Convective Heat Transfer in an Annulus of Concentric and Eccentric Cylinders with an Inner Rotating Cylinder

This numerical study details the engine oil flow behaviour of convective heat transfer through a concentric and an eccentric annulus formed between a heated inner rotating cylinder and a cooled outer stationary cylinder. The three-dimensional governing equations for continuity, momentum, and energy have been solved using a finite volume method (FVM). The computational simulations are developed using well-known commercial software ANSYS-FLUENT. Besides this, a sensitivity analysis is executed via response surface methodology (RSM) using the statistical software of Design-Expert 12 to predict the optimum design that improves the hydrothermal performance in an eccentric annular cylinder. The findings are reported for numerical calculations of the moment coefficient (Cmc), surface temperature (Ts) of the inner rotating cylinder and Nusselt number (Nu) for a range of values of (0.25 - 0.75) aspect ratio (R*), (0.5 - 2.5 cm) eccentricity (E), (0° – 180°) inclination angle of the inner rotating cylinder (θ) and a wide range of Taylor number (Ta) of (2 – 4.5×104). In the case of a concentric annular cylinder, the averaged Nusselt number increases by increasing the Taylor number and decreasing the aspect ratio. Also, increasing the Taylor number and decreasing the aspect ratio causes a gradual decrease in the moment coefficient and surface temperature of the inner rotating cylinder. Whereas in the case of the eccentric annular cylinder, the maximum averaged Nusselt number and minimum surface temperature with the moderate value of moment coefficient are obtained at the optimum case of 2.5 cm eccentricity and 180° inclination angle, which are considered the optimum-estimated parameters of the eccentric annular gap. The influences of these physical parameters are graphically depicted in terms of velocity contours and temperature fields. Therefore, the rotation of the inner cylinder is shown to have a significant impact on the thermal-flow field of confined fluid.