APPENDIX C

THE DETERMINATION OF SLURRY DENSITY BASED ON THE VOLUME AND WEIGHT CONCENTRATION OF THE SOLID PARTICLES

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This section explains how the specific gravity of a slurry (SG_M) is related to the solid's particle weight and volume concentration.

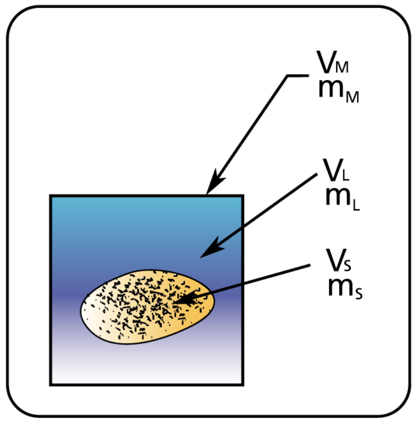

Figure C-1 Variables related to the calculation of the specific gravity of a slurry.

Definitions:

V_M is the volume the slurry mixture.
m_M is the mass of the slurry mixture.
V_L is the volume of the liquid portion of the mixture.
m_L is the mass of the liquid portion of the mixture.
V_S is the volume of the solid portion of the mixture.
m_S is the mass of the solid portion of the mixture.
C_V is the volume concentration of the solid particles in the mixture.
C_W is the mass concentration of the solid particles in the mixture.
SG_S is the specific gravity of the solids portion of the mixture.
SG_L is the specific gravity of the liquid portion of the mixture.
SG_M is the specific gravity of the mixture.

ρ_W is the density of water at standard conditions.

The total mass of the solid particles (m_S) is:

$$m_S = \rho_S \ V_S \qquad [C-1]$$

The density of the solid particles ρ_S can be expressed as:

$$\rho_S = SG_S \ \rho_W \qquad [C-2]$$

The volume concentration of the solid particles is expressed by:

$$V_S = C_V \; V_M \tag{C-3}$$

By replacing equations [C-2] and [C-3] into equation [C-1] we obtain the total mass of the solid particles m_S :

$$m_S = SG_S \; \rho_W \; C_V \; V_M \tag{C-4}$$

Using a similar reasoning, the total mass of the liquid particles m_L is:

$$m_L = SG_L \; \rho_W \; (1-C_V) \; V_M \tag{C-5}$$

Therefore, the total mass of the mixture m_M is:

$$m_M = m_S + m_L = SG_S \; \rho_W \; C_V \; V_M + SG_L \; \rho_W \; (1-C_V) \, V_M \tag{C-6}$$

After simplification equation [C-6] becomes:

$$m_M = \rho_W \, V_M \, (SG_S \; C_V + (1-C_V) \; SG_L) \tag{C-7}$$

By definition, the specific gravity of the mixture is:

$$SG_M = \frac{\rho_M}{\rho_W} = \frac{m_M}{V_M \; \rho_W} = \frac{m_S + m_L}{V_M \; \rho_W} = \frac{\rho_W \; V_M \, (SG_S \, C_V + (1-C_V) \, SG_L)}{V_M \; \rho_W} \tag{C-8}$$

After simplification equation [C-8] becomes:

$$\boxed{SG_M = SG_L + C_V \; (SG_S - SG_L)} \tag{C-9}$$

The specific gravity of the mixture SG_M was expressed in equation [C-8] as:

$$SG_M = \frac{m_S + m_L}{V_M \; \rho_W} \tag{C-10}$$

From equation [C-4] we know that:

$$\rho_W \, V_M = \frac{m_S}{SG_S \; C_V} \tag{C-11}$$

By substituting equation [C-11] into [C-10] we obtain:

$$SG_M = \frac{m_S + m_L}{\frac{m_S}{SG_S\ C_V}} = SG_S\ C_V\ \frac{m_S + m_L}{m_S} \qquad \text{[C-12]}$$

By definition:

$$C_W = \frac{m_S}{m_S + m_L} \qquad \text{[C-13]}$$

Therefore

$$\boxed{SG_M = SG_S\ \frac{C_V}{C_W}} \qquad \text{[C-14]}$$

Typically the concentration by volume (C_V), the concentration by weight (C_W) and the specific gravity (SG_S) of the solid particles will be given or known for a particular slurry. This is enough information to calculate the specific gravity of the slurry (SG_M) using equation [C-14]. The specific gravity of the carrier fluid can be calculated from equation [C-9] if required.

Often the purpose of the slurry mixture is to transport solid particles in a fluid form to a discharge point further away. In that case, we are mainly interested in the amount of tons per hour of solids that are transported.

The mass flow rate is given by:

$$M = \rho_S\ C_V\ q\ = SG_S\ \rho_W\ C_V\ q$$

$$M\left(\frac{tn}{h}\right) = SG_S \times \frac{62.34\,lbm}{ft^3} \times C_V \times q\left(\frac{USgals.}{\min}\right) \times \frac{60\min}{h} \times \left(\frac{ft^3}{7.48\,USgals.}\right) \times \frac{tn}{2000\,lbm}$$

After simplification, the mass flow rate is:

$$\boxed{M\left(\frac{tn}{h}\right) = 0.25\,SG_S\ C_V\ q\left(\frac{USgals.}{\min}\right)} \qquad \text{[C-15]}$$