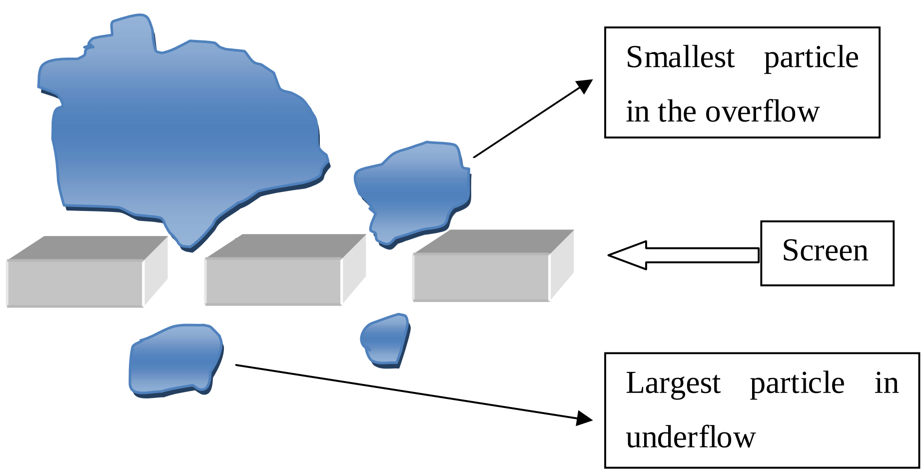
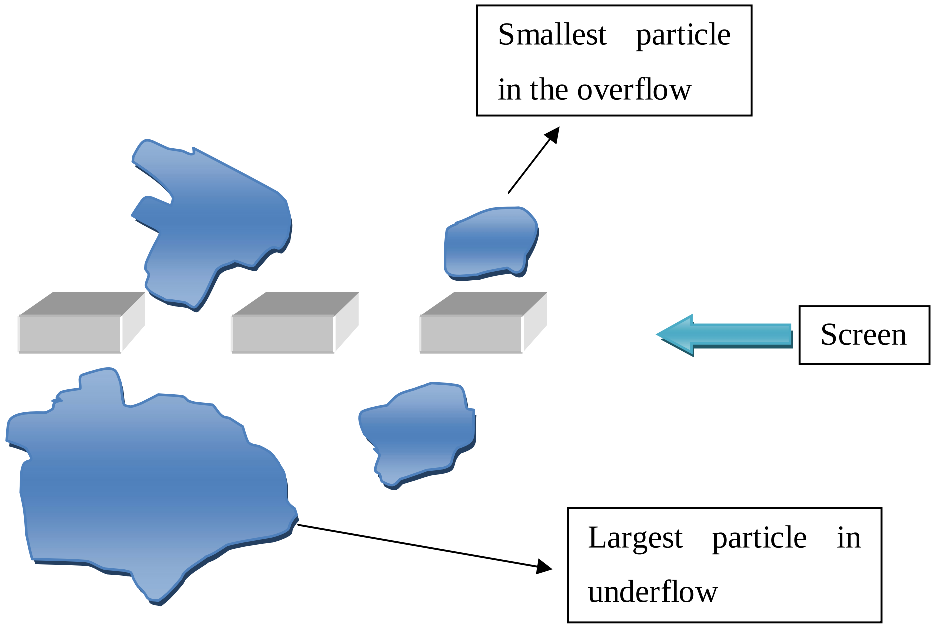
Screen Effectiveness

The objective of the screen is to accept a feed containing a mixture of particles of various sizes and separate it into two fractions, an underflow that is passed through the screen and an overflow that is rejected by the screen. An ideal screen would sharply separate the feed mixture in such a way that the smallest particle would be just largest than the largest particle in the underflow. Such an ideal separation is defines as cut diameter D_{pc} that marks the point of separation between the particles. Usually it is chosen to be equal to the mesh opening of the screen. Actual screens do not give a perfect separation about the cut point. There is an overlap between the smallest particle in the overflow and the largest particle in the underflow.



Condition of ideal separation (where the largest particle in the underflow is just smaller than the the opening of the screen)



Condition in case of overlapping (where the oversize contains particles smaller than the mesh opening and the undersize contain particle larger than the mesh opening)

Or in other words screen effectiveness is measure of success of a screen in closely separating two materials ***A*** and ***B***. if the screen is perfect, then ***A*** will be in *overflow* and ***B*** will be in *underflow.*

Let us assume that the material ***A*** is of our interest and we want to separate it from mixture of particle containing both ***A*** and ***B***.

Screen effectiveness is calculated using the formula:

Effectiveness = recovery * rejection

Let ***F, P*** and ***R*** be the mass flow rate of the *feed, overflow* and *underflow.*

X_F, X_P and X_R be the mass fraction of ***A*** (desired material) in *feed, overflow* and *underflow.*

$(1-X_F)$, $(1- X_P)$ and $(1-X_R)$ be the mass fraction of ***B*** (desired material) in *feed, overflow* and *underflow*

Then effectiveness is the ratio of oversize material ***A*** that is actually in *oversize* to the amount of ***A*** in the feed.

Also it is based on undersize particle as the ratio of undersize material ***B*** that is actually in *undersize* to the amount of ***B*** in the feed.

Thus overall efficiency or effectiveness is the product of above two statements and can be represented as:

$$E_c = \frac{(x_F - x_R)x_P}{(x_P - x_R)x_F}\left[1 - \frac{(x_F - x_R)(1 - x_P)}{(x_P - x_R)(1 - x_F)}\right]$$

In addition to effectiveness, capacity is important in industrial screening. The capacity of screen is measured by the mass of material that can be fed per unit time to a unit area of the screen.

Capacity and effectiveness are inversely proportional to each other. To obtain maximum effectiveness the capacity must be small, and large capacity is obtained only at the expense of a reduction in the effectiveness.

Question: One ton per hour of dolomite is produced by a ball mill operating in a closed circuit grinding with a 100 mesh screen. The screen analysis (weight %) is as follows. Calculate the screen effectiveness?

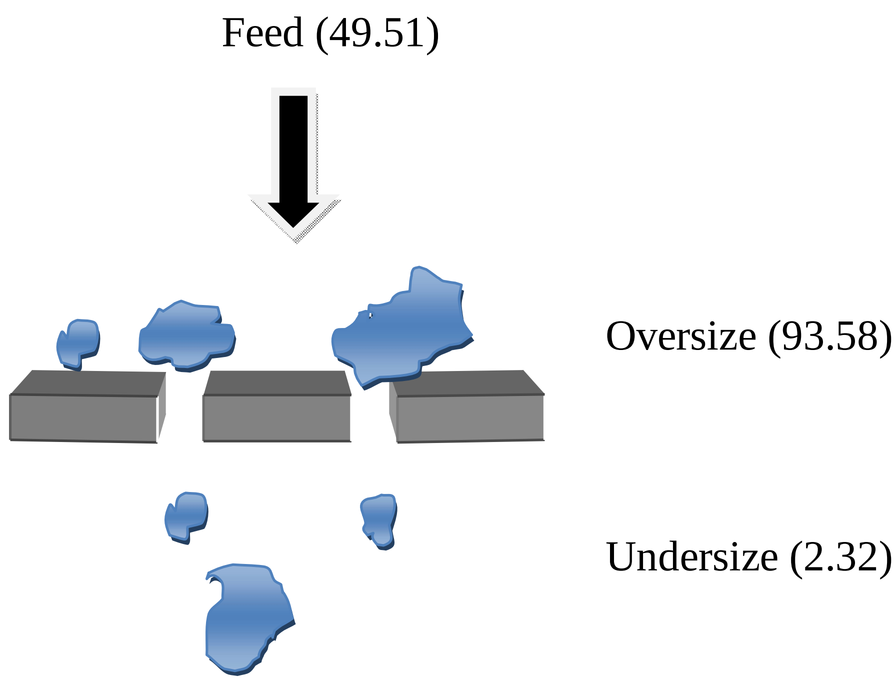
Mesh	Feed %	Oversize%	Undersize%
35	7.07	13.67	0
48	16.60	32.09	0
65	14.02	27.12	0
100	11.82	20.70	2.32
150	9.07	4.35	14.32
200	7.62	2.07	13.34
-200	33.80	0	70.02

Answer:

In the question we can observe that the material after grinding is been screened and the desired material that is there in the *feed*, *oversize* and *undersize* is expressed in terms of percentage. As

100 mesh screen is the distinguishing criteria we based our calculation around the 100 mesh screen.

If we assume the basis that the total percentage of desired material as 100 and also that the material after crushing falls only on 100 mesh screen then the above table can be simplified as:



feed falling on 100 mesh screen = 100 – (feed passes through 100 mesh screen)

feed in oversize = 100 – (oversize feed passes through 100 mesh screen)

$= 100 - (4.35+2.07+0)$

$= 93.58$

feed in undersize = 100 – (undersize feed passes through 100 mesh screen)

$= 100 - (14.32+13.34+70.02)$

$= 2.32$

As the total material is assumed as 100 then feed fraction is **0.4951**, *oversize* is **0.9358** and *undersize* is **0.0232**. Substituting the values in equation of screen effectiveness we will obtain the value as **0.9312** which is **93.12**%

Note: If in the question it is asked to calculate the load to the crusher then the first thing that we should look for is whether the desired material is *undersize* or *oversize*. In the above question if we apply the mass balance around the screen then:

Overall mass Balance => $\boldsymbol{F = P + R}$

Component mass balance => $\boldsymbol{F*X_F = P*X_P + R*X_R}$

For calculation based on oversize, eliminate $\boldsymbol{R}$ from above component balance equation by substituting the overall mass balance equation in terms of $\boldsymbol{R}$ as $\boldsymbol{R = F - P}$

For calculation based on undersize, eliminate $\boldsymbol{P}$ from above component balance equation by substituting the overall mass balance equation in terms of $\boldsymbol{P}$ as $\boldsymbol{P = F - R}$ so the final equation will be

$$\frac{P}{F} = \frac{x_F - x_R}{x_P - x_R} \quad \text{and} \quad \frac{R}{F} = \frac{x_P - x_F}{x_P - x_R} = 1 - \frac{P}{F}$$

Question:

A quartz mixture having the screen analysis shown below in the following table is screened through a standard 10 mesh screen. The cumulative screen analysis of the overflow and underflow is given in the table. Calculate (i) mass ratios of the overflow and underflow with respect to feed (ii) overall effectiveness of the screen

	cumulative fraction smaller than Dp			
mesh	Dp(mm)	Feed	Oversize	Undersize
4	4.699	0	0	
6	3.327	0.025	0.071	
8	2.362	0.15	0.43	0
10	1.651	0.47	0.86	0.195
14	1.168	0.73	0.97	0.58
20	0.833	0.885	0.99	0.83
28	0.589	0.94	1	0.91
35	0.417	0.96		0.94
65	0.208	0.98		0.975
PAN		1		1

Answer:

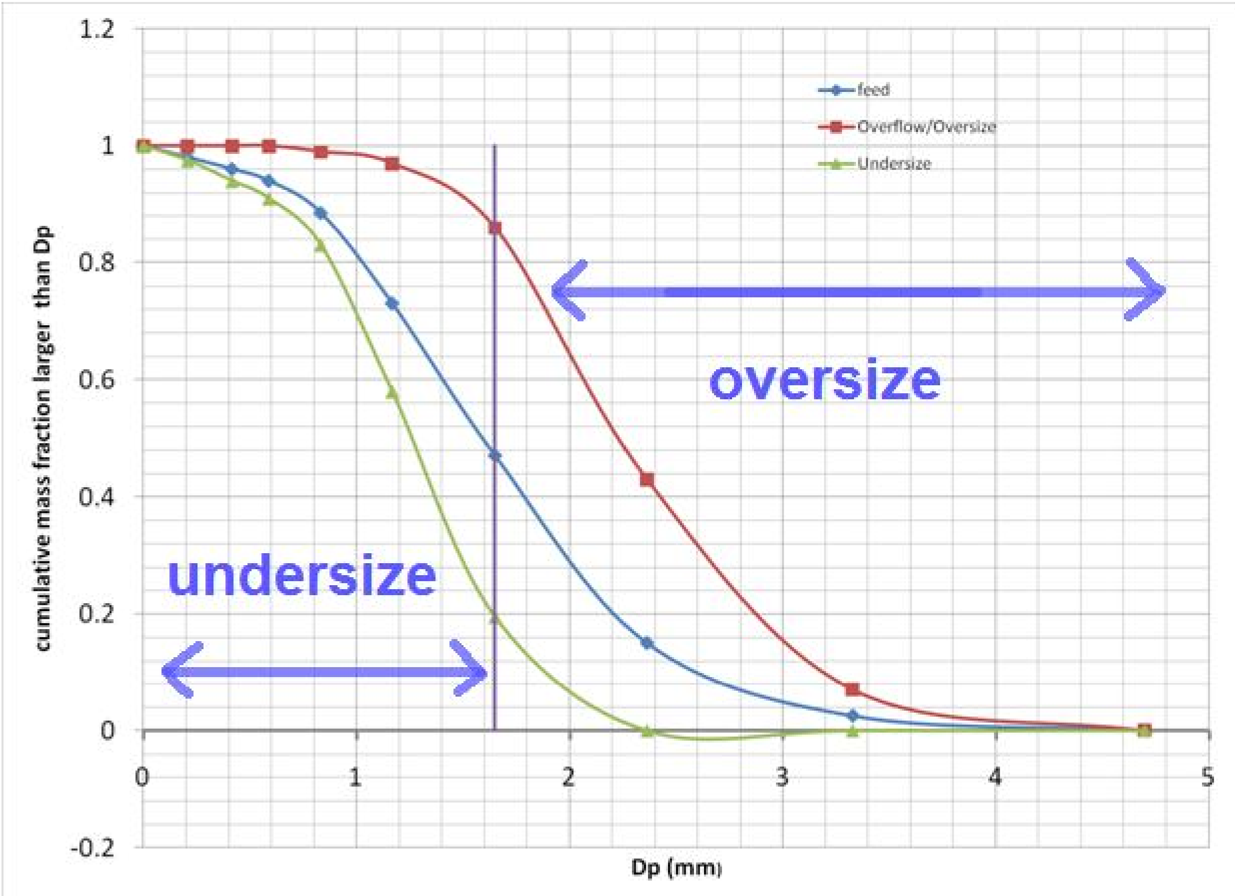
In the previous question the given data was based on differential analysis, but in this question as we can observe that the data is based on cumulative analysis. In the figure plotted below we can see a vertical line segregating the graph into oversize and undersize.

As the 10 mesh screen is of our interest the value of X_F, X_P and X_R are **0.47, 0.85** and **0.195** respectively.

Screen effectiveness can now be calculated by using the formula and for calculating the mass ratios use the formula that can be derived my applying the component mass balance i.e. (**P/F** and **R/F**).

Self test:

- How we have obtained the value of X_F, X_P and X_R as **0.47, 0.85** and **0.195** respectively.
- Convert the cumulative analysis into differential analysis.



1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
1
2
3
4
5
feed
Overflow/Oversize
Undersize
cumulative mass fraction larger than Dp
Dp (mm)
oversize
undersize