Assignment-2
Thermo-Fluids
TFL4801-Y-2024

Answer all questions:

1. Derive an expression for displacement thickness δ^* in a boundary layer that formed due to flow over a flat plate. **[10]**

2. Derive an expression for momentum thickness "θ" in a boundary layer that formed due to flow over a flat plate. **[10]**

3. In a metal casting process, Aluminum metal flows through a mold cavity at 770 ^{0}C. Molten Aluminum metal density at this temperature is given as 3600 kg/m^3. The diameter of the mold cavity is 140mm and the velocity of molten metal is 0.1 m/s. As it flows through the cavity the temperature of the metal reduces linearly to 620 ^{0}C over a distance of 2m. The viscosity of molten metal at the inlet of the cavity is given as approximately $1.2x10^{-2}$ Pa.s. As the metal flows through cavity its viscosity increases linearly up to $1.4x10^{-2}$ Pa.s. Determine the Reynolds number at 3 locations along the cavity and draw the variation of Re as a function of distance.
[10]

4. A certain type of thermo-fluid flows over a hot plate. Assume the plate is heated from the bottom with constant wall heat flux condition. For this situation, represent hydro dynamic and thermal boundary layer formation. Represent different flow regimes in a boundary layer that formed on a flat surface, including potential flow regime and no-slip condition. Write a mathematical expression for no-slip condition. The velocity distribution in a boundary layer is given as $u/U = \{(y)/(\delta)\}$, where, "δ" being the boundary layer thickness. Determine the ratio of displacement thickness to boundary layer thickness (δ^*/δ) and the ratio of momentum thickness to boundary layer thickness (θ/δ).
[10]

5. A rectangular metal plate is heated to a temperature of say 200 ^{0}C. To cool this plate naturally in air, it is suspended along the longer edges of the plate. Illustrate the flow around the plate created due to buoyancy and draw the temperature and velocity profiles for the fluid on both sides of the plate. A double pipe heat exchanger facilitates the exchange of heat between two fluids. There are two thermo-fluids that exchange heat in two possible flow configurations namely 1) Parallel flow and 2) counter flow. Draw the temperature and velocity profiles for each case when the flow is fully developed. It is recommended that hot fluid flows in the inner pipe

while the cold fluid flows in the annular space. What are the scientific reasons, for the above recommendations. **[10]**

[Total 50 Marks]