$$\Sigma_{PROCESS} = \frac{Q}{U_t} \qquad (1)$$

where $U_t$ is the terminal settling velocity of the critical particle under consideration. This is the area of a settling basin that would perform the same duty under the given flow rate. The theoretical capacity of the centrifuge is

$$\Sigma_{MACHINE} = \frac{\pi(r_2^2 - r_1^2)L\omega^2}{g\ln(r_2 / r_1)} \qquad (2)$$

5.

i)

Derive an expression for the volume fraction of the machine between $r_S$ and $r_2$ (i.e. $p$).

$$p = \frac{(r_2^2 - r_s^2)}{(r_2^2 - r_1^2)}$$

*this is the volume fraction of the machine between an arbitrary radius* $r_S$ *and the outer radius* $r_2$.

ii)

Using $r_S$ instead of $r_1$, equating (1) and (2) and using $V$ for volume, derive an expression for $r_S$.

$$r_s = \frac{r_2}{\exp(U_t V\omega^2 / gQ)}$$

iii)

Combine the answers to give an expression for the proportion of particles removed as a function of flow and material properties, i.e. $p$ or the grade efficiency=...

$$p = \frac{r_2^2}{r_2^2 - r_1^2}\left[1 - \exp\left(\frac{-2U_t V\omega^2}{Qg}\right)\right]$$

The best way of thinking about the above equation is as follows:

- When the start radius is equal to the inner radius, $p$=1, i.e. all the volume within the centrifuge is processed.
- For values of start radius between the inner and outer radii, $p$ is the proportion of the volume of the machine that is processed (i.e. particles are removed from the flow).
- For each different particle size, the terminal settling velocity will be different.
- Hence, the volume from within the machine that all particles of this size will be removed will be different for the different particles.
- The equation in (iii) calculates the fraction of particles, of a given size (i.e. settling velocity) removed from the flow. It is called the grace efficiency.