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$$G = \sqrt{\frac{P}{\mu V}}$$

$\Rightarrow$ $P = G^2 \mu V$

@ 15$^{\mathrm{o}}$C: $P = (100/s)^2 \times (1.139 \times 10^{-3}\ N - s/m) \times (2800\ m^3) = 31900\ W$

$= 31.9\ kW$

@ 5$^{\mathrm{o}}$C: $P = (100/s)^2 \times (1.518 \times 10^{-3}\ N - s/m) \times (2800\ m^3) = 42500\ W$

$= 42.5\ kW$

Results indicate that as temperature ↓, viscosity ↑, so more power input is required for the same intensity of mixing

Slide#35

i) 10^{-4} m = 0.1 mm

a) Determine $v_{p(t)}$ using Stoke's law

$$v_{p(t)} = \frac{g(\rho_p - \rho_w){d_p}^2}{18\mu} = \frac{9.81\ m/s^2 \cdot (1.050 - 0.998) \times 10^3\ kg/m^3 \cdot (10^{-4}\ m)^2}{18 \cdot (1.002 \times 10^{-3}\ N-s/m^2)}$$

$$= 2.83 \times 10^{-4}\ m/s$$

b) Check N_R

$$N_R = \frac{v_p d_p \rho_w}{\mu} = \frac{(2.83 \times 10^{-4}\ m/s) \cdot (10^{-4}\ m) \cdot (0.998 \times 10^3\ kg/m^3)}{1.002 \times 10^{-3}\ N-s/m^2} = 0.028$$

⇨ *N_R<1, so Stoke's law applies as assumed.*

So, $\underline{\boldsymbol{v_{p(t)} = 2.83 \times 10^{-4}\ m/s}}$

Slide#35

ii) 10^{-3} m = 1 mm

a) Determine $v_{p(t)}$ using Stoke's law

$$v_{p(t)} = \frac{g(\rho_p - \rho_w){d_p}^2}{18\mu} = \frac{9.81\ m/s^2 \cdot (1.050 - 0.998) \times 10^3\ kg/m^3 \cdot (10^{-3}\ m)^2}{18 \cdot (1.002 \times 10^{-3}\ N - s/m^2)}$$

$$= 2.83 \times 10^{-2}\ m/s$$

b) Check N_R

$$N_R = \frac{v_p d_p \rho_w}{\mu} = \frac{(2.83 \times 10^{-2}\ m/s) \cdot (10^{-3}\ m) \cdot (0.998 \times 10^3\ kg/m^3)}{1.002 \times 10^{-3}\ N - s/m^2} = 28$$

⇨ *N_R>1, so Stoke's law cannot be applied.*

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ii) 10^{-3} m = 1 mmc) Use the N_R calculated and apply the transient region solution

$$C_D = \frac{24}{N_R} + \frac{3}{\sqrt{N_R}} + 0.34 = \frac{24}{28} + \frac{3}{\sqrt{28}} = 1.76$$

$$v_{p(t)} = \sqrt{\frac{4g}{3C_D}\left(\frac{\rho_p - \rho_w}{\rho_w}\right)d_p} = \sqrt{\frac{4 \cdot 9.81\ m/s^2}{3 \cdot 1.76}\left(\frac{1.050 - 0.998}{0.998}\right) \cdot 10^{-3}\ m}$$

$$= 1.97 \times 10^{-2}\ m/s$$

The result does not match with the $v_{p(t)}$ used to get N_R (Stoke's solution – 2.83 x 10^{-2} m/s)

Have to assume a smaller $v_{p(t)}$

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d) Assume $v_{p(t)}$, calculate NR, then calculate CD, then calculate $v_{p(t)}$ until assumed $v_{p(t)}$ = calculated $v_{p(t)}$

Eventually, if you assume $v_{p(t)} = 1.7 \times 10^{-2}\ m/s$,

$$N_R = \frac{v_p d_p \rho_w}{\mu} = \frac{(1.7 \times 10^{-2}\ m/s) \cdot (10^{-3}\ m) \cdot (0.998 \times 10^3\ kg/m^3)}{1.002 \times 10^{-3}\ N - s/m^2} = 16.9$$

$$C_D = \frac{24}{N_R} + \frac{3}{\sqrt{N_R}} + 0.34 = \frac{24}{16.9} + \frac{3}{\sqrt{16.9}} = 2.49$$

$$v_{p(t)} = \sqrt{\frac{4g}{3C_D}\left(\frac{\rho_p - \rho_w}{\rho_w}\right) d_p} = \sqrt{\frac{4 \cdot 9.81\ m/s^2}{3 \cdot 2.49}\left(\frac{1.050 - 0.998}{0.998}\right) \cdot 10^{-3}\ m}$$

$$= 1.65 \times 10^{-2}\ m/s$$ *(close to the assumption)*

So, $\underline{\boldsymbol{v_{p(t)} \approx 1.7 \times 10^{-2}\ m/s}}$

You may use computer software (e.g, Excel "find solution" function) to automate the calculation!