MECHANICAL OPERATIONS (CH31007)
CLASS TEST 1

Date: 06/09/2019

Part A

1. Calculate screen efficiency when quartz mixture is screened through a 1.5mm screen to obtain +1.5mm fraction. The size analyses of feed, overflow and underflow is obtained by sampling and sieve analysis. The results are given in the table. If the feed rate to the screen is 100 tons/hr, calculate the tonnage of fines remained in overflow.

Size analyses of feed, overflow and underflow

	Weight percent retained this size		
Screen size mm	*Feed*	*Overflow*	*Underflow*
3.3	3.5	7.0	–
2.3	13.5	36.0	–
1.5	33.0	37.0	15.0
1.0	22.7	13.0	43.0
0.8	16.0	4.0	25.0
0.6	5.4	3.0	8.0
0.4	2.1	–	3.0
0.2	1.8	–	2.0
−0.2	2.0	–	4.0

5

Solution:

From the values of table

Fraction of +1.5 mm material in the feed=y_F =3.5+13.5+33.0=50% ⇒ 0.5

Fraction of +1.5 mm material in the overflow product =y_P=7.0+36.0+37.0 =80% ⇒ 0.8

Fraction of +1.5 mm material in the underflow product=y_R=15% ⇒0.15

Flow rate of the feed material =F =100 tons/hr

In the problem, the objective is to obtain coarse material

∴ Coarse material or 1.5 mm oversize is the product (P)

∴ Fine material or 1.5 mm undersize is the reject (R)

Total material balance $F = P + R$

+1.5mm material balance $Fy_F = Py_P + Ry_R$

On substitution of the given values the equations becomes

$100 = P + R$

$100 \times 0.5 = P \times 0.8 + R \times 0.15$

Solving the above two equations ⇒ P = 53.85 tons/hr; R = 46.15 tons/hr;

∴ Efficiency of the screen in separating coarse (oversize material)
Screen efficiency η = *(Recovery)×(Rejection)*

$$\textbf{\textit{Recovery}}=\frac{\textbf{\textit{Desired material in the product}}}{\textbf{\textit{Desired material in the feed}}}=\frac{Py_p}{Fy_F}$$

$$\textbf{\textit{Rejection}}=\frac{\textbf{\textit{Undesired material in the reject}}}{\textbf{\textit{Undesired material in the feed}}}=\frac{R(1-y_R)}{F(1-y_F)}$$

$$\eta=\frac{Py_p}{Fy_F}\times\frac{R(1-y_R)}{F(1-y_F)}\times 100=\frac{53.85\times 0.8}{100\times 0.5}\times\frac{46.15\times(1-0.15)}{100\times(1-0.5)}\times 100=\mathbf{67.59\%}$$ (Ans)

Alternatively

If you substitute the P/F and R/F as a function of y_F, y_P and y_R (see class notes)

$$\eta=\frac{(y_F-y_R)y_p}{(y_p-y_R)y_F}\left[1-\frac{(y_F-y_R)(1-y_p)}{(y_p-y_R)(1-y_F)}\right]\times 100=\frac{(0.5-0.15)0.8}{(0.8-0.15)0.5}\times\left[1-\frac{(0.5-0.15)(1-0.8)}{(0.8-0.15)(1-0.5)}\right]\times 100$$

$\Rightarrow \eta$=86.15×(1–0.2154)×100=**67.59%** (Ans)

Tonnage of fines remained in overflow = P $(1-y_P)$ = 53.8 (1−0.8) = **10.76 tons/hr** (Ans)

2. The following results were obtained in a laboratory experiment designed to find the work index of an ore: 1000 grams of copper zinc ore were ground in a laboratory mill for 12 minutes. The power input to the empty mill (contained ball charge only) was 226.9 watts. The power input to the mill when grinding the sample was 283.2 watts. Feed to the mill was 80% minus 1530 microns. Product from the mill was 80% minus 79 microns.

Find

(a) Net kWhr per ton of ore required to grind ore from 1530 microns to 79 microns.

(b) Work Index.

1+2=3

Solution:

Given

Weight of copper zinc ore grounded = 1000 gm=1kg

Time of grinding = 12 minutes

Power input to the empty mill with ball charge = 226.9 watts

Power input for grinding the ore = 283.2 watts

Feed size to the mill =D_F = 1530 microns

Product from the mill =D_P = 79 microns

(a) Net wattage input=283.2−226.9=56.3 watts

Net power used=56.3×12 watt minutes= 56.3×12 1000×60 =0.01126 kWhr

0.01126 kWhr power is used to grind 1000 gm (1 kg)

∴ Net power required to grind one ton of ore=0.01126×1000 =**11.26 kWhr** (Ans a)

(b) $$W = W_i\sqrt{\frac{100}{D_P}}\left(1-\frac{1}{\sqrt{RR}}\right)$$

Here W= 11.26 kWhr/tonne;

$$RR = \frac{D_F}{D_P} = \frac{1530}{79} = 19.367$$

$$\therefore 11.26 = W_i\sqrt{\frac{100}{79}}\left(1-\frac{1}{\sqrt{19.367}}\right)$$ ⇒ ***W_i* =12.95 kWhr/ton** (Ans b)

Or

$$W = K_b\left[\frac{1}{\sqrt{D_P}}-\frac{1}{\sqrt{D_F}}\right]$$

now as per the definition of W_i, it is the gross energy requirement in kilowatt hours per ton of feed needed to reduce a very large feed to such a size that 80 percent of the product passes a 100 µm screen.

∴ if D_p is in microns and W is in kWhr/ton

Then $K_b = \sqrt{100}W_i = 10W_i$

$$\therefore\ W = \sqrt{100}W_i\left[\frac{1}{\sqrt{D_P}}-\frac{1}{\sqrt{D_F}}\right] \Rightarrow 11.26 = 10\times W_i\left[\frac{1}{\sqrt{79}}-\frac{1}{\sqrt{1530}}\right]$$

⇒ ***W_i* =12.95 kWhr/ton** (Ans b)

3. Determine the minimum diameter of the rolls and angle of nip in a roll crusher to reduce 3.81 cm pieces of rock to 1.27 cm if the coefficient of friction between the rock and steel is 0.4.

1+1= 2

Solution:

Given

Size of the feed particle = 3.81 cm

Size of the product particle = 1.27 cm

Coefficient of friction between rock and steel=0.4

Coefficient of friction= μ= tan θ = 0.4 ⇒ θ =21.8°

Angle of nip = 2θ =2× 21.8°=43.6°=43°36' (Ans)

∴ cos θ = cos 21.8 =0.9285

$$\cos\theta = \frac{(D+L)}{(D+d)} \Rightarrow 0.9285 = \frac{(D+1.27)}{(D+3.81)}$$

⇒ D=31.72 cm (Ans)

Diameter of the roll to reduce 38.1mm pieces of rock to 12.7mm is 31.72 cm (Ans)