The procedure is as follows

1- Obtain power data using non-Newtonian liquid and calculate the power number from $P = \frac{P_A}{\rho N^3 D^5}$ for various agitator speed N .
2- Read the $(Re)_m$ from the appropriate Newtonian power curve for each value of p and N .
3- For each value of $(Re)_m$ and N in the laminar flow region calculate the apparent viscosity (μ_a) from $\mu_a = \frac{\rho N D_A^2}{(Re)_m}$
4- Compare a log – log plot of (μ_a) against N with a log – log plot of (μ_a) against $\dot{\gamma}$ experimentally determined using a viscometer .
   Plot $\dot{\gamma}$ against N on ordinary Cartesian coordinates for corresponding values of (μ_a) . The plot is a straight line of slope . k which is dimensionless proportionality constant of the equ. $\dot{\gamma_{av}} = KN$
5- For various value of P and N beyond the laminar flow region calculate $\dot{\gamma}$ from $\dot{\gamma} = KN$. Read (μ_a) from $\log(\mu_a)$ against $\log \dot{\gamma_{av}}$ and calculate $(Re)_m$ for each value of N and P . Exlend the power curve beyond the laminar flow region by plotting these values of P and $(Re)_m$.

Heat Transfer in mixing Vessel

Vessel with Helical cooling coil

The overall heat transfer coefficient may be expressed by the relation :

$$\frac{1}{U_A} = \frac{1}{h_i A_i} + \frac{x_w}{k_w A_w} + \frac{1}{h_0 A_0} + \frac{R_0}{A_c} + \frac{R_i}{A_i}$$

Where :

R_0 and R_i are the foaling factor

****) Inside heat transfer coeff.**

The value of (h_i) can be found from

For water $\frac{h_i d}{k} = 0.023(Re)^{0.8}(Pr)^{0.4}$ (Ditlus-Boelter eq.)

If a viscous brine is used for cooling

$$\frac{h_i d}{k} = 0.023(Re)^{0.8}(Pr)^{0.4}\left(\frac{\mu}{\mu_{wall}}\right)^{0.14}$$ (Sieder-Tate eq.)

These eq.s have been obtained for straight tubes ; with a coil somewhat greater transfer is obtained for the same physical condition .

$$h_i(coil) = h_i(straight\ pipe) * \left(1 + 3.5\frac{d}{d_c}\right)$$

Where :

d = inside dia. of tube .

d_c = the dia. of the helix .

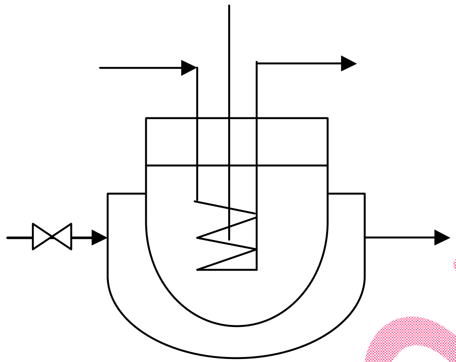
**) Outside film coeff.

$$\frac{h_0 D_T}{k} = 0.87\left(\frac{\rho N D^2}{\mu}\right)^{0.62}\left(\frac{\mu C_p}{k}\right)^{1/3}\left(\frac{\mu}{\mu_{wall}}\right)^{0.14}$$

The value of const. (0.87) depend on the mixer type there are more specific relations to determine (h_0) in the literature .

Vessel with Jacket

When heat is applied to the jacket passing water through the coil



$$\frac{h_w D_T}{k} = 0.36\left(\frac{\rho N D^2}{\mu}\right)^{2/3}\left(\frac{\mu C_p}{k}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

For cooling

$$\frac{h_w D_T}{k} = 0.55\left(\frac{\rho N D^2}{\mu}\right)^{2/3}\left(\frac{\mu C_p}{k}\right)^{1/4}\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

Heating liquids in Tanks :

The required time of heating the content of a large batch or storage tank is

$$UA(T_s - T) = mC_p \frac{dT}{dt}$$

$$\int_{T1}^{T2} \frac{dT}{T_s - T} = \frac{UA}{mC_p}\int_0^t dt \rightarrow \ln\frac{T_s - T_1}{T_s - T_2} = \frac{UA}{mC_p} t$$

T_s = steam temp. , $T_2 > T_1$

Mixing of Pastes and Plastic Masses

Mixing Index (criteria of mixer effectiveness)

$$\boldsymbol{s = \sqrt{\frac{\sum_{i=1}^{N}(x_i-\bar{x})^2}{N-1}} = \sqrt{\frac{\sum_{i=1}^{N} x_i^2-\bar{x}\ \sum_{i=1}^{N} x_i}{N-1}}} \qquad \text{----------*}$$

S = standard deviation .

N = number of spot samples .

X_i = measured fraction of tracer .

$\overline{Xi}$ =a verage measured fraction of tracer = $\frac{\sum x_i}{N}$

Befor mixing has begun , the material in the mixer exist as two layers , one of which contains no tracer material and one of which is tracer only . Samples from the first layer would have the analysis x_i = 0 ,in the other layer x_i =1 . Under these conditions the standard deviation is given by :

$$\sigma_0 = \sqrt{\mu(1-\mu)} \qquad (\ **)$$

Where :

μ : is the overall fraction of tracer in the mix .

σ_0 : is the standard deviation at zero time or zero mixing .

The mixing index for pastes (I_P) is then :

$$I_P = \frac{\sigma_0}{S} = \sqrt{\frac{\mu(1-\mu)(N-1)}{\sum_{i=1}^{N}(x_i-\overline{x})^2}} = \sqrt{\frac{\mu(1-\mu)(\ N-1)}{\sum_{i=1}^{N} x_i^2 - \bar{x}\ \sum_{i=1}^{N} x_i}}$$