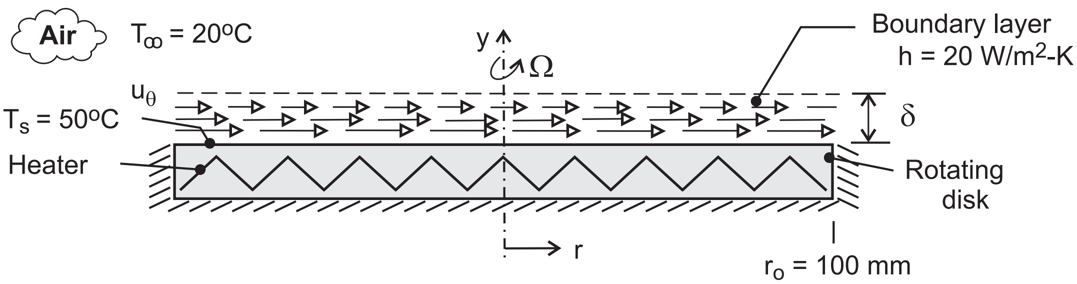
PROBLEM 6.16

KNOWN: Local convection coefficient on rotating disk. Radius and surface temperature of disk. Temperature of stagnant air.

FIND: Local heat flux and total heat rate. Nature of boundary layer.

SCHEMATIC:



ASSUMPTIONS: (1) Negligible heat transfer from back surface and edge of disk.

ANALYSIS: If the local convection coefficient is independent of radius, the local heat flux at every point on the disk is

$$q'' = h\left(T_s - T_\infty\right) = 20\,W/m^2 \cdot K\left(50 - 20\right)°C = 600\,W/m^2 \qquad <$$

Since h is independent of location, $\bar{h} = h = 20\,W/m^2 \cdot K$ and the total power requirement is

$$P_{elec} = q = \bar{h}A_s\left(T_s - T_\infty\right) = \bar{h}\pi r_o^2\left(T_s - T_\infty\right)$$

$$P_{elec} = \left(20\,W/m^2 \cdot K\right)\pi\left(0.1m\right)^2\left(50 - 20\right)°C = 18.9\ W \qquad <$$

If the convection coefficient is independent of radius, the boundary layer must be of uniform thickness δ. Within the boundary layer, air flow is principally in the circumferential direction. The circumferential velocity component u_θ corresponds to the rotational velocity of the disk at the surface (y = 0) and increases with increasing r ($u_\theta = \Omega r$). The velocity decreases with increasing distance y from the surface, approaching zero at the outer edge of the boundary layer ($y \rightarrow \delta$).