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HEAT TRANSFER OF SWIRLING RADIAL FLOW BETWEEN PARALLEL CIRCULAR DISKS AND ITS HEAT EXCHANGERS APPLICATION

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ABSTRACT

The steady forced convection between two stationary parallel circular disks in a radial sink flow cooling system is numerically investigated. The inward flow between two circular disks resembles flows that occur in many engineering applications such as solar chimney power plant collector, exit of a geothermal reservoir and disk type heat exchangers. In recent years, the higher cost of energy and material directed investigators in developing more efficient and compact heat exchangers, and more effort aimed at development of the heat transfer and effectiveness of heat exchangers. For these applications, techniques for enhancing heat transfer rate are required. A literature review shows that many investigators studied the fluid dynamics for flow between stationary and/or rotating disks but less heat transfer studies with stationary disks were conducted.

This investigation is devoted to study the effect of swirling flow and /or grooved surface on the heat transfer and the thermo-hydraulic parameter of the flow between two circular disks. Moreover, it is suggested to study the effectiveness-NTU analyses in a circular disks heat exchanger with radial and swirling sink flow for a wide range of Reynolds number, as an application on the study of the swirling inflow between two circular disks.

Turbulent steady and incompressible radial flow is numerically studied using the commercial code (FLUENT 6.3). The validation study demonstrates the good predictions of the numerical model used.

A wide range of inlet Reynolds number (Re), $100 \leq Re \leq 10^5$, inlet swirl ratio (S), $0 \leq S \leq 20$ and the gap spacing ratio (G), $0.01 \leq G \leq 0.1$ is considered in the study. The rectangular grooves are characterized by ribs with three dimensionless lengths; height (t/δ), $0.1 \leq t/\delta \leq 0.35$, the interval spacing between ribs (i/R_o), $0.025 \leq i/R_o \leq 0.1$, and the width of rib ($w/R_o$), $0.025 \leq w/R_o \leq 0.1$.

For the circular disks heat exchanger study, the variation of the thermal effectiveness and the number of transfer units (NTU) are presented with hot water Reynolds numbers (Re_h), $50 \leq Re_h \leq 10^4$, for different cold water flow rates with a wide range of the capacity ratio (Cr), $0.1 \leq Cr \leq 1.0$. The study considered the pure radial sink flow (S=0.0) and the strong swirling sink flow (S=20), for the two designs of the flow arrangements of the circular disk heat exchanger (distributed and undistributed)

The numerical results are reported as stream lines, pumping friction factor ratio, local Nusselt number, average Nusselt number and thermo-hydraulic performance factor. While for the circular disks heat exchanger study the results are reported for temperature contours and the effectiveness – NTU results. Moreover, correlations for the effectiveness – NTU relation are resolved.

In addition, it is studied the outflow (source flow) with the ribs on the lower disk. Results have clearly shown that the ribs on lower disk can significantly increase heat transfer capabilities of radial source flow cooling systems.

Finally, recommendations and some of studying points that we hope to be studied in the future are listed.