THE MODIFICATION OF EKMAN-HARTMANN LAYER BY THE IMPOSITION OF AXIAL VELOCITY

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SUMMARY

The effect of normal blowing on a linear, steady, axisymmetric Ekman-Hartmann boundary layer on an infinite flat insulating plate is analyzed. The problem is governed by three parameters, namely the Ekman number $E\left(=\frac{\upsilon}{L^2\Omega}\right)$, the magnetic interaction parameter $\alpha^2\left(=\frac{\sigma B_0^2}{\rho\Omega}\right)$ and the Injection Rossby number $R\left(=\frac{U}{L\Omega}\right)$. In the parametric range $E^{1/2}\alpha^{-1} << R >> E^{1/2}\alpha$ and $E^{1/2} << R << 1$, the viscous Ekman-Hartmann layer is blown up by the injection of the fluid, and it becomes inviscid to the lowest order. Injection and magnetic terms balance each other giving rise to a ***new boundary layer*** of thickness $O\left(\frac{R}{\alpha^2}\right)$, which may be called ***linear resistive layer***. Since, the resistive layer is thicker than the Ekman-Hartmann layer, it can support more electric and mass flux, thus signifying a possible faster spin-up compared to conventional hydromagnetic case. The electric current increases with magnetic interaction parameter α beyond the saturation value, and finally approaches the saturation value as $R \to E^{1/2}\alpha$. The vertical mass flux into the resistive layer decreases with magnetic field as expected because of the stiffening effect of the magnetic field. This resistive layer, characterized by dispersive and diffusive length scales for $\alpha^2 < O(1)$ merges with the interior and becomes a resistive region in the parameter range $E^{1/3} << R >> E^{1/2}\alpha^{-1}$ and $R >> \alpha^2$. The other parameter ranges are clearly identified wherein the resistive $\frac{R}{\alpha^2}$ layer merges smoothly into the Ekman layer, the $\frac{R^3}{E}$ injection layer that occurs when $\alpha = 0$, the Ekman-Hartmann layer and the $\frac{E^{1/2}}{\alpha}$ Hartmann layer. In addition to exact solutions, asymptotic solutions are also given for $\alpha^2 \geq O(1)$ and $\alpha^2 < O(1)$ to understand the problem more systematically and physically.