FINITE ELEMENT MODELING OF LAMINAR FLOW OF A THIRD GRADE FLUID IN A DARCY-FORCHEIMMER POROUS MEDIUM WITH SUCTION EFFECTS

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A mathematical model to simulate the steady laminar flow of an incompressible, third grade, non-Newtonian fluid past an infinite porous plate embedded in a Darcy-Forcheimmer porous medium is presented. A number of special cases are examined for the governing nonlinear differential equation. The model is solved with appropriate boundary conditions using the finite element method. Velocity and velocity gradient are plotted graphically for variation in permeability (k), Forcheimmer parameter (b), third grade material parameter (β_3), and suction effect (Vo). It is shown that velocities are generally decreased transverse to the plate surface with increasing Forcheimmer parameter; increasing permeability conversely boosts the velocities, as this corresponds to an increasingly fluid (i.e., progressively less porous) regime. The third grade material parameter is also seen to substantially increase the velocities in the direction normal to the plate surface. The special case of a second order viscoelastic flow is also studied. The flow scenario finds applications in polymer extrusion processes, and other important industrial rheology systems.

Key words: mathematical model, finite element numerical solution, third grade fluid, perforated surface, non-Darcy porous medium, suction velocity, stress moduli, permeability, Forcheimmer parameter, polymer and rheological materials processing.

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