200°C. Typical flow rate is 1.33 kg per second and pressure ranges from 1.8 to 3.1 bar.

Results and Discussion

The solar collector is still under construction so that the actual thermal performance has not been assessed. Simulated studies using actual meteorological data for the two-sectional cone receiver with inlet temperature of 80°C and outlet temperature of 200°C has produced daily energy recovery of between 5.7 and 6.8 MWh of thermal energy. (Yusof Sulaiman et al. 1997a). This corresponds to an efficiency of conversion of 40%. Effort to design a better receiver will be the main objective of the work in the near future (Yusof Sulaiman et al. 1997b).

Conclusions

The UPM solar collector will be the only fixed mirror distributed focus collector to be studied for the equatorial region. Its performance will be highly dependent on the design of the receiver. A simulated study using actual meteorological data for a two-sectional thermal cone receiver has produced an efficiency of conversion of 40%. A receiver with a higher efficiency is needed before the collector can be commercialised.

References

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