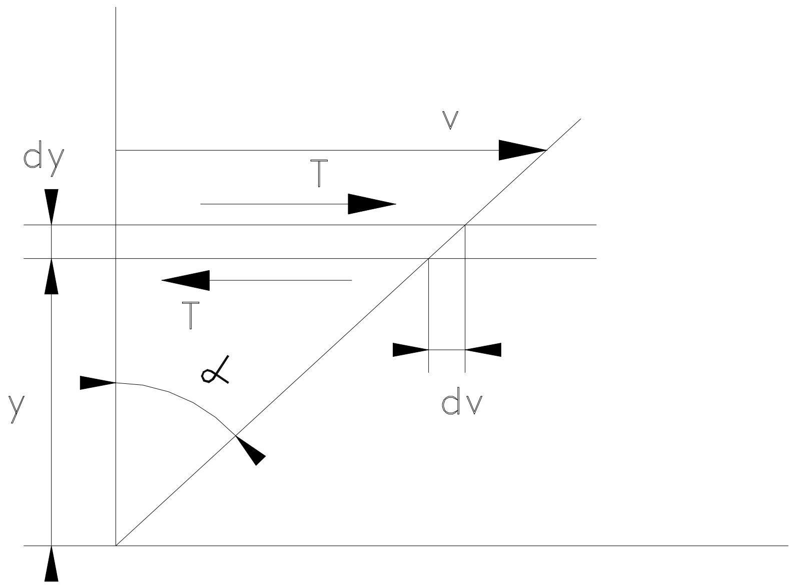
Air-viscosity / Reynolds-number



Shearstress : $\frac{T}{A} = \tau = \eta * \frac{dv}{dy}$ (Stokes law)

τ= material-constant * velocity-gradient

η= viscosity : dimension : N/m^2 * m/m/(sec) = Ns/m^2

v= η/rho(air) = dynamic viscosity : dimension : Ns/m^2/(kg/m^3) = Nsm/kg

Under the circumstances where the gas behaves as an ideal gas, η can be considered as independent of the pressure.
In pneumatic conveying, the pressures are so low that this is permissible.

The dependency of temperature is given by :

$\eta = \eta_0 * \sqrt{(T/T_0 * (1-c/T_0)/(1+c/T))}$

for air :

η_0 = 1.72 * 10^-5 Ns/m^2

$T_0 = 273\ ^oK$

c = 113

for nitrogen :

η_0 = 1.67 * 10^-5 Ns/m^2

$T_0 = 273\ ^oK$

c = 100.8

i.e. :
air at 20 ^oC η = 1.8 10^-5 Ns/m^2

Derivation of Reynolds-number

Method : prototype-/model comparison
p = prototype
m = model

$L_p = c_l * L_m$ (length)

$v_p = c_v * v_m$ (velocity)

$\rho_p = c_\rho * \rho_m$ (density)

$\eta_p = c_\eta * \eta_m$ (viscosity)

$g_p = c_g * g_m$ (gravitational acceleration)

$\zeta_p = c_\zeta * \zeta_m$ (resistance due to roughness)

Resistance of prototype :

$W_p = \eta_p * dv_p/dy_p * A_p$

Resistance of model :

$W_m = \eta_m * dv_m/dy_m * A_m$

Substituted :

$Wp = c_\eta * c_v/c_l * c_l\text{^}2 * \eta_m * dv_m/dy_m * A_m$

$Wp = c_\eta * c_v * c_l * W_m$

Also :

$W_p = 1/2 * \zeta_p * \rho_p * v_p\text{^}2 * A_p$

$W_m = 1/2 * \zeta_m * \rho_m * v_m\text{^}2 * A_m$

Substituted :

$Wp = c_\zeta * c_\rho * c_v\text{^}2 * c_l\text{^}2 * W_m$

Result in :

$c_\eta * c_v * c_l = c_\zeta * c_\rho * c_v\text{^}2 * c_l\text{^}2$

For $c_\zeta = 1$ (Equal roughness for prototype and model)

$(c_\rho * c_v * c_l)/c_\eta = 1$

$\rho_p/\rho_m * v_p/v_m * L_p/L_m * \eta_m/\eta_p = 1$

or :

$$\frac{\rho_p * v_p * L_p}{\eta_p} = \frac{\rho_m * v_m * L_m}{\eta_m}$$

In case the value : $\frac{\rho * v * L}{H}$

is equal for model and prototype , the scaling-factors are applicable for both situations.
This ,because the flows are comparable regarding friction-forces.

Reynoldsnumber : $\mathbf{Re = \frac{\rho * v * L}{\eta}}$

or :

$$\mathbf{Re = \frac{v * L}{\nu}}$$

in which :

$$\mathbf{\nu = \eta/\rho}$$