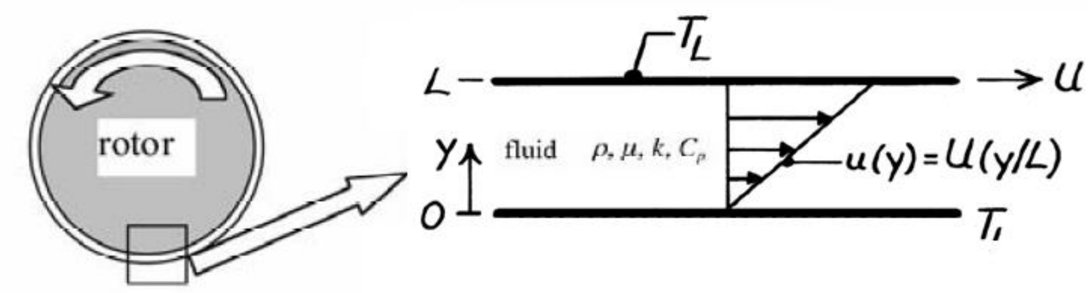
1. Couette flow is generated by the relative motion of two parallel plane walls. One of the walls is moving in its own plane with the constant velocity *U*. The other wall is assumed to be at rest. The wall motion drives the fluid filling the gap of spacing L between the two walls (Figure). This situation is relevant to lubrication, where a rotor rotates in a bearing. The gap spacing is assumed to be very small compared to the rotor/bearing radii so that curvature effects may be ignored.

(i) Determine the temperature profile, expressing your result in terms of fluid properties and the temperature and speed of the moving plate.

(ii) Obtain an expression for the heat flux at the moving plate.

(iii) Determine the influence of dissipation on the velocity profile and heat transfer between the walls and the fluid.



Practice the following (We have already solved the 1st and 2nd part of the problem in the class)

Plot: η *vs* θ, η *vs* heat flux and η *vs* heat flow rate for Br=0, 1, 2, 6 and 20. Use the non-dimensionalized expression of temperature and heat flux (Solved in the class) for this plot. This will give you an idea of the effect of viscous dispassion on the energy transport for this type of problem. Assume $\frac{k(T_L - T_1)}{L} = 1$; while plotting.

2. In problem 1 solve the following,

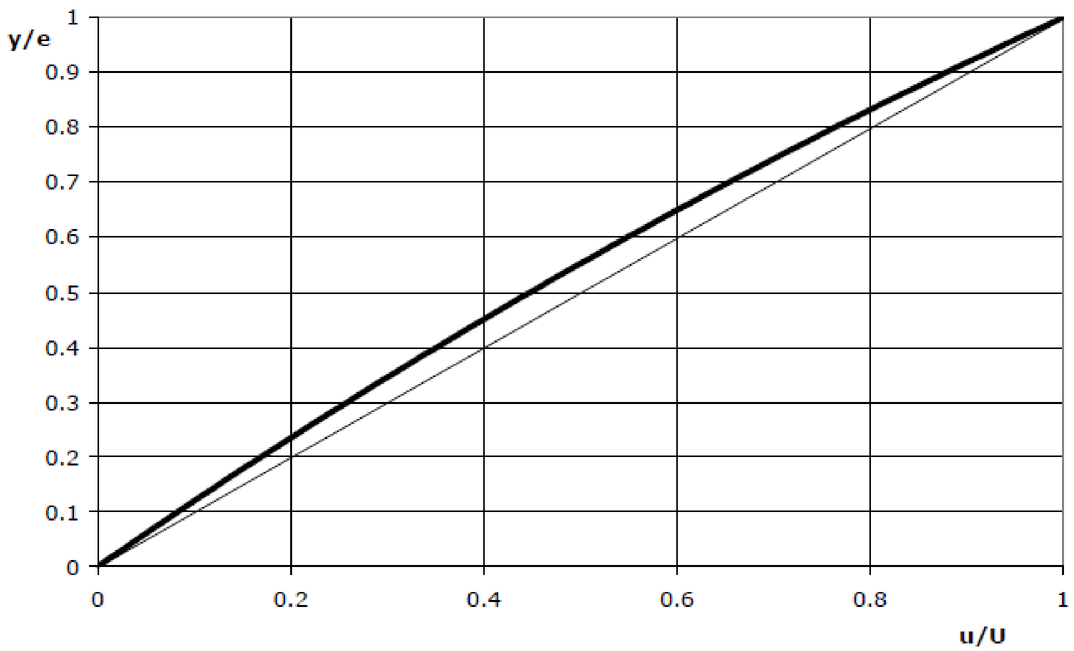
(i) Determine the velocity profile when the fluid viscosity varies linearly as a function of temperature in the range defined by the walls' temperature.

(ii) Compare the skin-friction τ (with the linearly varied viscosity) to τ_m (at constant viscosity, which would be exerted on the walls if the fluid were at the uniform temperature $[T_1 + T_L]/2$). Comment on your findings based on the experimentally obtained data.

Data: An experiment is carried out with oil in the gap between the two walls: L = 1 cm, T_1 = 27°C, T_L = 37°C, ν (27°C) = 5.5 $\times 10^{-4}$ m^2 s^{-1}, ν (37°C) = 3.63 $\times$ 10^{-4} m^2 s^{-1}.

Ans: (i) $$\frac{u(\eta)}{U} = \frac{\ln\left(1 - \frac{2\lambda\eta}{1+\lambda}\right)}{\ln\left(\frac{1-\lambda}{1+\lambda}\right)}$$

Where $\lambda = \frac{\Delta\mu}{\mu_m} = \frac{\mu(T_1) - \mu(T_L)}{\mu(T_1) + \mu(T_L)}$ and $\eta = \frac{y}{L}$



Velocity profile in a Couette flow with variable physical properties, $\lambda = 0.205$

(ii) $\frac{\tau}{\tau_m} = \frac{2\lambda}{\ln\left(\frac{1+\lambda}{1-\lambda}\right)}$

The skin-friction calculated by taking the viscosity variations into account is very close to the corresponding value obtained with the average viscosity at $(T_1 + T_L)/2$ (deviation: 1.6%).