Lecture 12: Exercise on mineral processing

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Problems 1 to 7

A floatation plant treats feed whose grade is 0.8% Cu. The plant produces concentrate and tailings. The copper grade of concentrate is 26% and that of tailings is 0.16%. Calculate:

a) Cu recovery in concentrate
b) Fraction of feed in concentrate
c) Enrichment ratio

Let \( M_F \) = mass of feed, \( M_C \) = mass of concentrate and \( M_T \) is mass of tailing, \( f \), \( c \) and \( t \) are Cu grade in feed, concentrate and tailing respectively.

Material balance

\[
M_F = M_C + M_T
\]
\[
M_F \times f = M_C \times c + t \times M_T
\]

By 1 and 2 we get

\[
\frac{M_F}{M_C} = \frac{c-t}{f-t}
\]

plant recovery = \[
\frac{M_C \times c}{M_F \times f} \times 100
\]

By 3 and 4 we get.

\[
\frac{M_F}{M_C} = \frac{c(f-t)}{f(c-t)} \times 100
\]

Plant recovery is copper recovery and by equation 5 it is 82.73% Ans.

Fraction of feed in concentrate = \[
\frac{M_C}{M_F} = \frac{f-t}{c-t} = 0.0286 \text{ Ans}
\]

Enrichment ratio = \[
\frac{c}{f} = 28.9
\]

Problem 2

In the circuit shown below, the dry solids of density 300Kg/m³ are fed at the rate of 25 tons/hr. The feed to the cyclone contains 36% solids by weight. It is found that 250 µm size in the rod mill discharge, ball mill discharge and cyclone feed is 27%, 5%, and 14% respectively. Determine the volumetric flow rate of feed (solid+ water) to the cyclone.
**Solution: material balance**

cyclone feed ($C_F$) = Ball mill feed ($B$) + Rod mill feed ($R$)

$$C_F = B + 25 \quad (1)$$

Performing balance on 250 µm size

$$C_F \times 14 = 5B + 25 \times 27 \quad (2)$$

Solving equation 1 and 2 we get $C_F = 61.1$ tons/hr.

Volumetric flow rate of feed (dry) to cyclone = $20.36 \text{ m}^3/\text{hr.}$ Ans

Volumetric flow rate of water $\frac{64}{36} \times \frac{61.1}{1} = 108.6 \text{ m}^3/\text{hr.}$ Ans

Note $\frac{64}{36}$ is dilution ratio. Density of water $1 \text{ton/m}^3$

**Problem 3**

A hydro cyclone produces two products i.e. underflow and overflow from the feed. The overflow is treated further for concentration of valuable mineral; whereas underflow is recirculated. In a hydro cyclone a slurry of density 1140 Kg/m$^3$ is fed for separation. It produces underflow of slurry density 1290 Kg/m$^3$ and overflow of slurry density 1030 Kg/m$^3$. Determine mass flow rate of feed to cyclone, when 3 liter sample of underflow takes 4s. Density of dry solid is 3000 Kg/m$^3$. Calculate % solids in feed, underflow and overflow by the following equation

**Solution**

$$\% \text{ solids} = \frac{100 \times \rho_s (\rho_m - 1000)}{\rho_m (\rho_m - 1000)} \quad \text{equation 6 of lecture 11}$$

Figure 12.1: Flow sheet showing flow of materials
% solids in feed = 18.42%
% solids in underflow = 33.72%
% solids in overflow = 4.37%

Dilution ratio of feed, underflow and overflow can be calculated by equation 10 of lecture 11. These dilution ratios are 4.42, 1.97 and 21.97 respectively.

Mass flow rate of underflow = \( F \times \rho_u \times \% \text{ solid in UF} \)

Where is volumetric flow rate = \( \frac{3}{1000} \times \frac{3600}{4} \) m\(^3\)/hr.

Mass flow rate of underflow = 1172 kg/hr.

Water balance on the cyclone gives \( M_F = 1336 \) kg/hr Ans.

**Problem 4:**

Analyze the following circuit and determine unknowns

![Flow sheet for materials flow](image)

**Solution:**

Apply material balance and get the answer

Flow rate of concentrate 123 t/hr and tailing 877 t/hr.

**Problem 5:** Do yourself
In a hydro cyclone a slurry containing 30% solid is fed for separation of course and fines. The underflow has 50% solids and the overflow has 15% solids. If the feed enters at 20 tons/hr in the hydro cyclone, calculate the tonnage of solid/hr in underflow. Answer \(14.3 \text{T/hr}\)

**Problem6**: Do yourself

A plant treats 210 tonnes of material in a shift of metal grade 40% and tailing has metal grade 0.2%. Calculate mass of concentrate and tailing. **Answer 12 and 198 T/hr**

**Problem7**

A floatation circuit consists of rougher-cleaner circuit to concentrate PbS

The grade of PbS in feed is 15% and is delivered qt 1200t/h. The grade of cleaner tailing is 20%. The cleaner tailings are recycled to rougher and circulating load is 0.25 (recycle/fresh feed). The recovery and grade in the concentrate is 98% and 89% respectively. Calculate the flow rates and grade of the respective streams.

**Solution**

![Floatation circuit](image)

**Figure12.3**: Floatation circuit to show arrangement of rougher and cleaner along with inputs and outputs.

**Solution:**

Material balance at steady state of rougher

\[1200 + 300 = (m_T)_R + (m_C)_R\]  \(1\)

Cleaner total mass balance
\( (m_C)_R = (m_C)_C + 300 \) \hspace{1cm} (2)

\( (m_T)_R \) is mass of rougher tailing in t/hr, \( (m_C)_R \) is mass of rougher concentrate, \( (m_C)_C \) mass of cleaner concentrate.

Rougher PbS balance

\[ 1200 \times 0.15 + 300 \times 0.2 = (m_T)_R \ t_R + (m_C)_R \ C_R \] \hspace{1cm} (3)

\( t_R \) and \( C_R \) is PbS grade in rougher tailing and cleaner concentrate respectively.

Cleaner PbS balance

\[ (m_C)_R \ C_R = (m_C)_C \ C_C + 300 \times 0.2 \] \hspace{1cm} (4)

\( C_C \) is PbS grade in cleaner concentrate

Recovery = \( \frac{\text{mass of PbS in cleaner concentrate}}{\text{mass of PbS in fresh feed}} \times 100 \)

\[ = \left( \frac{(m_C)_C \times 0.89}{1200 \times 0.15} \right) \times 100 \]

\[ \therefore \ (m_C)_C = 198.6 \text{ Tons/hr.} \]

\[ (m_C)_R = 498.6 \text{ Tons/hr.} \]

\[ (m_T)_R = 1001.4 \text{ Tons/hr.} \]

By equations 3 and 4 we can determine

\( \text{Grade of rougher concentrate} = 47.5\% \)

\( \text{Grade of rougher tailings} = 0.316\% \) \hspace{1cm} \textbf{Answer.}