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Dynamic of a capillary ridge of free surface flow on an inclined heated plate

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Formation of capillary ridge on a gravity-driven thin liquid film flowing over a plate is used in lots of commercial applications. Painting and coating, contact lens manufacturing, microchips and microchips fluidic devises are some examples. Capillary ridge forms due to the surface tension, geometrical structure of the flow and the temperature of the fluid. Capillary ridge height varies with the surface tension coefficient, inclination angle and initial thickness. Its height is increased with higher surface tension, steeper inclination angle and bigger initial thickness. In this work, a mathematical model has been developed for a two-dimensional, laminar, incompressible flow of second grade non-Newtonian fluid with temperature-dependent viscosity on an inclined planar plate. Also the capillary ridge height and corresponding velocities, pressure and temperature of the zeroth order expansion are discussed. The thin plate is heated locally and inclined at an angle with the fixed horizontal axis. Simplified Navier-Stokes equations are solved together evolution equation for the description of the liquid thin film height which is derived by using the long-wave approximation. The solution of the resulting equation for the liquid thin film height is approximated using explicit finite difference method on a uniform grid. The solutions are simulated to identify the flow patterns. Capillary ridge height and velocities, pressure and temperature are obtained using the asymptotic expansion. It can be observed that there is an oscillatory behavior of capillary ridge height along the direction of the plate. Furthermore, the upstream of capillary ridges change slightly with the advancement of time and the downstream of capillary ridges do not change with the time. The results indicate that the temperature varies proportionally with the space variable from left end of the domain to the right end of the domain. Behavior of the velocity and the pressure has been discussed in the different directions of fluid flow domain. The results indicate that the velocity component in x direction decreases when negative x approaches to zero and it increases when x increases from zero to the right end of the domain. Velocity component in z direction decreases linearly when x increases. It is also realized that the pressure decreases to zero when negative x increases to zero and the pressure increases when x increases from zero to the right end of the domain.

Keywords: Capillary ridge height, second grade fluid, thin film, locally heated plate