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Simulation Modelling of the Transmission of Concentrated Solar Radiation through Optical Fibres to Thermal Application

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Abstract : One of the main challenges in high-temperature solar thermal applications transfer concentrated solar radiation to the load with minimum energy loss and maximum overall efficiency. The use of a solar concentrator in conjunction with bundled optical fibres has potential advantages in terms of transmission energy efficiency, technical feasibility and cost-effectiveness compared to a conventional heat transfer system employing heat exchangers and a heat transfer fluid. In this paper, a theoretical and computer simulation method is described to estimate the net solar radiation transmission from a solar concentrator into and through optical fibres to a thermal application at the end of the fibres over distances of up to 100 m. A key input to the simulation is the angular distribution of radiation intensity at each point across the aperture plane of the optical fibre. This distribution depends on the optical properties of the solar concentrator, in this case, a parabolic mirror with a small secondary mirror with a common focal point and a point-focus Fresnel lens to give a collimated beam that pass into the optical fibre bundle. Since solar radiation comprises a broad band of wavelengths with very limited spatial coherence over the full range of spectrum only ray tracing models absorption within the fibre and reflections at the interface between core and cladding is employed, assuming no interference between rays. The intensity of the radiation across the exit plane of the fibre is found by integrating across all directions and wavelengths. Results of applying the simulation model to a parabolic concentrator and point-focus Fresnel lens with typical optical fibre bundle will be reported, to show how the energy transmission varies with the length of fibre.

Keywords : concentrated radiation, fibre bundle, parabolic dish, fresnel lens, transmission
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