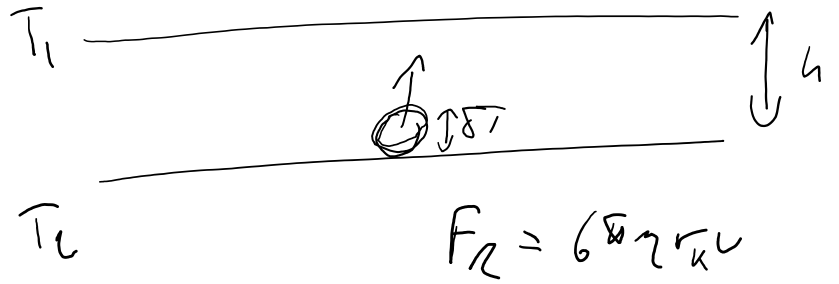
Konvektion



$T_2 - T_1 = \Delta T > 0$

$F_R = 6\pi\eta r_K v$

Auftriebskraft $F_A = (\rho_K - \rho_u) g \cdot V_K = \alpha \delta T \rho_u g V_K$

$\alpha = \frac{1}{V}\frac{\partial V}{\partial T}$ $\qquad \rho_K = \alpha \cdot \delta T \rho_u + \rho_u$

$\rho_K - \rho_u = \alpha \delta T \rho_u$

Parameter der beschreibt wie "einfach" Konvektion ist

$$\boxed{Ra \sim \frac{\alpha \Delta T g \rho}{\eta \kappa} h^3}$$

κ: Wärmediffusionskoeffizient

Ra: soll eine Zahl sein

$$1 = \frac{K^{-1} K m s^{-2} kg m^{-3} m^a}{kg m^{-1} s^{-1} m^2 s^{-1}} = m^{\boxed{1-3+1-2+a}} \qquad 1-3+1-2+a \overset{!}{=} 0$$

$\Rightarrow a = 3$

Steiggeschwindigkeit: aus $F_R = F_A$

$$6\pi\eta r v = \alpha\,\delta T\, g\,\rho\,\frac{4\pi}{3} r^3 \qquad \Big|\, : 6\pi\eta r$$

$$v = \frac{\alpha\,\delta T\, g\,\rho\, 2 r^2}{9\eta}$$

$\Rightarrow$ Zeit um Durchmesser zu steigen:

$$\tau_s = \frac{2r}{v} = \frac{2r\cdot 9\eta}{\alpha g \rho\, \delta T\, 2 r^2} = \frac{9\eta}{\alpha\,\delta T\,\rho\, g\, r}$$

Für Konvektion: $\tau_s < \tau_{WL} = \frac{r^2}{6\kappa}$

$$\frac{9\eta}{\alpha\,\delta T\,\rho\, g\, r} < \frac{r^2}{6\kappa}$$

$$54 < \frac{\alpha\,\delta T\,\rho\, g\, r^3}{\kappa\eta} \qquad \delta T = \frac{\Delta T}{h}\, 2r$$

$$27 < \frac{\alpha\,\Delta T\,\rho\, g\, r^4}{h\,\kappa\,\eta} \qquad \frac{h}{4} < r < \frac{h}{2} \quad \Rightarrow \quad r \approx \frac{h}{3}$$

$$81\cdot 27 < \boxed{\frac{\alpha\,\Delta T\,\rho\, g\, h^3}{\kappa\eta}}$$

2000

Wärmestrahlung

$$3p = T\,\frac{\partial s}{\partial V} - p \qquad \frac{\partial S}{\partial V} = \frac{\partial}{\partial V}\left(-\frac{\partial F}{\partial T}\right) = \frac{\partial}{\partial T}\left(-\frac{\partial F}{\partial V}\right) = \partial$$

$$3p = T\frac{\partial S}{\partial V} - p$$

$$\frac{\partial S}{\partial V} = \frac{\partial}{\partial V}\underbrace{\left(-\frac{\partial F}{\partial T}\right)}_{S} = \frac{\partial}{\partial T}\underbrace{\left(-\frac{\partial F}{\partial V}\right)}_{p} = \frac{\partial p}{\partial T}$$

$$4p = T\frac{\partial p}{\partial T}$$

$$4\int\frac{dT}{T} = \int\frac{dp}{p} \qquad \ln T^4 = \ln p \qquad p \sim T^4$$