A NOVEL APPROACH FOR THE SUPPRESSION OF NATURAL CONVECTION AND RADIATION HEAT LOSS IN SOLAR CAVITY RECEIVERST.

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The concentrating solar power technology has great potential to be used for energy production and it is a promising alternative to conventional fossil fuel-based energy technologies, such as coal power plants, due to the abundance of solar energy as an energy resource, as well as its minimal impact on the environment. The parabolic dish receiver assembly is one such promising concentrating solar power technology. It usually consists of a reflector in the form of a dish with a downward-facing receiver at the focus of the dish. A cavity receiver is used to maximise the absorption of the concentrated flux. However, the receiver is subjected to environmental variations, as well as changes in receiver inclination angle, which lead to heat losses that affect the overall receiver's performance.

The need for the commercialisation of economically viable parabolic dish systems necessitates further in-depth investigation into cavity receiver designs. As the cavity receiver plays a critical role in transferring solar heat to the engine, any heat loss from the cavity receiver can significantly reduce the efficiency and, consequently, the system's cost effectiveness. It is therefore essential to assess and effectively minimise heat loss in the cavity receiver to improve the thermal performance of the system, which can contribute to the commercialisation of this type of technology.

This research focused on the modified cavity receivers that are employed in medium- and high-temperature solar dish systems with operating temperatures of up to 1 200 K. Firstly, a three-dimensional numerical investigation was conducted on a modified cavity receiver to quantify the natural convection heat loss, and to determine the effects of the operating temperature, receiver inclination angle and aperture size on heat loss.

Secondly, a novel approach of suppressing natural convection heat loss in a cavity receiver was investigated. The proposed model has not been observed in literature. A cavity receiver with plate fins attached to the inner aperture surface was investigated as a possible low-cost means of suppressing natural convection heat loss in a cavity receiver. Employing air as the working fluid, laminar natural convection heat transfer from the cavity receiver with plate fins attached to the inner aperture surface was investigated for a range of Rayleigh numbers, inclination angles, and fin heights and thicknesses.

Finally, a numerical study and optimisation of the combined laminar natural convection and surface radiation heat transfer in the cavity receiver with plate fins were conducted, and a three-dimensional simulation model was developed to estimate and optimise the convective and radiative heat loss. The influence of operating temperature, emissivity of the surface, orientation and the geometric parameters on total heat loss (convection and radiation) from the receiver were investigated. The results in steady state were obtained for a Rayleigh number range of 10^5 to 10^7. The overall thermal efficiency of the receiver was also analysed at different operating temperatures.

From this research, it can be concluded that there is a significant deviation between the Boussinesq and non-Boussinesq models of up to 20% at high temperatures. Therefore, natural convection at high temperature differences can accurately be predicted using the non-Boussinesq model. It was also observed that a significant reduction in natural convection heat loss (up to 20%) from the cavity receiver can be achieved through plate fins, which act as

heat suppressors. The results obtained provide a novel approach for improving the design of cavity receivers for optimal performance.

When natural convection was studied together with radiation, the overall cavity efficiency marginally increased by approximately 2% with the insertion of fin plates in the cavity receiver, although the convective heat loss was suppressed by about 20%. This is due to the fact that radiation heat loss dominates at high operating temperatures compared to convective heat loss.

Keywords: parabolic dish; cavity receiver; natural convection; radiation; plate fin; Rayleigh number.