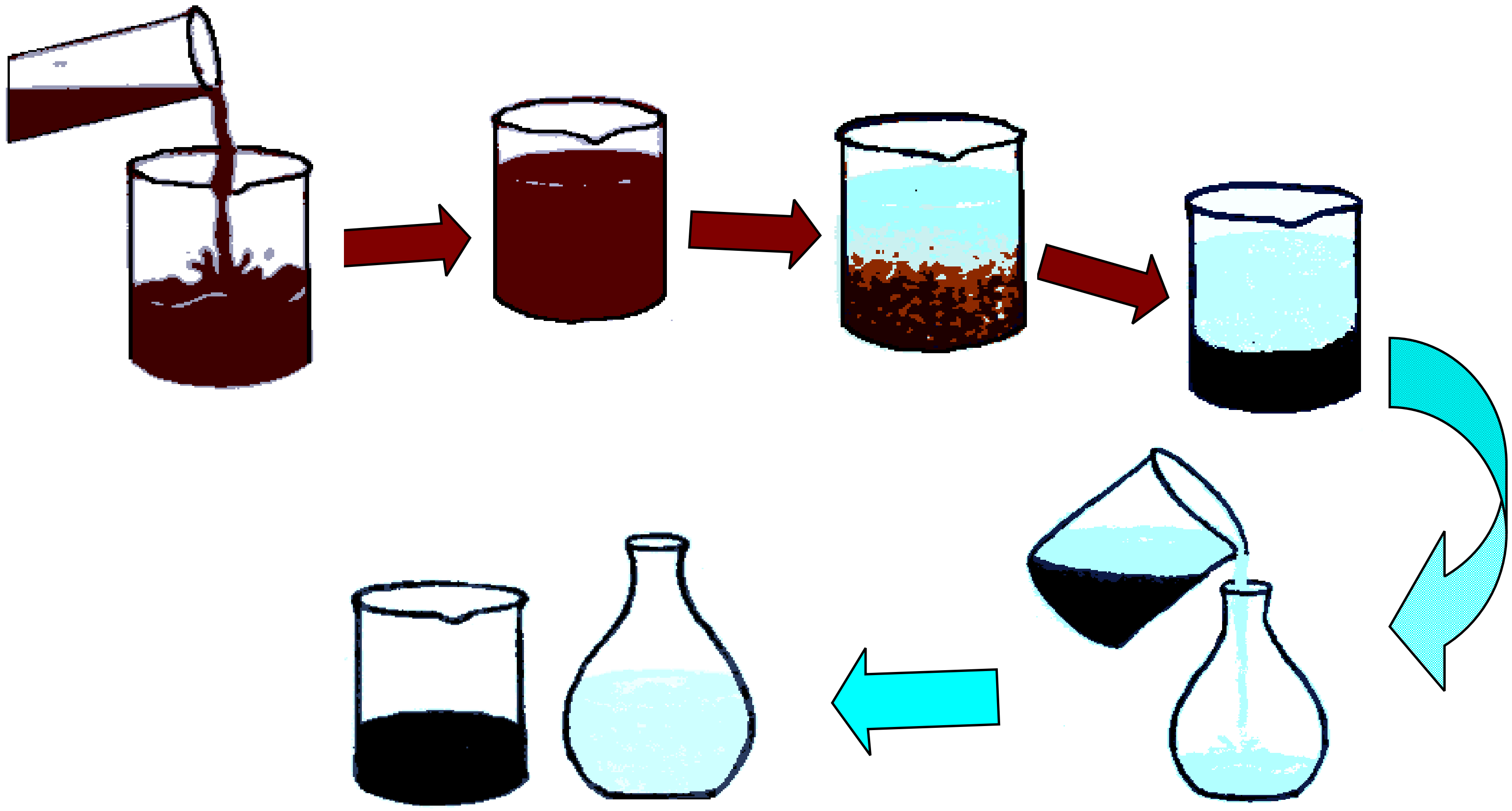
Energy Efficiency in Mechanical Separation

Water Arabia 2011 – Bahrain

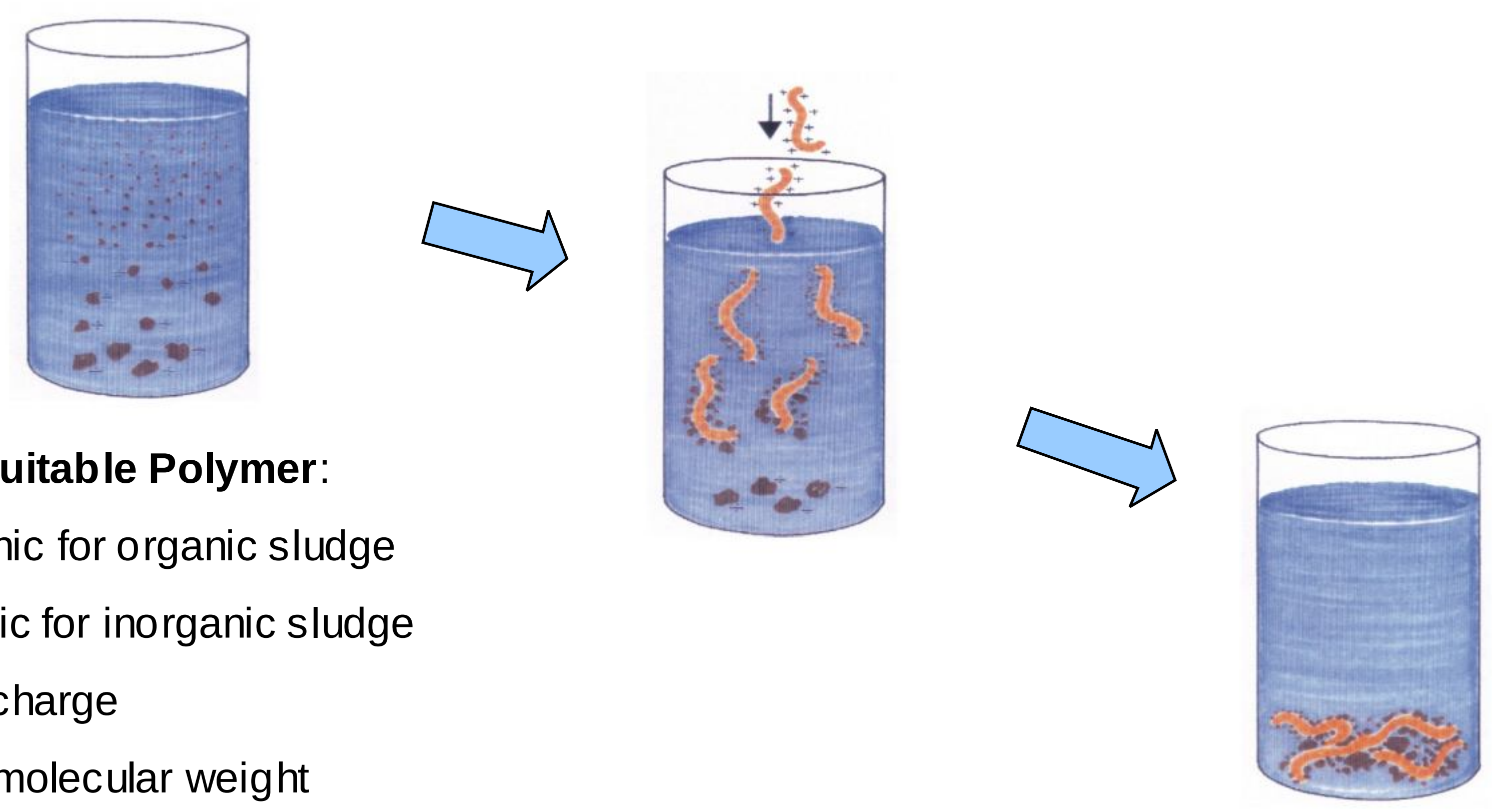
Andreas Rak

GEA Mechanical Equipment / **GEA Westfalia Separator Group GmbH**

Separation



Flocculent & Polymer

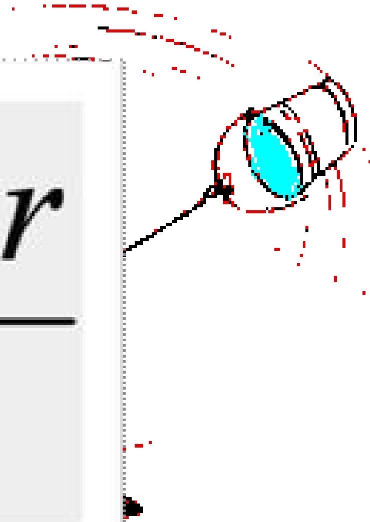


Most suitable Polymer:

- Cationic for organic sludge
- Anionic for inorganic sludge
- High charge
- High molecular weight
- Powder or emulsion

Centrifugal force

$$C = \frac{4 \cdot \pi^2 \cdot n^2 \cdot r}{g}$$



Gravity on earth: 1 x g

Centrifugal force: C x g

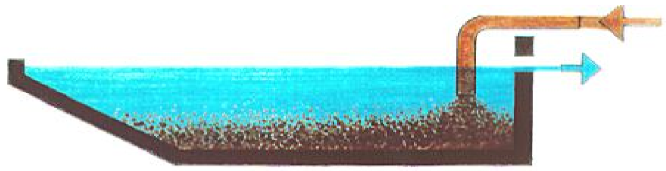
Centrifugal force in a decanter:

$$C = \frac{4 \cdot \pi^2 \cdot n^2 \cdot r}{g}$$

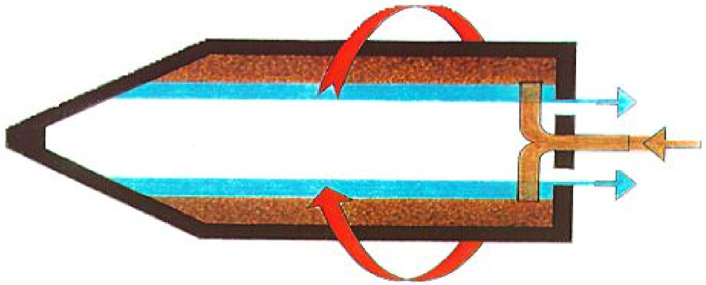
r = bowl diameter (m)
n = rpm (1/sec)

Decanter basics

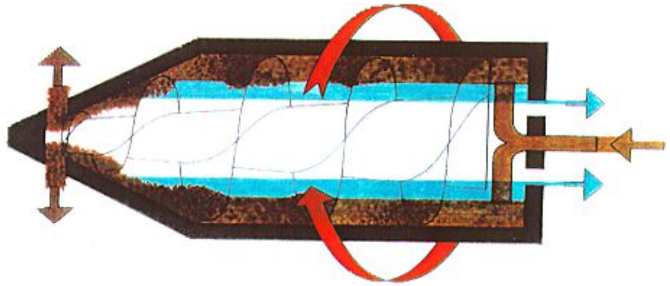
Sedimentation



Sedimentation +
Centrifugal force



Sedimentation + centrifugal force +
continuous solids removal



Power demand of decanter centrifuge 1/3

The total power demand is the sum of three single power demands:

$$P_{centr} = P_{solid} + P_{liquid} + P_{noload}$$

1.) Power demand solids:

$$P_{solid} = \dot{m}_{solid} \cdot u_{solid}^{2}$$

m_solid = Mass flow at solids discharge

u_solid = circumferential speed solids at discharge port

2.) Power demand liquids:

$$P_{liquid} = \dot{m}_{liquid} \cdot u_{liquid}^{2}$$

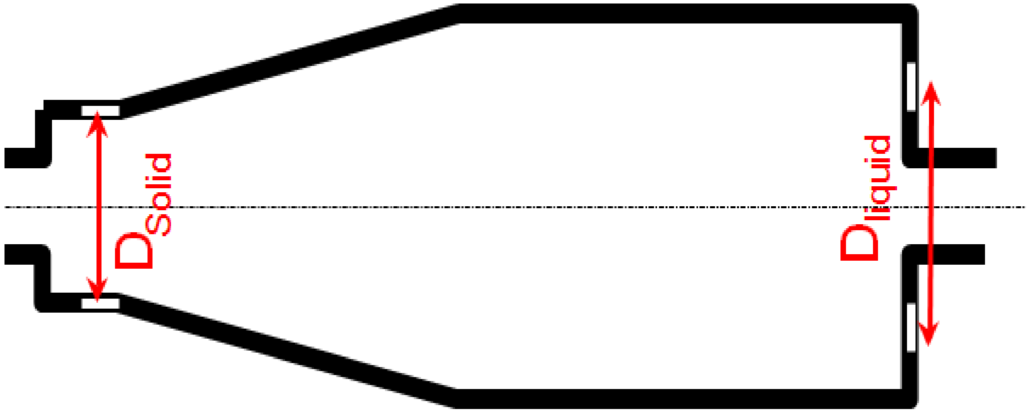
m_liquid = Mass flow at liquid discharge

u_liquid = circumferential speed liquid at discharge port

Circumferential speed at discharge ports

$$u_{solid} = \omega \cdot \frac{d_{solid}}{2}$$

$$\omega = 2 \cdot \pi \cdot n_{bowl}$$



Power demand of decanter centrifuge 2/3

3.) Power demand of running, not operating decanter P_{noload}:

The power demand no load combines all friction losses:

- friction losses in the bearings, gearbox, etc
- friction losses due to air friction on the decanter bowl
- etc.

$$P_{centr} = P_{solid} + P_{liquid} + P_{noload}$$

Power demand of decanter centrifuge 3/3

Basic correlations for the power demand of a decanter centrifuge:

-The power demand is proportional to the hydraulical throughput

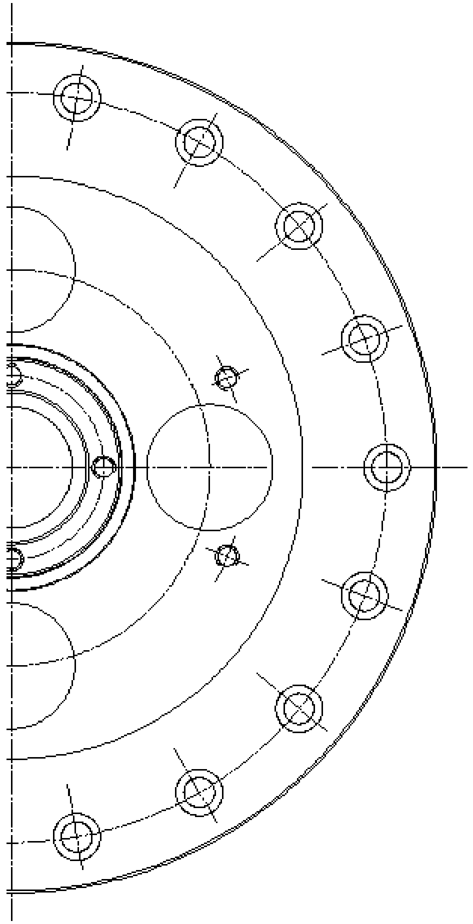
-The power demand increases quadratic in relation to the bowl speed

-The power demand is depending on the discharge diameter of the solids & liquid

-The power demand is depending on the energy efficiency of the decanter drive system

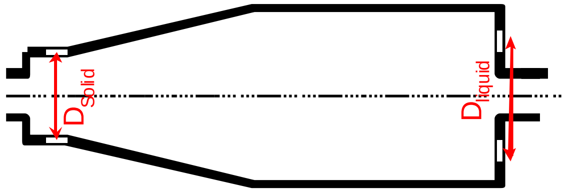
$$P_{tot\_elec} = \frac{P_{centri}}{\cos \varphi \cdot \eta_{motor}}$$

Reduction of discharge diameter 1/2



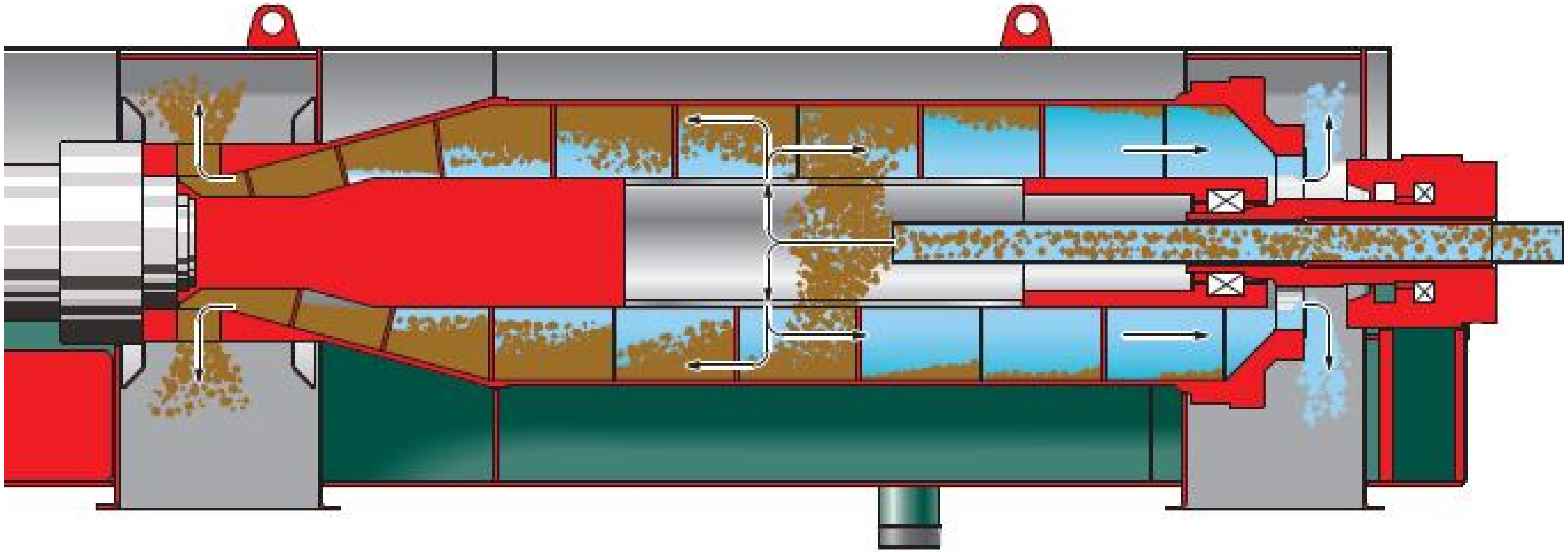
- Energy efficient mechanical separation can be achieved by small as possible solids and liquid discharge diameter. Physically : as smaller the diameter as smaller the braking power (losses of energy in the system) and as a result the power demand.

$$\frac{d_{Centrate}}{d_{Bowl}} = 0,50 - 0,45$$



Reduction of discharge diameter 2/2

The reduction of the discharge diameter is limited by safety & design reasons. The limiting factors are among other things the diameter and strength of the screw body and shaft as well as the vibration and strength characteristics of the rotating parts.



Power demand of decanter centrifuge 1/3

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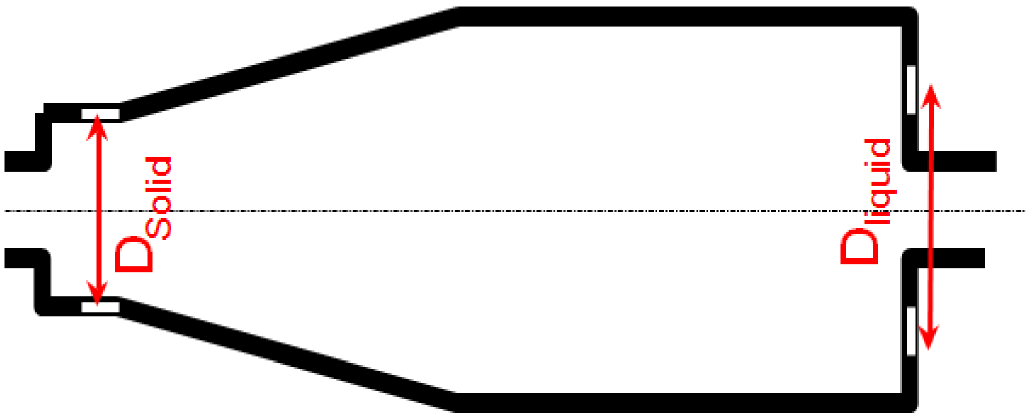
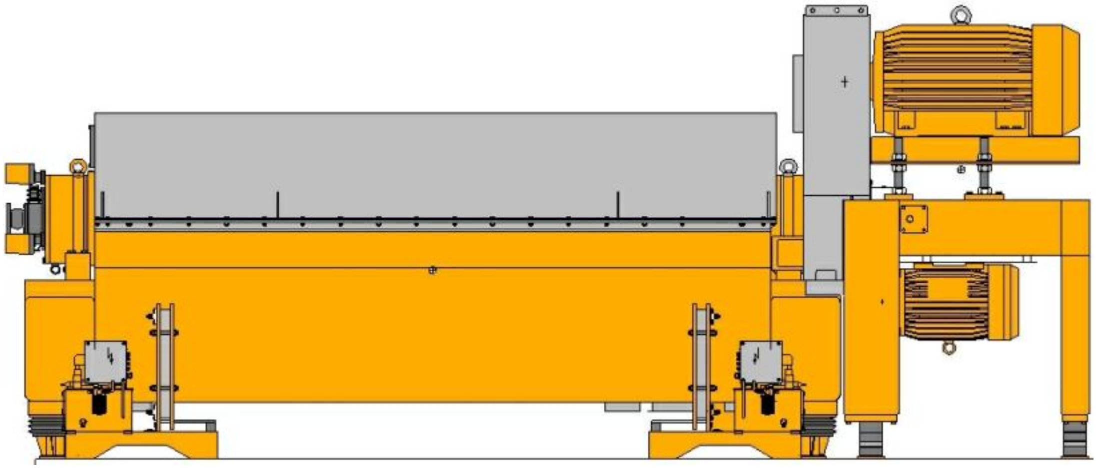


Thickening with fixed pond depth



200 m³/h

0,5 %-DS

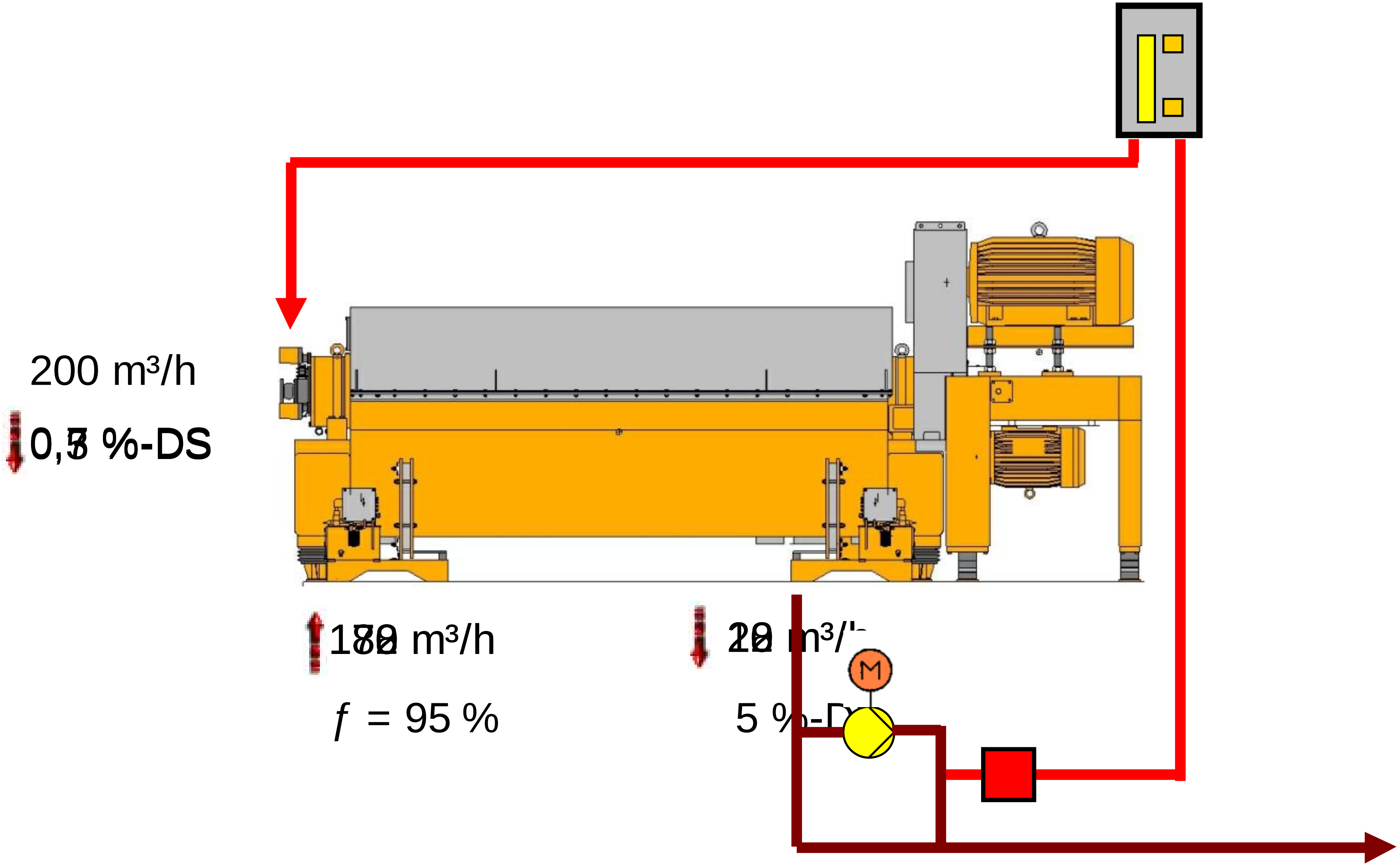
180 m³/h

f = 95 %

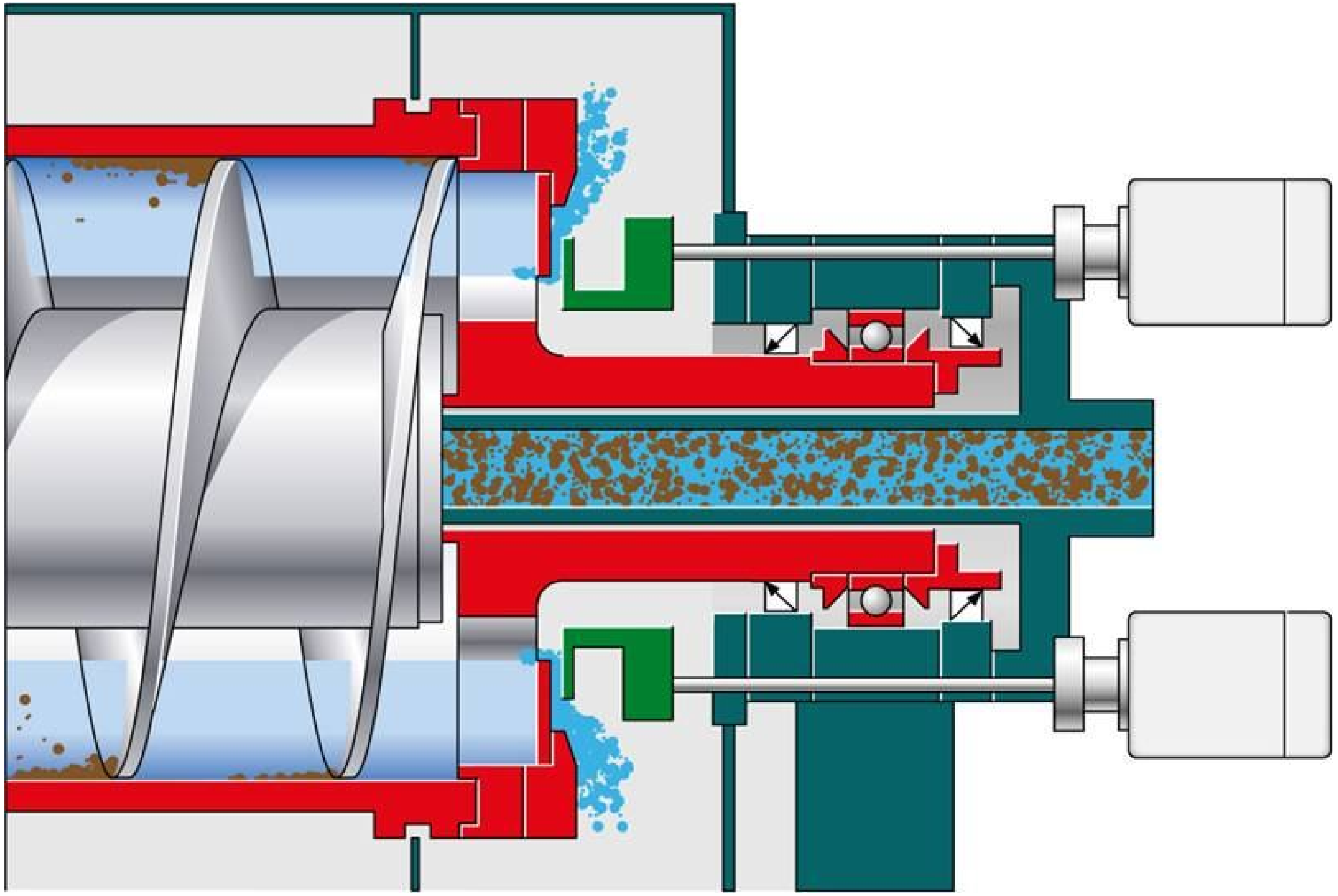
20 m³/h

5 %-DS

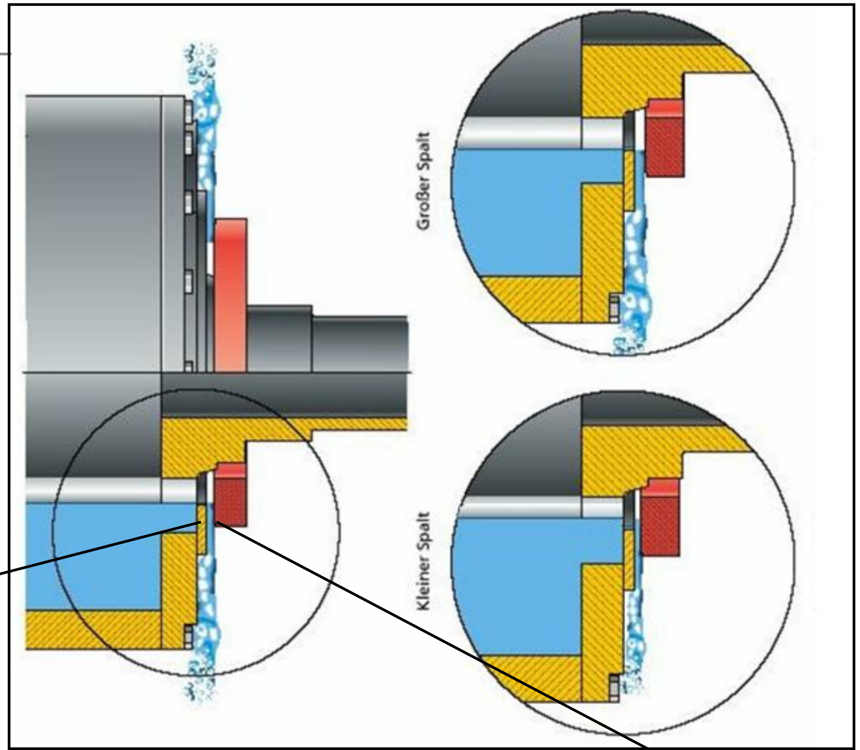
Thickening with variable pond depth - Varipond®



Variable pond depth - Varipond®



Variable process control



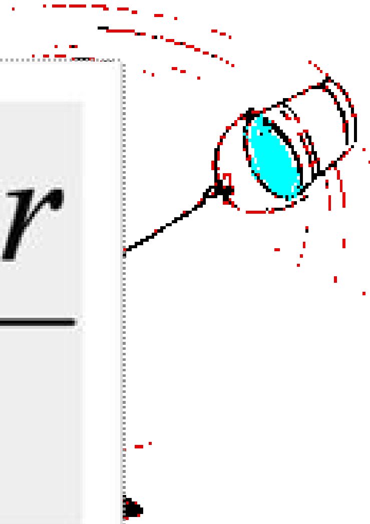
Combination of:

- variable Pond depth
- variable bowl speed

Working range VARIPOND® (0-100%)			
Working range (0-50%)			Safety range (50-100%)
Decreasing bowlspeed	No change of bowlspeed	Increasing Bowlspeed	

Centrifugal force

$$C = \frac{4 \cdot \pi^2 \cdot n^2 \cdot r}{g}$$



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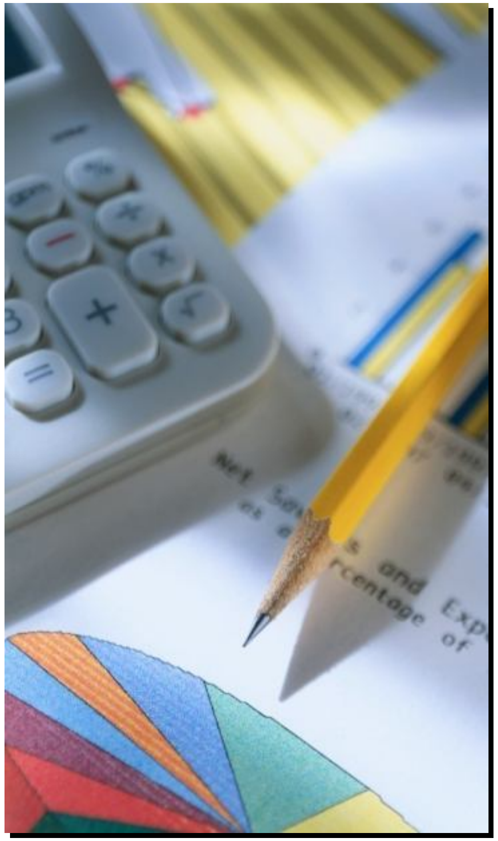
Summary Thickening with decanter centrifuge



Power demand
0,35 - 1,0 kWh/m³

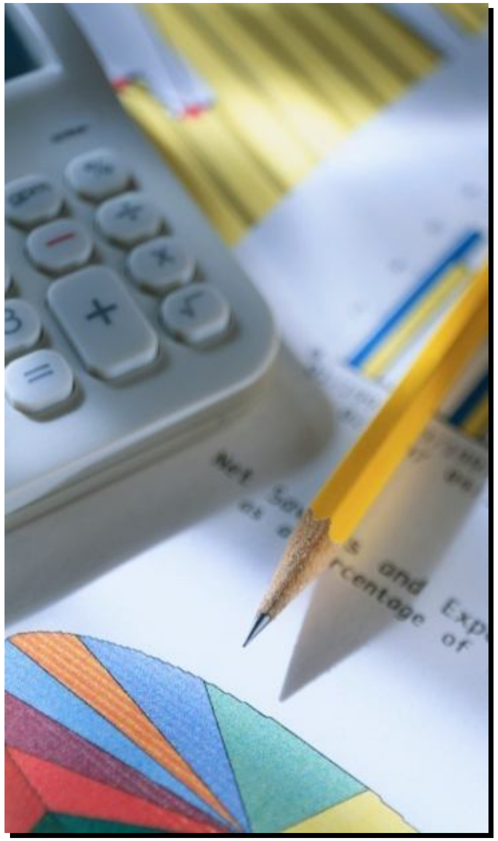
To estimate the power demand for thickening mainly the acceleration of the liquid phase is causal.

The sludge volume index is giving the necessary bowl speed and as a result the power demand of the centrifuge.

The polymer is enhancing the sedimentation process and can as a result reduce the power demand.

The patented energy saving system is adjusting the lowest possible bowl speed according to sludge characteristic.

Summary Dewatering with decanter centrifuge



To estimate the power demand for dewatering beside the acceleration of the liquid phase also the torque of the decanter screw is causal.

The achievable DS in the cake is correlated to the torque of the decanter screw is correlated to the ash content (inorganics)

Energy efficient mechanical separation can be achieved by small as possible solids and liquid discharge diameter.

Power demand
0,7 - 1,2 kWh/m³

efficiency in food and energy processes.

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