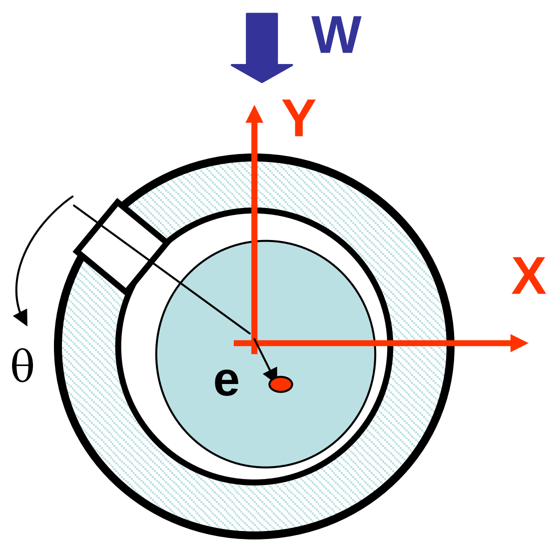
Luis San Andres – Fall2009 (NUS)



All journal bearings have a supply port (axial groove or hole) to feed cold lubricant into the film separating the rotating journal and its the bearing. The lubricant gets hotter (increase in temperature) as it flows down thru the hydrodynamic wedge. Some hot lubricant leaves the bearing through its sides. The spinning journal draws some hot lubricant around towards the inlet port where it mixes with the cold stream of lubricant. The temperature of the lubricant at the inlet of the film land is higher than the oil supply temperature.

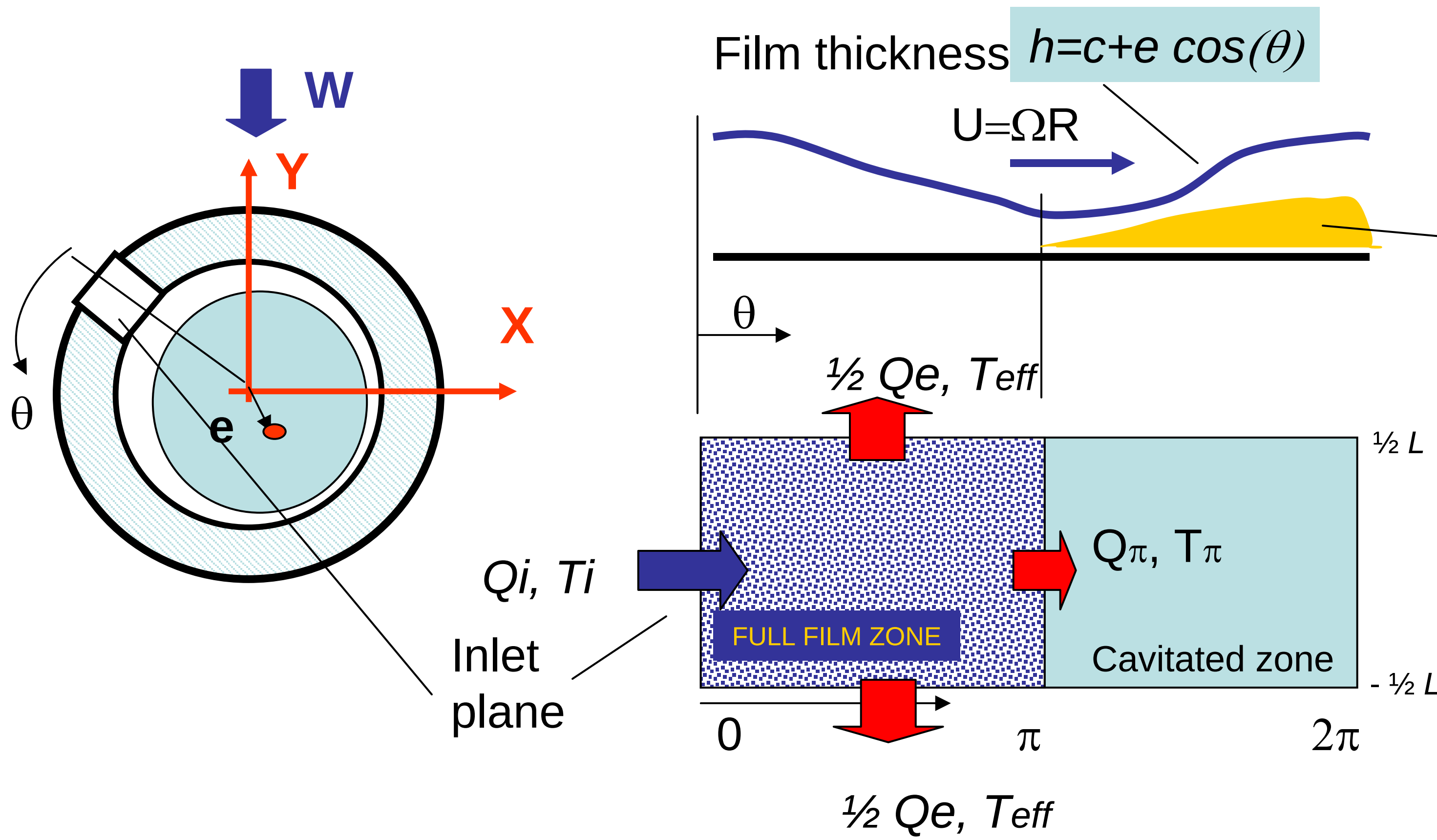
Appendix to Notes 4 : Static load performance of journal bearing

Simple lumped parameter thermal analysis for predicting the exit temperature and effective viscosity in a short length journal bearing

Nomenclature

Q : flow

T : temperature

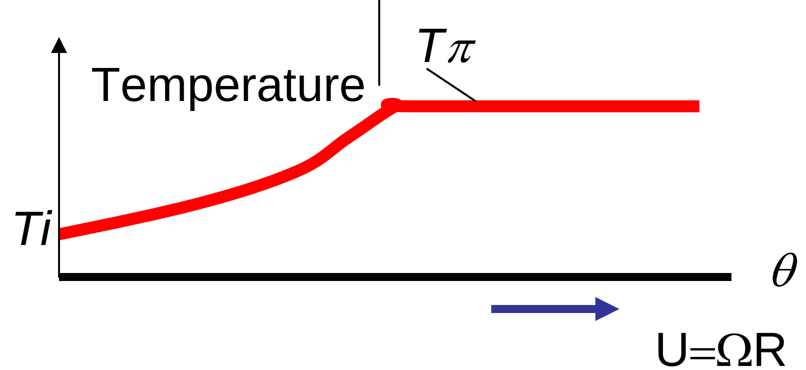


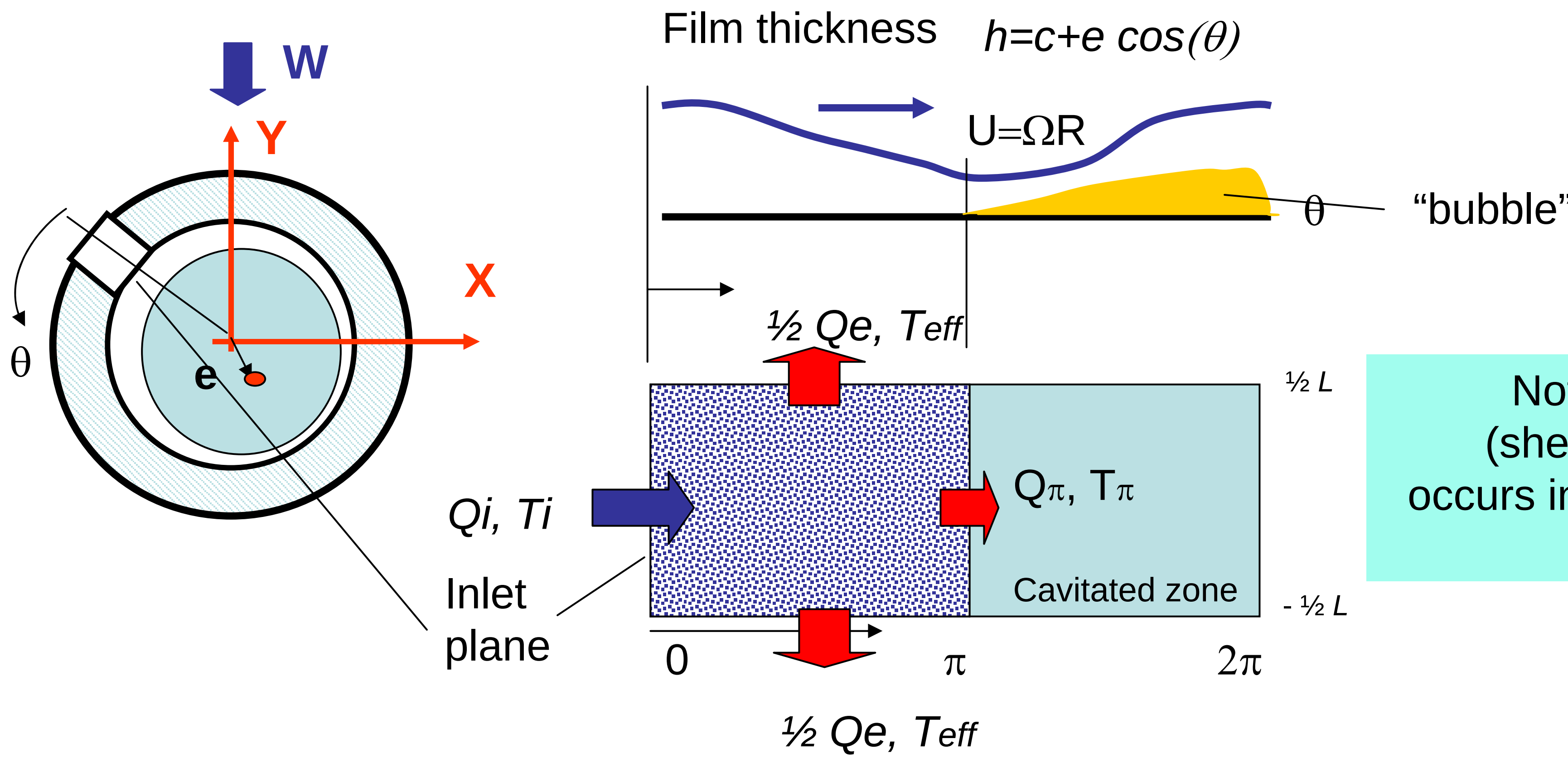
Note: drag (shear) only occurs in region θ [0,π[

Let:

$$T_{eff} = \tfrac{1}{2}\,(T_i + T_\pi)$$

As a weighed average





Note: drag (shear) only occurs in region θ [0,π[

GLOBAL FLOW CONTINUITY EQN

$$Qi=Qe+Q_{\pi}$$

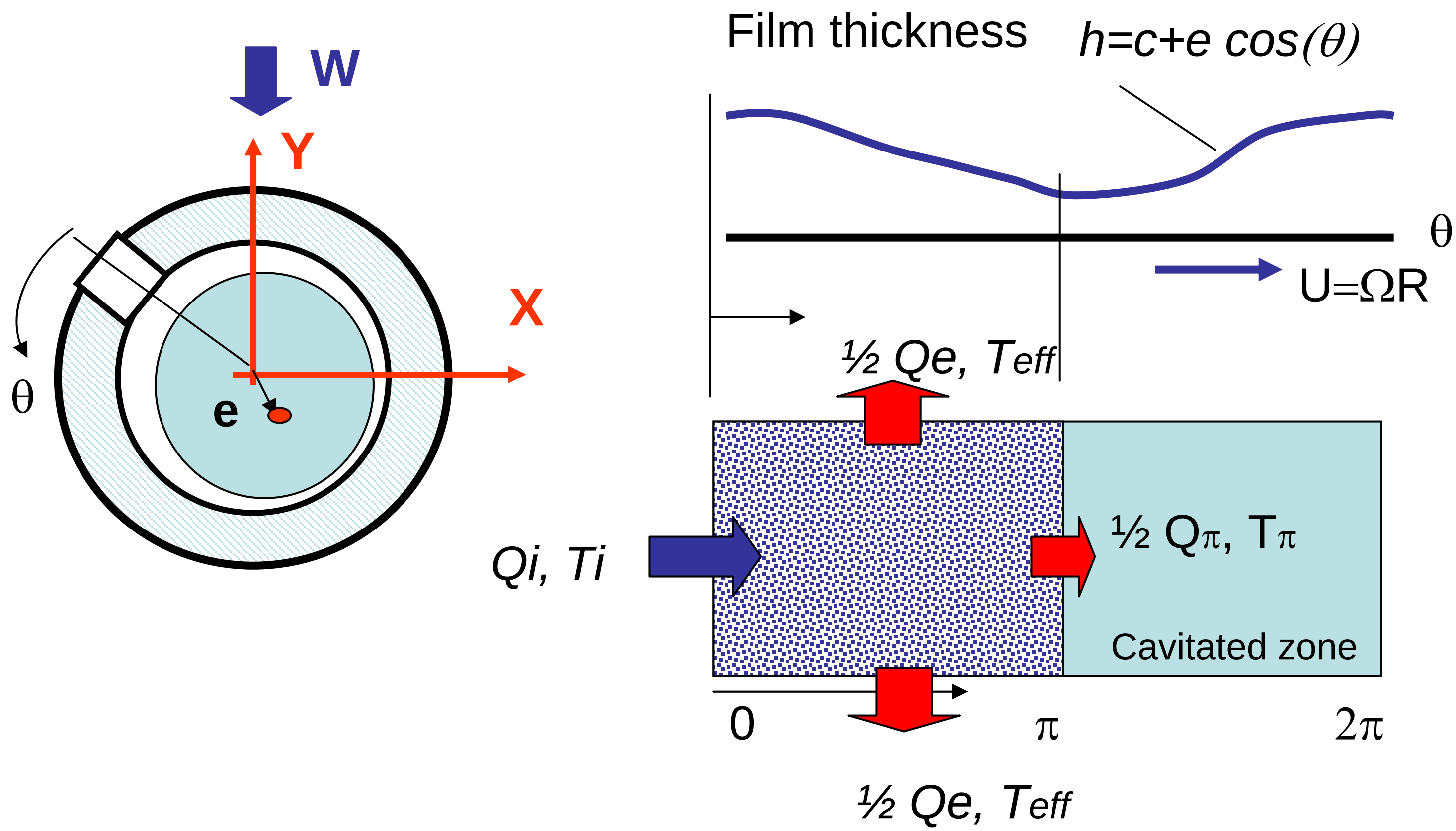
1D ENERGY TRANSPORT EQUATION

$$Eo-Ei=\kappa\ Power$$

κ is a fraction of the mechanical power is converted into heat and carried away by lubricant flow

$$Ei = \rho\, C_p\, Qi\ Ti$$

$$Eo = \rho\, C_p\, Qe\ T_{eff} + \rho\, C_p\, Q_{\pi}\, T_{\pi}$$



Note: drag (shear) only occurs in region θ [0,π[

Working with both eqns. leads to

$$\frac{\kappa\, Power}{\rho\, C_p} = (Qi - \tfrac{1}{2}\, Qe)\,(T_\pi - T_i)$$

Nomenclature

Q : flow

T : temperature

λ : thermal mixing coefficient = 0.80 (TYP)

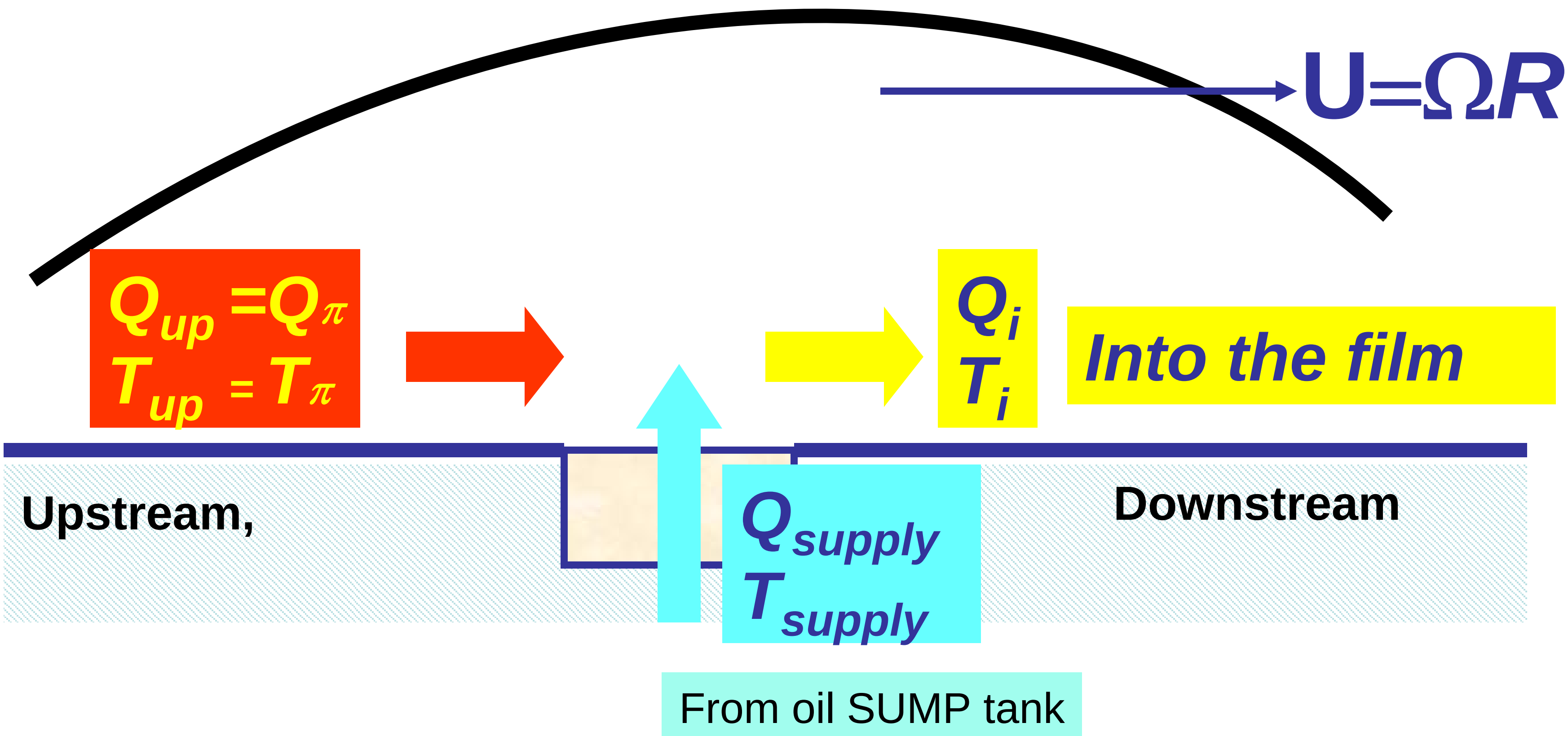
Heat carry-over coefficient

Flow balance

$$Q_i = Q_{supply} + \lambda Q_{up}$$

Energy balance

$$Q_i T_i = Q_{supply} T_{supply} + \lambda Q_{up} T_{up}$$



Thermal mixing at bearing inlet “groove”

Nomenclature

Q : flow

T : temperature

E : Energy

Flow & energy balance in feed groove

$$Q_i = Q_{supply} + \lambda\, Q_\pi$$

$$Q_i\, T_i = Q_{supply}\, T_{supply} + \lambda\, Q_\pi\, T_\pi$$

Flow & energy balance in film land

$$Qi = Qe + Q\pi$$

$$Eo - Ei = \kappa\, Power$$

$$Ei = \rho\, Cp\, Qi\, Ti$$

$$Eo = \rho\, Cp\, Qe\, Teff + \rho\, Cp\, Q\pi\, T\pi$$

$$Q_i \sim \frac{U}{2} h_{\theta=0} = L \cdot (c+e) \cdot \frac{R\Omega}{2};$$

$$Q_\pi \sim \frac{U}{2} h_{\theta=p} = L \cdot (c-e) \cdot \frac{R\Omega}{2}$$

$$Q_e = Q_i - Q_\pi = e\, L\; R\Omega$$

$$Power \sim Torque\ \Omega = \Omega \int_0^L \int_0^\pi \mu \left(\frac{\partial u}{\partial y} \right)_{y=0} R^2\, d\theta\, dz;\ \ \text{recall}\ \ u = U\, {}^{y}\!/_{h}$$

$$\sim \Omega \int_0^L \int_0^\pi \mu \left(\frac{\Omega R}{h} \right)_{y=0} R^2\, d\theta\, dz;$$

$$Power \sim \mu_{eff} \frac{\Omega^2 R^3 L}{c} \int_0^\pi \frac{1}{1+\varepsilon \cos\theta} d\theta = \mu_{eff} \frac{\Omega^2 R^3 L}{c} \frac{\pi}{\sqrt{1-\varepsilon^2}}$$

Thermal energy transport – short journal bearing