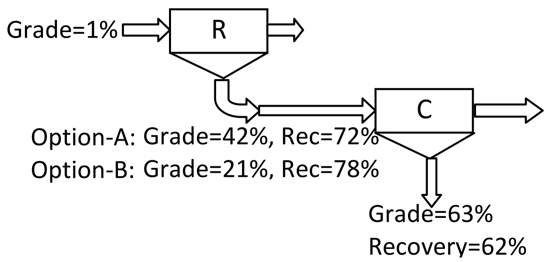
MM320 Tutorial-1

Separation efficiency for a mineral concentration process ***(See box for derivation)***
Grade ***is defined as % metal (or mineral) in the process stream.***
assay ***is the result of evaluation of composition of an ore. Assay is used to express % of metal value in a product (e.g. concentrate or tailing).***
%recovery ***of metal (or mineral) is defined as,*** $= \frac{total\ metal(or\ mineral) recovered\ in\ a\ process\ stream}{total\ metal(or\ mineral)\ present\ in\ the\ feed}$ ***. 100***
Separation efficiency ***is defined as, SE = (%recovery of valuable mineral in concentrate) - (% recovery of gangue into the concentrate) =*** $100.C.m\frac{c-f}{(m-f).f}$ ***.................... (1)***
Where recovery of valuable mineral in concentrate = $100.C\frac{c}{f}$ ***..... (2)***
and, recovery of gangue in concentrate is $100.C.\frac{m-c}{(m-f)}$ ***..........(3)***
f= assay of metal in feed, c= assay of metal in concentrate, C ***is the fraction of total feed weight that reports to concentrate and m = %metal content of valuable mineral (e.g. pure*** SnO_2 ***contains 78.6% Tin. (Atomic wt. Sn = 118,*** O_2***=32).***

Problem: A Tin concentration plant has rougher and concentrator circuits. Feed assaying 1% Tin metal is fed to the rougher. Concentrator performance: Grade= 63% Tin metal in concentrate at Recovery of 62%.



The operator has to choose from the following two options for the Rougher circuit operation.
1. Option-A (medium grade): 42%Tin metal in concentrate at 72% recovery
2. Option-B (Low grade): 21% Tin metal in concentrate at 78% recovery

- Determine which of these combinations for rougher circuit produce best separation efficiency
- If you choose rougher operation based on best of the two provided options, how does rougher SE compare with the SE of concentrator.

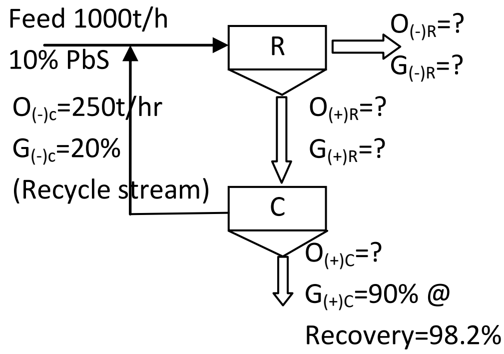
[Assume Tin is totally contained in the mineral Cassiterite (SnO_2). Since %recovery of concentrator is given, find C from eqn-(2), where m%, is percentage of Tin metal in SnO_2. Subsequently find SE (use eqn-1)]. Now use the grade of chosen rougher method as feed grade for concentrator and calculate SE for concentrator.]

Product Valuation:
A smelter producing Zinc from Sphalerite (ZnS) concentrate, has the following schedule-
Payments:
Zinc: Pay for 85% Zn content at published price minus Rs 1.43/Kg....(effective price=published-Rs1.43/kg)
Cadmium: Pay for 40% of Cadmium content at published price minus Rs 208/Kg. ....(effective price=published - Rs208/kg)
Lead: Deduct 1.5units (one unit is 1%), and pay for 65% of remainder at published price minus Rs 7.15/Kg. No payment for less than 3% Lead.
Silver: Deduct 170gm from Ag contained in 1 tonne of concentrate, and pay for 60% of remainder at published price minus Rs 0.15/g.
Deductions:
Treatment Charges: Rs 10400/tonne of the total concentrate.
Iron: Deduct 8 units. Charge for excess at Rs 94.50/unit of total concentrate.

Problem: A Zinc concentrate is produced from a feed containing 10% ZnS. The concentrate assays 70% ZnS. The concentrate contains 1g of Cd and 2 g of Ag per Kg of ZnS. The concentrate contains a high Iron content of 12%. Calculate returns per tonne of concentrate if metal prices published at LME are - Zinc: Rs132.3/kg; Cd: Rs245.7/kg; Ag: Rs1852.2/Oz. (where one unit is 1% of a tonne i.e. 10Kg. 1Oz=28.35g) [calculate returns /tonne (or 1000kg) of concentrate. Atomic wt of Zn=65; S=32].

Material Balance calculations:

Problem: A PbS concentrate is produced by a rougher-cleaner flotation circuit. The cleaner tailings assay 20% PbS and are recycled to the rougher cells, and the circulating load (recycle/fresh feed) is 0.25. The fresh feed assays 10% PbS and is delivered at the rate of 1000t/hr. The recovery and grade in the concentrate are 98.2% and 90% respectively. What are the flow rates and assays of other streams?



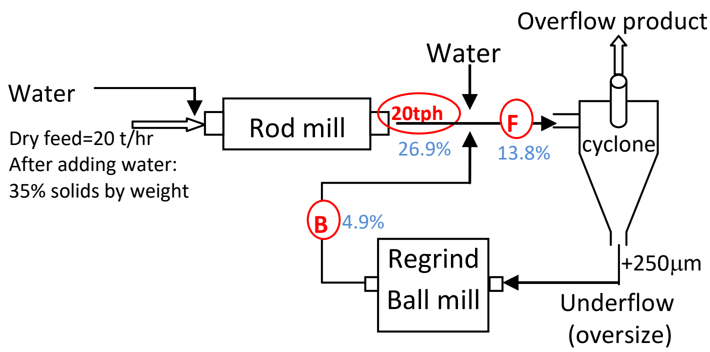
Solution: [Solve using mass balance. G=grade, O=mass flow rate.] (5 unknowns) Setup four equations→ 1. Rougher total mass balance; 2. Cleaner total mass balance; 3. Rougher PbS mass balance & 4. cleaner PbS mass balance. To calculate the fifth unknown $O_{+(C)}$, use recovery = $\dfrac{\textit{Mass of PbS in cleaner concentrate}}{\textit{mass of PbS in fresh feed}} . 100$

Problem: In a mineral grinding circuit, a hydrocyclone separates +250µm particles produced by grinding coarse feed in rod and ball mills. Rod mill is fed of 20t/h of dry solids (density 2900kg/m^3). Ground product from rod mill is fed to a **hydrocyclone**** whose feed contains 35% solids by weight. Size analyses of the rod mill discharge, ball mill discharge and hydrocyclone feed shows:

Rod mill discharge	26.9% of +250µm material.
Ball mill discharge	4.9% of +250µm material.
Hydrocyclone feed	13.8% of +250 µm material.

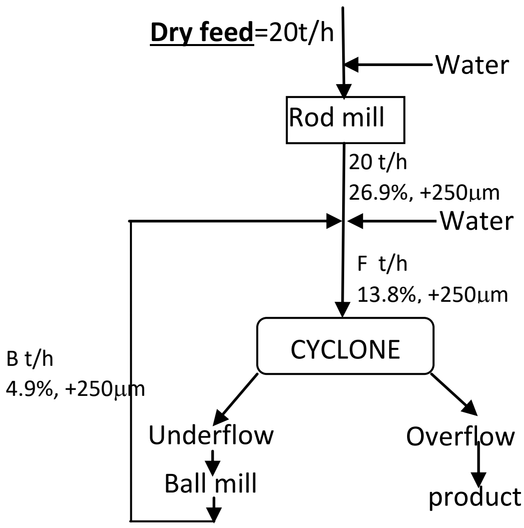
calculate **the volumetric flow rate** of feed to the cyclone.

%age of +250µm particles in stream shown in blue



(Assume there is no accumulation, namely feed = product). [use material balance on cyclone feed { F=(20+B)t/h, where F=cyclone feed and B= ball mill discharge(=(F-20)t/h)} and mass balance of +250µm material]. (Expected answer=108.7m^3/h).

****Hydrocyclone** separates the ground product into an overflow (which has all particles below the desired particle size), and diverts all oversize material to the underflow. The underflow is ground in a ball mill and circulated back at the feed point of hydrocyclone).



Derivation of Separation efficiency

The premise of following derivation is

1. Entire valuable metal is contained in the same mineral, hence recovery of valuable mineral to the concentrate is equal to metal recovery.
2. Separation efficiency of a mineral beneficiation process is defined for separation of minerals (and not for the metal).
3. Concentrate always contains valuable mineral as well as some amount of gangue minerals.

Thus, Separation efficiency (S.E.) = %Recovery of valuable mineral (R_m)% – %Recovery of gangue into the concentrate (R_g%).

i.e. SE = $R_m\% - R_g\%$ ………………(1)

Evaluating mineral composition of a process stream is lot more difficult than evaluating its metal content. Hence, assay of various process streams yields metal content as follows.

Valuable metal in feed = f%

Valuable metal in concentrate = c%

Valuable metal in tailing = t%

Further, metal content of valuable metal = m%

If the fraction of total feed weight reporting to concentrate = 'C'

Then $\mathbf{R_m}\% = 100.\frac{\text{Valuable metal in concentrate(C.c)}}{\text{Total valuable metal in feed (1.f)}} = \mathbf{100.C.\frac{c}{f}}$ ………………(2)

Gangue content of concentrate = Total mineral content of concentrate – amount of valuable mineral

To compute gangue content of a stream, take basis = 100

Gangue content = (total mineral content – amount of valuable mineral)

For concentrate stream $= 100 - 100\frac{c}{m}$, where 'm' is %age of metal content in valuable mineral. …….. (dividing 'c' by 'm' here scales 'c', the percentage of metal in concentrate stream in terms of equivalent mineral content)

Thus gangue content of concentrate stream $= 100\left(1 - \frac{c}{m}\right)$

Likewise, Gangue content of feed stream $= 100\left(1 - \frac{f}{m}\right)$

$\therefore\ R_g\% = 100.\text{C x}\ \frac{\text{Gangue content of concentrate}}{\text{Gangue content of feed}}$

$\therefore\ \mathbf{R_g}\% = 100.\text{C}.\frac{100\left(1-\frac{c}{m}\right)}{100\left(1-\frac{f}{m}\right)}$ = $\mathbf{100.\mathit{C}.\frac{(m-c)}{(m-f)}}$ ………………(3)

From equations (1) - (3)

SE = $R_m\% - R_g\% = \frac{100.C.c}{f} - \left[\frac{100.C(m-c)}{(m-f)}\right] = \frac{100Ccm - \cancel{100Ccf} - 100Cmf + \cancel{100Ccf}}{f(m-f)} = \frac{\mathbf{100.C.m(c-f)}}{\mathbf{f(m-f)}}$