Degumming and Centrifuge Selection, Optimization and Maintenance

IUPAC-AOCS Workshop on Fats, Oils and Oilseeds Analysis and Production

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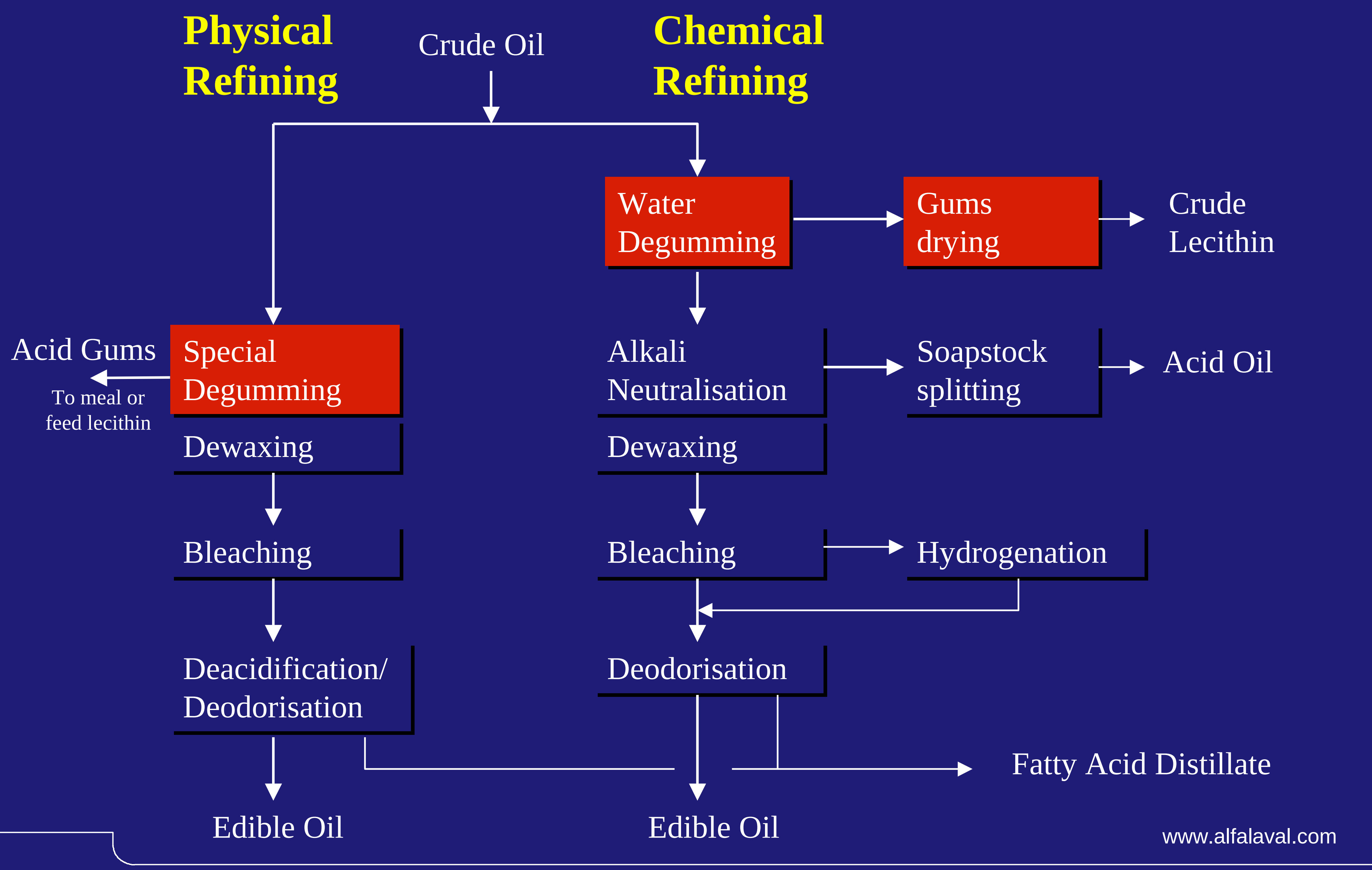
Alfa Laval Copenhagen A/S


Physical Refining
Crude Oil
Chemical Refining
Water Degumming
Gums drying
Crude Lecithin
Acid Gums
To meal or feed lecithin
Special Degumming
Alkali Neutralisation
Soapstock splitting
Acid Oil
Dewaxing
Dewaxing
Bleaching
Bleaching
Hydrogenation
Deacidification/ Deodorisation
Deodorisation
Fatty Acid Distillate
Edible Oil
Edible Oil
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Purpose of Degumming

- Commercial Lecithin production
- Prevent crude oil settling during storage or transport
- Waste water (prevent acidulation of gums)
- Physical Refining
- Reduction in neutralisation losses

Gums

- Two main types
  - Hydratable Phosphatides - easy to remove
  - Non-Hydratable Phosphatides (NHP) - hard to remove from oil
    - Some NHP removed with hydratables in water degumming
    - requires the use of a acid to convert to hydratable for complete removal

Gum Content of Various Oils

Oil type	Phosphatides (%)	Phosphorus (ppm)
Coconut	0.02 – 0.05	10 – 20
Corn	0.7 – 2.0	250 – 800
Cottonseed	1.0 – 2.5	400 – 1000
Groundnut	0.3 – 0 .7	100 – 300
Palm	0. 03 – 0.1	15 – 30
Rapeseed	0.5 – 3.5	200 – 1400
Soya	1.0 – 3.0	400 – 1200
Sunflower	0.5 – 1.3	200 – 500

Physical Refining

Feedstock Parameters

- Seed Oil (Soybean, Rapeseed, Sunflower)
  - FFA $\leq$ 2%
    - higher FFA indicates low quality oil and may not be suitable for physical refining
  - Phosphorous $\leq$ 5 ppm, $\leq$2 desired
  - Iron $\leq$ 0.2 ppm

Chemical Refining

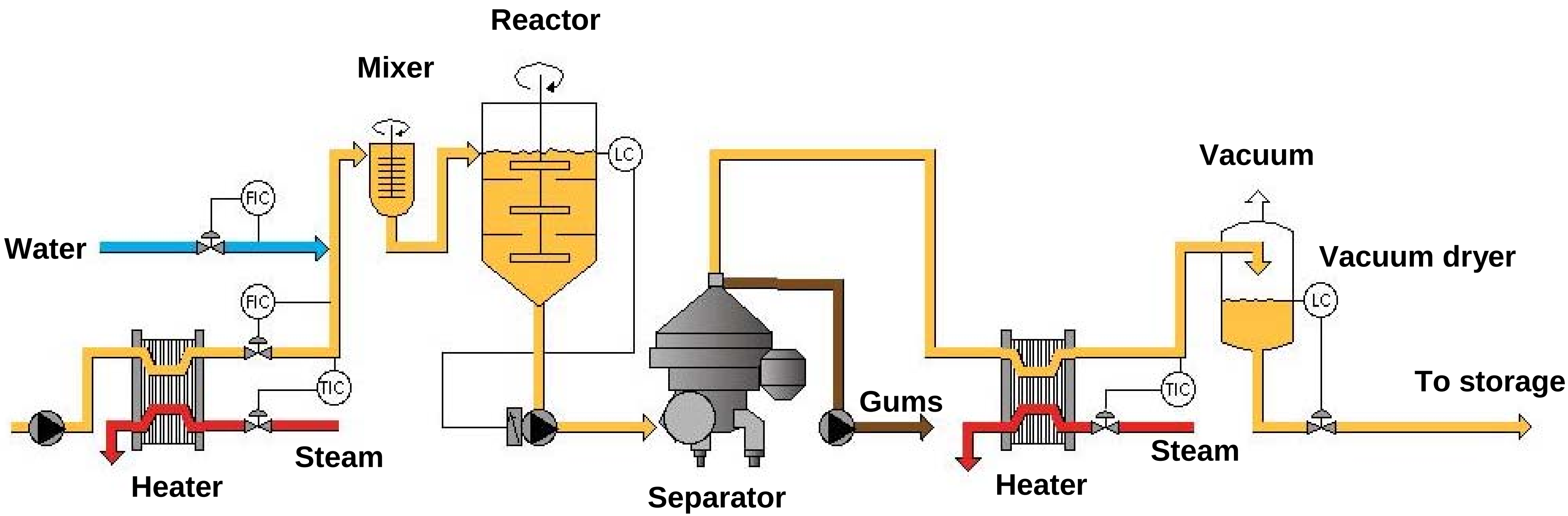
Feedstock Parameters

- Seed Oil (Soybean, Rapeseed, Sunflower)
  - FFA $\leq$ 3%
  - Phosphorous $\leq$ 1200 ppm, $\leq$ 200 ppm desired

Water Degumming Process Steps

- Heat oil to 60 - 70 °C
- Water addition and mixing
- Hydration mixing 30 minutes
- Centrifugal separation of hydrated gums
- Vacuum drying of degummed oil
- Gums - dried for edible lecithin or recombined in meal

Water Degumming



Water Degumming

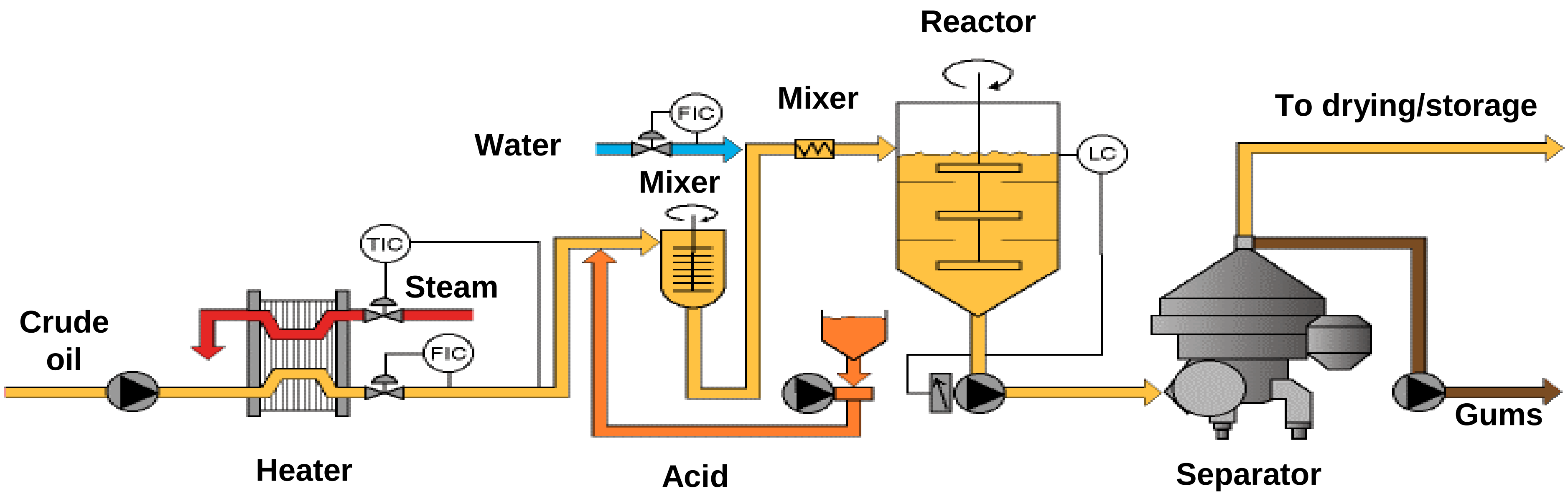
Target Results:

- Phosphorous in oil - 50 to 200 ppm max.
- AI% in dried gums - 65 to 70%.
- Moisture in dried oil - < 0.1%.

Acid Degumming Process Steps

- Heat oil to 60 - 70 °C
- Acid addition and mixing
- Hydration mixing 30 minutes
- Centrifugal separation of hydrated gums
- Vacuum drying of degummed oil
- Gums - recombined in meal

Acid Degumming



Acid Degumming

Target Results:

- Phosphorous in oil - 20 to 50 ppm max.
- AI% in dried gums - 65 to 70%
- Moisture in dried oil - < 0.1%

Major Deep Degumming Methods

- Alfa Laval Special Degumming
- Super/Uni Degumming
- TOP Degumming
- Organic Refining Process
- Soft Degumming
- Enzymatic Degumming

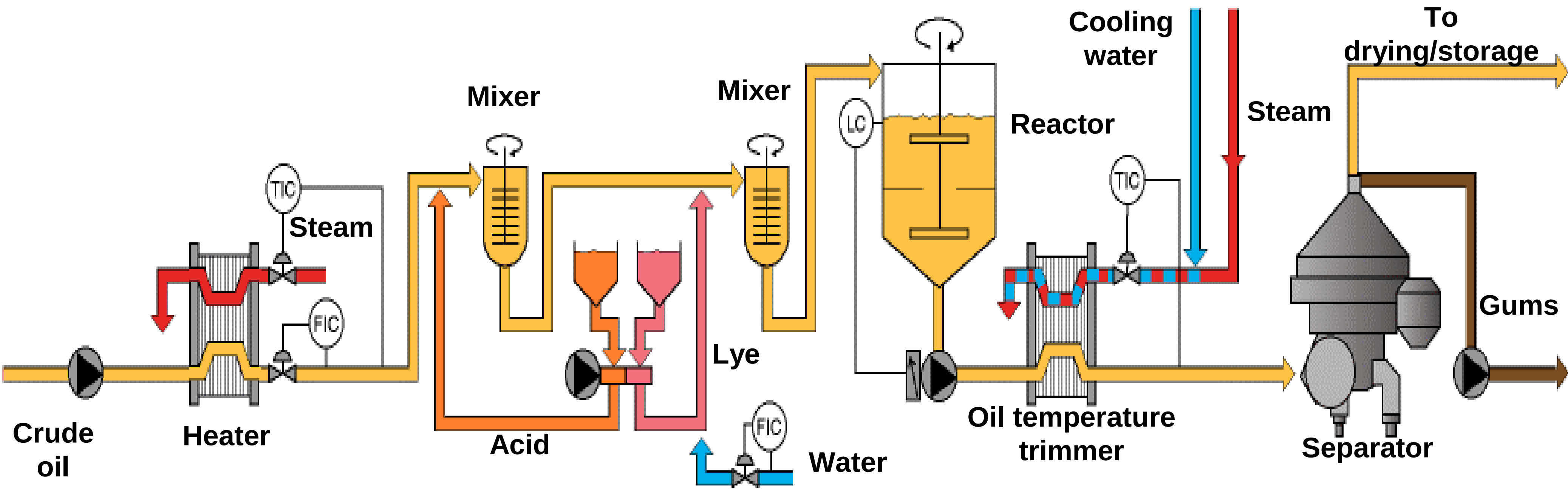
Deep Degumming

- Deep degumming utilizes a reagent like acid to chelate Iron, Calcium, and Magnesium away from the NHP complex. Once the Iron, Calcium, and Magnesium are removed from the NHP complex the phosphatide becomes hydratable
- Enzymatic degumming utilizes an enzyme to modify the NHP into a hydratable form.

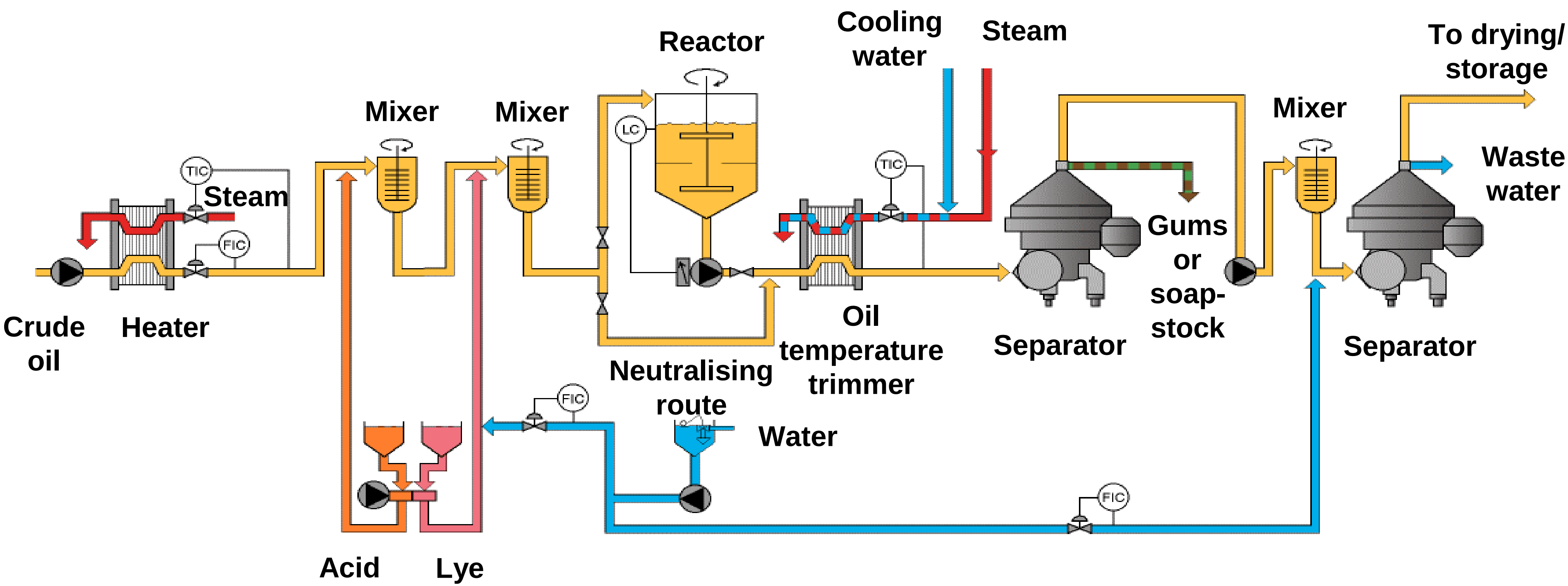
Alfa Laval Special Degumming

- Heat oil to 60 ^{o}C
- 0.05-0.2 % Phosphoric Acid with intensive mixing
- Partially neutralise with dilute lye (hydration water)
- Gentle mixing and holding for 60 minutes
- Gums centrifugation
- Optional water wash step for lower phosphorous
- Oil drying

Alfa Laval Special Degumming



Alfa Laval 2-stage Special Degumming



Alfa Laval Special Degumming

Target Results:

- Phosphorous in oil - 20 to 30 ppm max.
- Phosphorous in oil - 8 to 10 ppm max. with washing
- AI% in dried gums - 50 to 60%
- Moisture in dried oil - < 0.1%

Deep Degumming Results

Process	Phosphatides (%)	Phosphorus (ppm)
Special Degumming	< 0.02	< 10
Super/Uni Degumming	0.01 – 0.04	5 – 15
TOP Degumming	0.01 – 0.02	5 – 10
Soft Degumming	< 0.01	< 5
ORP	< 0.02	< 10
Enzymatic Degumming	0.01 – 0.02	5 – 10
Ultrafiltration	< 0.01	< 5

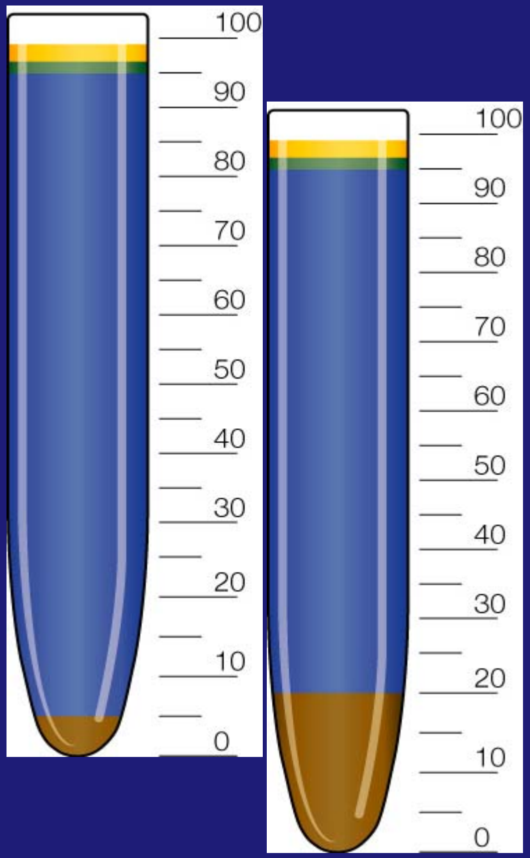
Disc Stack Centrifuges

Alternative name: High Speed Separators (HSS)

Separation by Density Difference

Stokes´ Law

$$V_g = \frac{d^2(\rho_p - \rho_l)}{18\,\eta}\,g$$

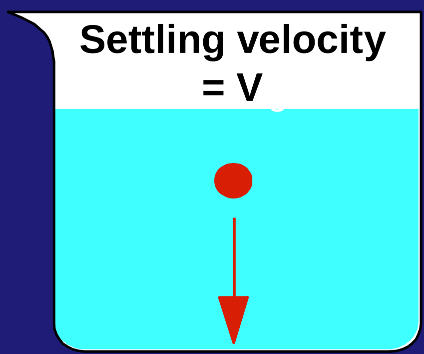


V_g = gravitational settling velocity (m/s)
d = particle diameter (m)
ρ_p = particle density (kg/m^3)
ρ_l = liquid phase density (kg/m^3)
η = liquid phase viscosity (kg/ms)
g = gravitational acceleration (m/s^2)

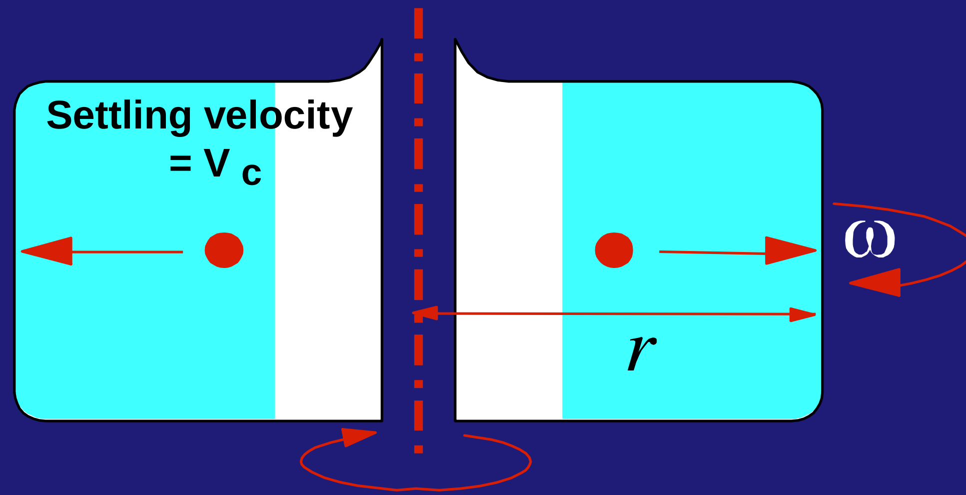
Centrifugal Separation

Forces coalescense/sedimentation

Settling velocity stated by Stokes´ Law

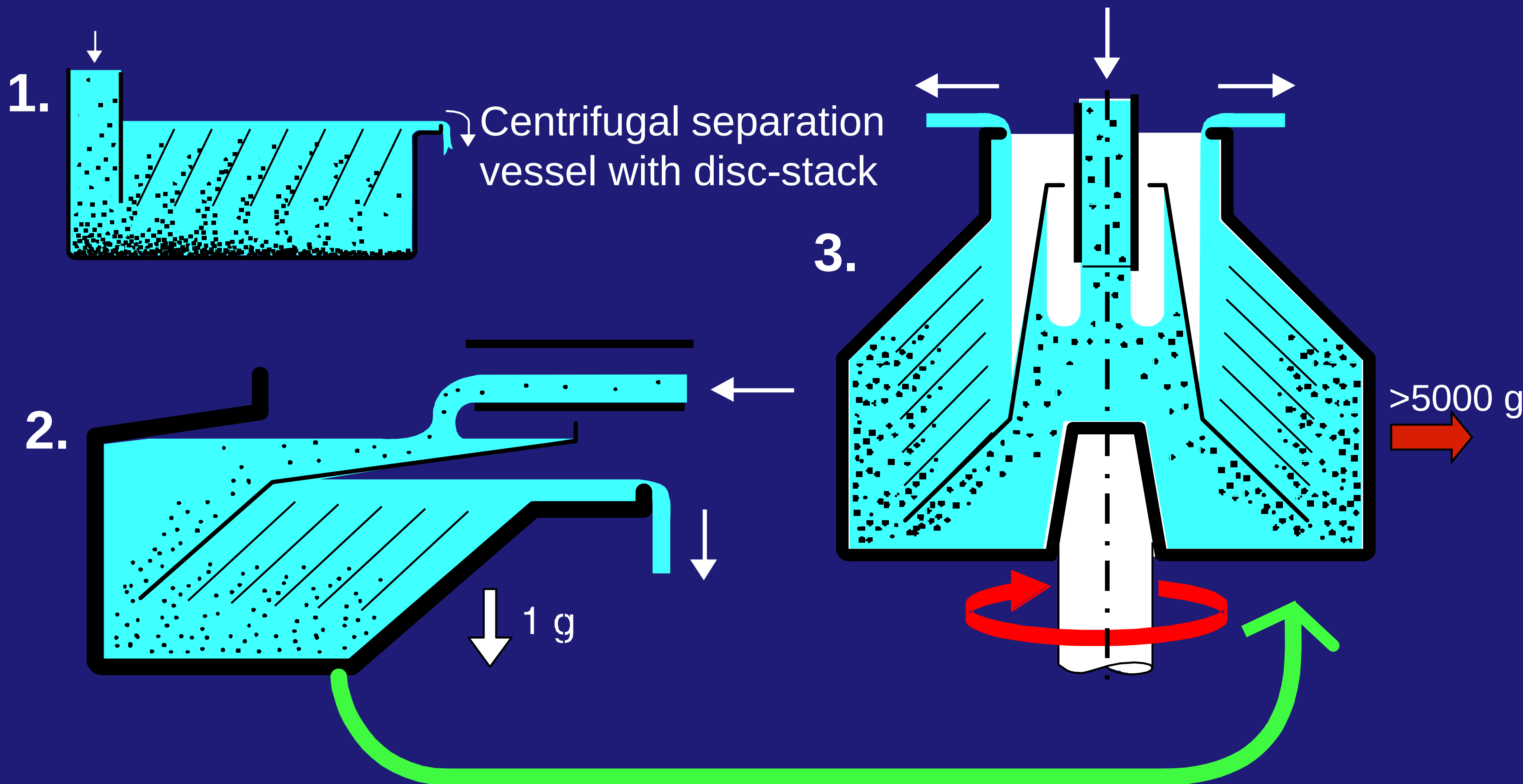


Gravity separation.
Driving force: 1g



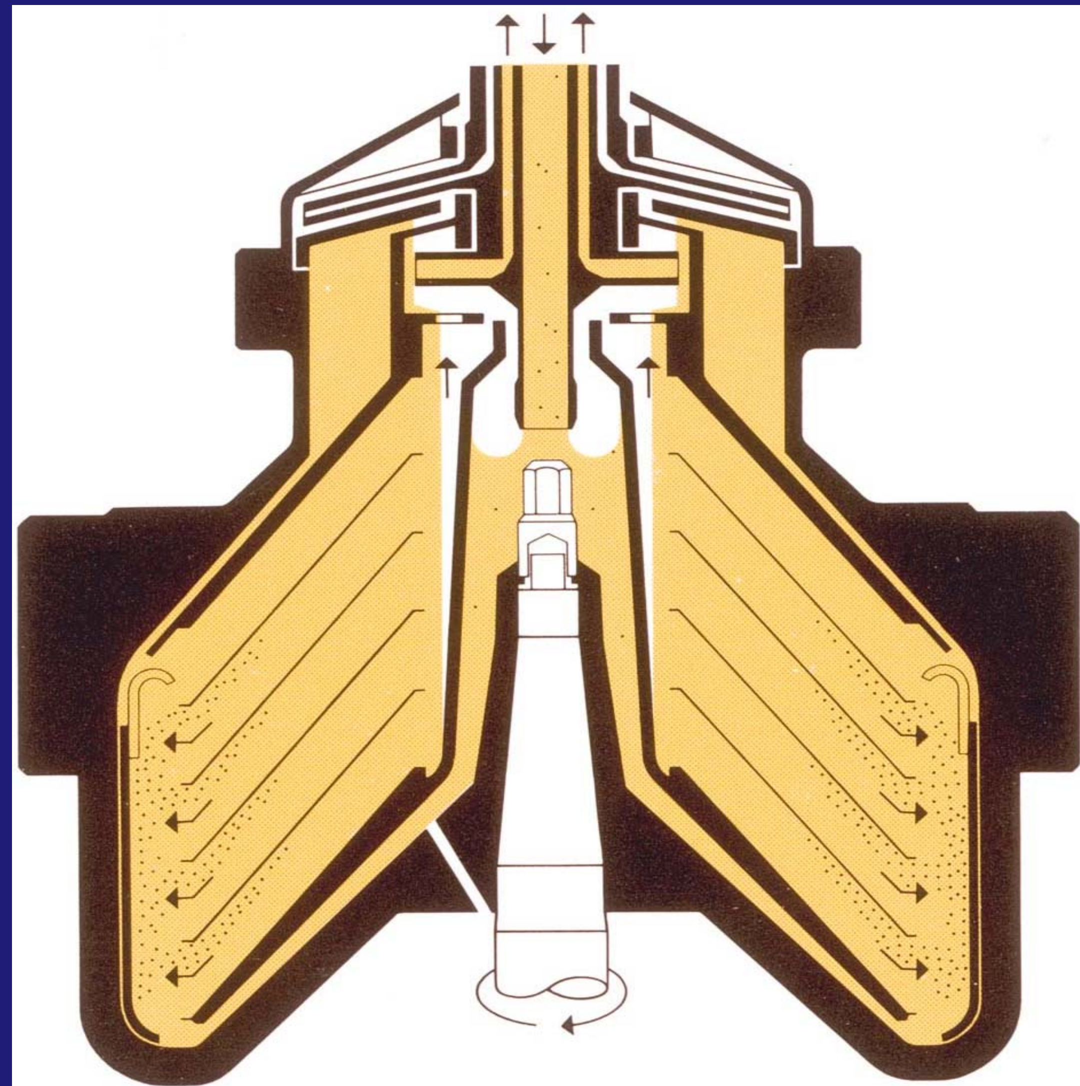
Centrifugal separation.
Driving force: $r \cdot \omega^2$

Gravitational to Centrifugal Force



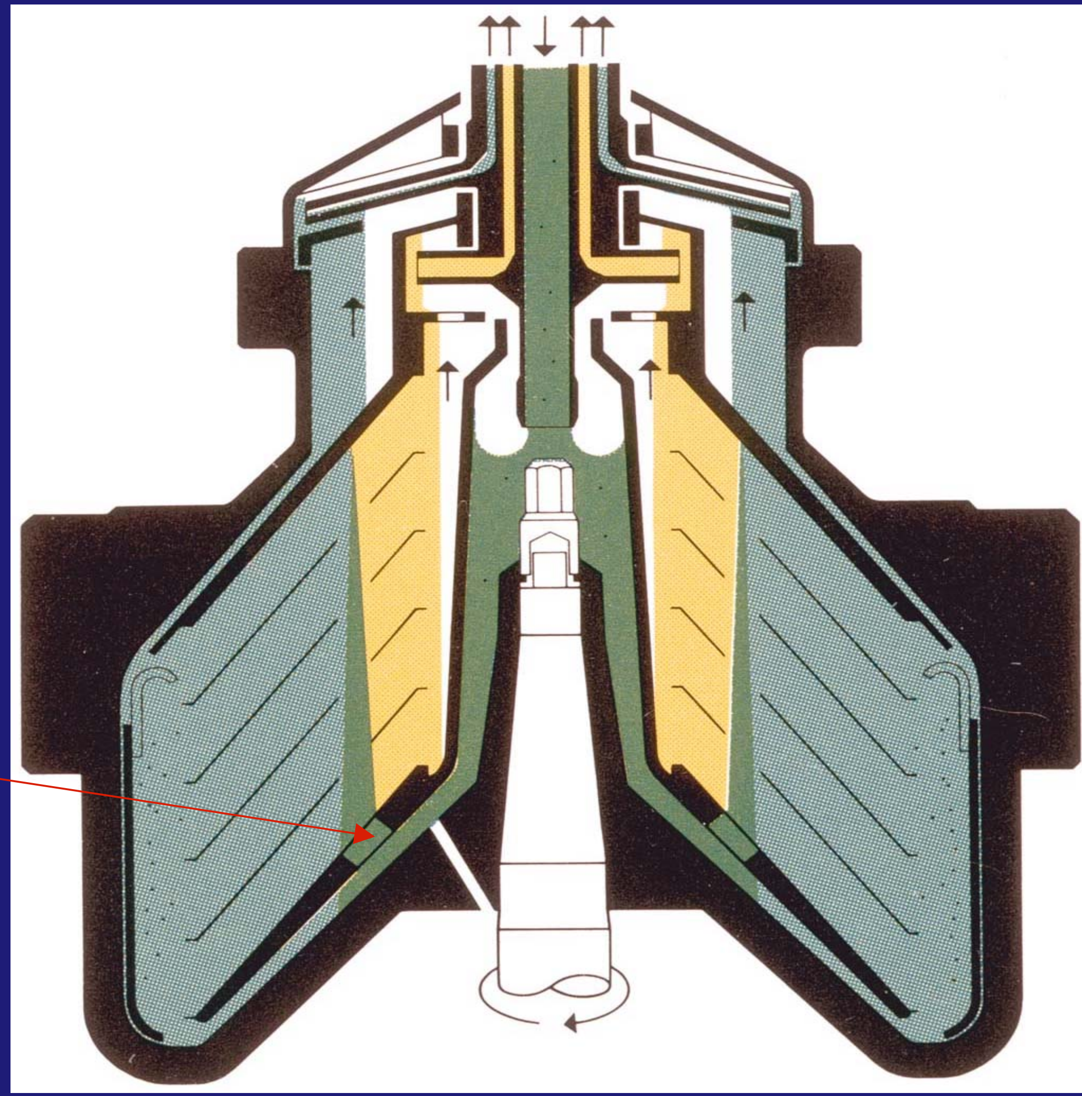
Clarification

- Removal of solids phase from a mixture of liquid and solids



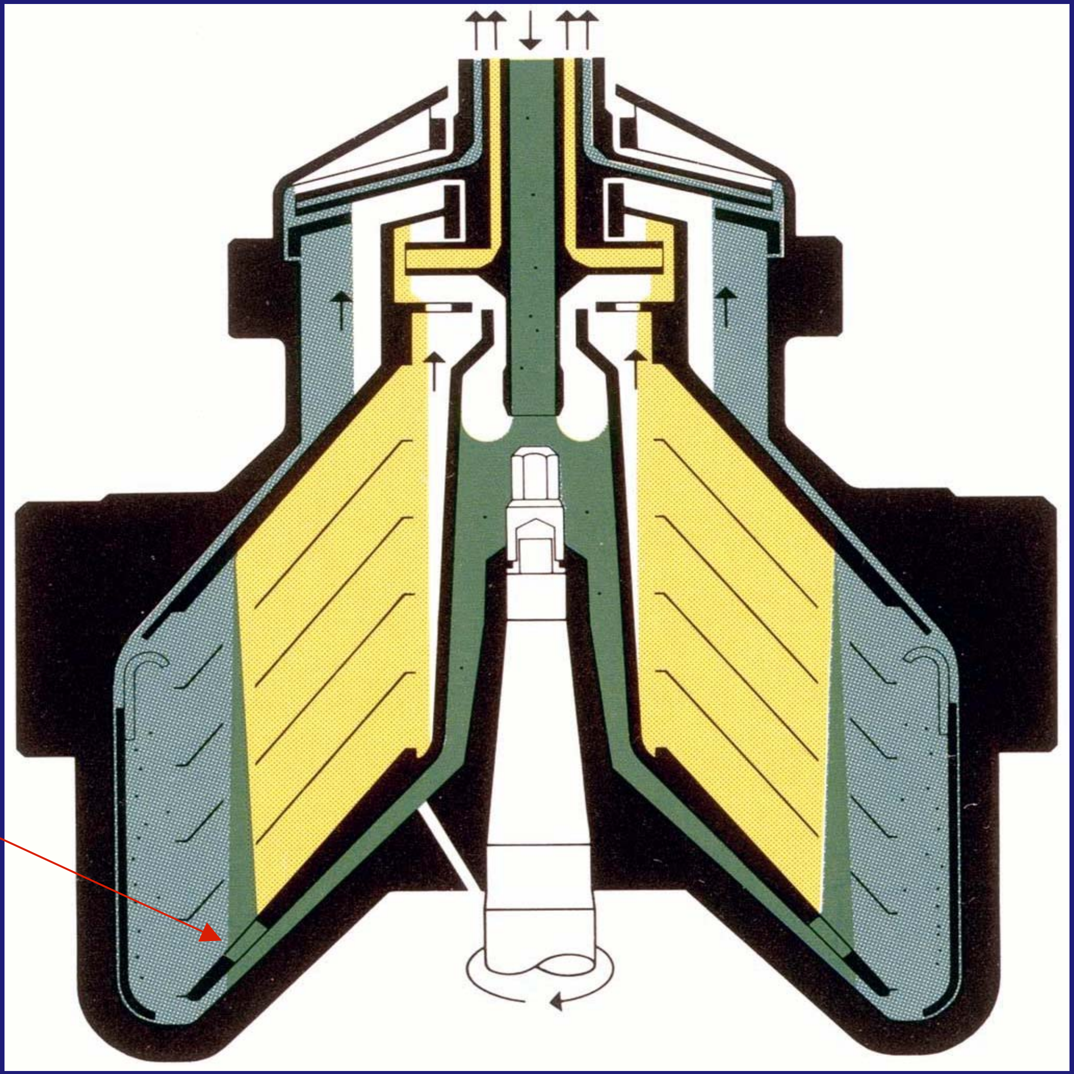
Concentration

- Liquid/liquid separation (also solids if present)
- Maximum cleaning of the **heavy** phase
- Therefore **holes** in disc-stack closer to the **centre**

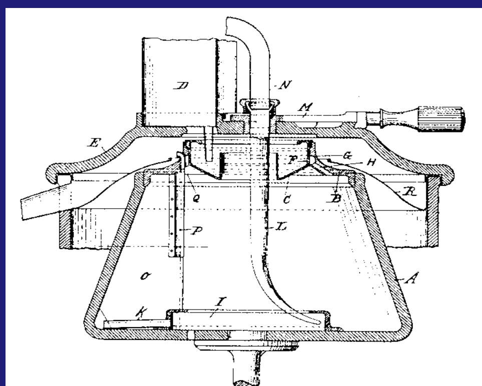


Purification

- Liquid/liquid separation (also solids if present)
- Maximum cleaning of the **light** phase
- Therefore **holes** in disc-stack closer to the **periphery**



HSS – Bowl Development



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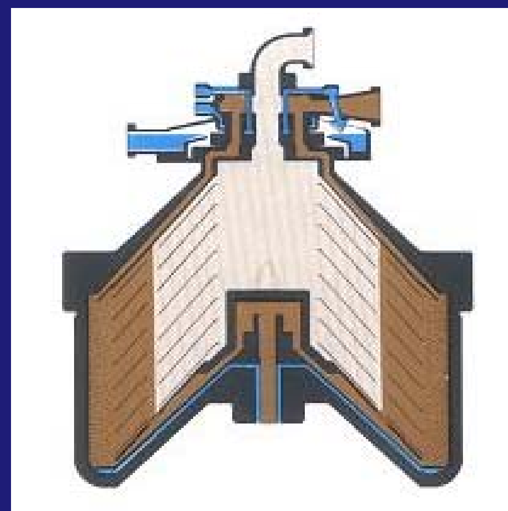

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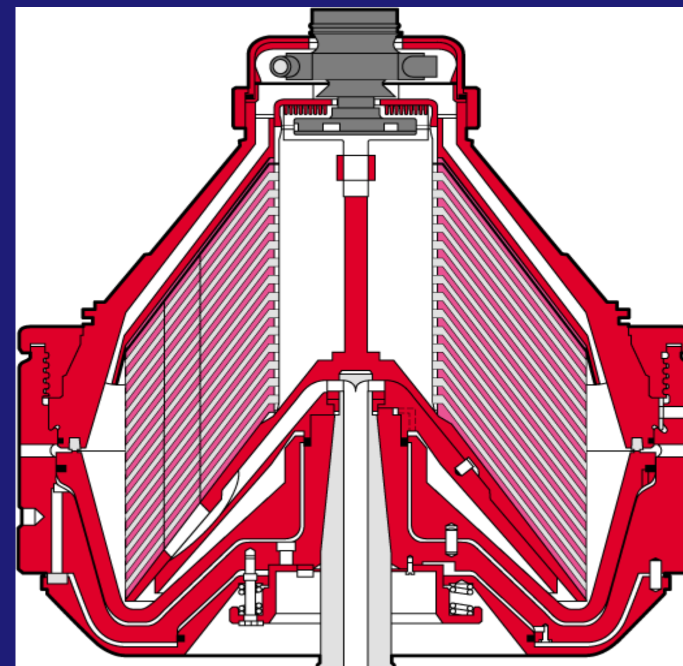

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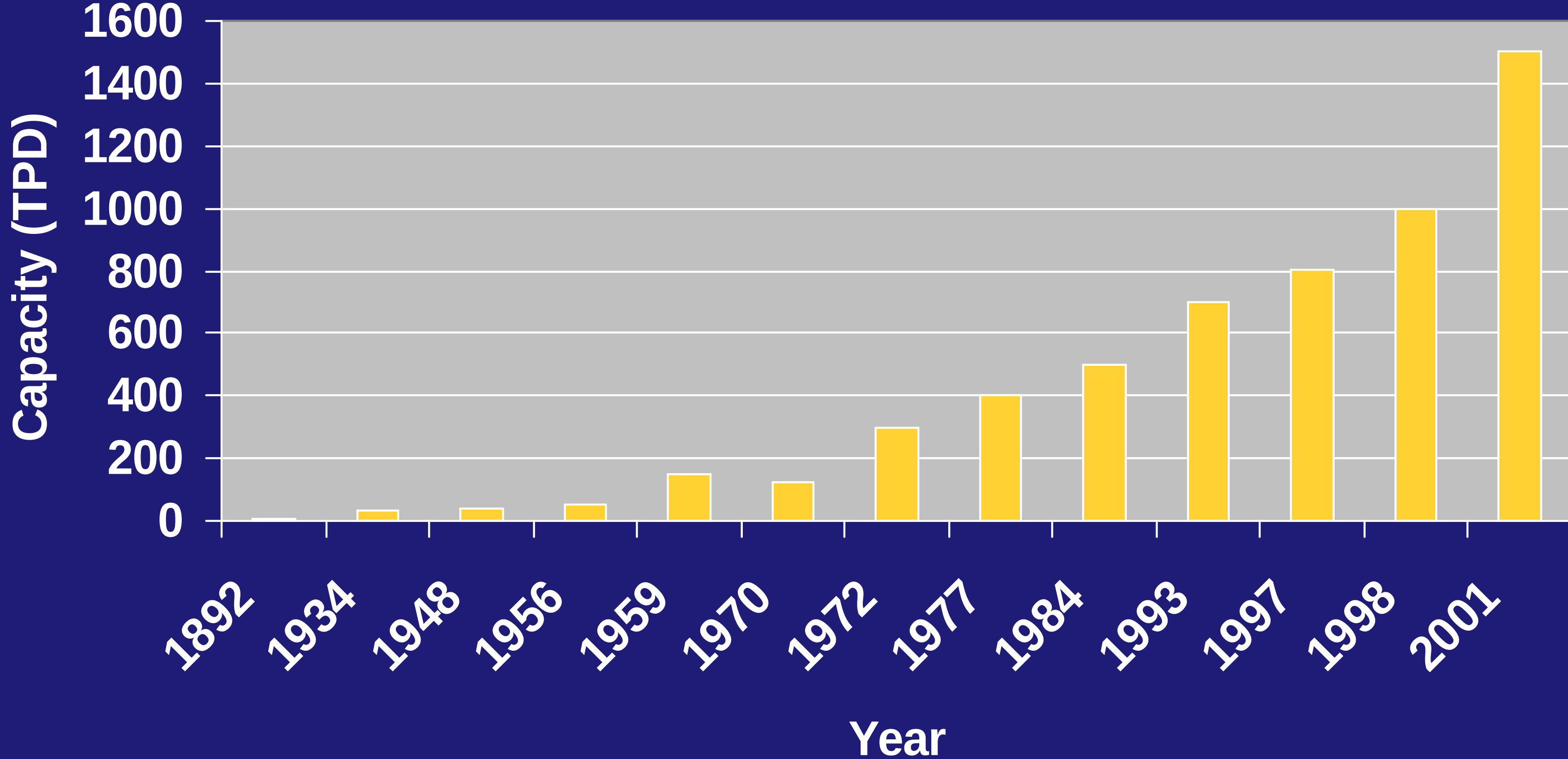
HSS – Unit Capacities

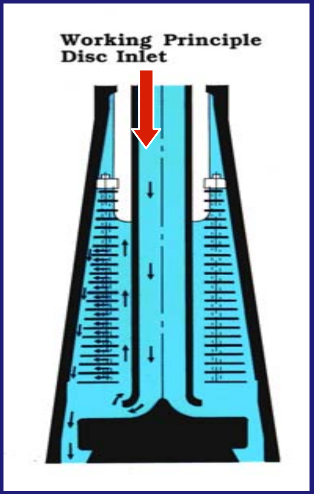


Optimising Separation Performance

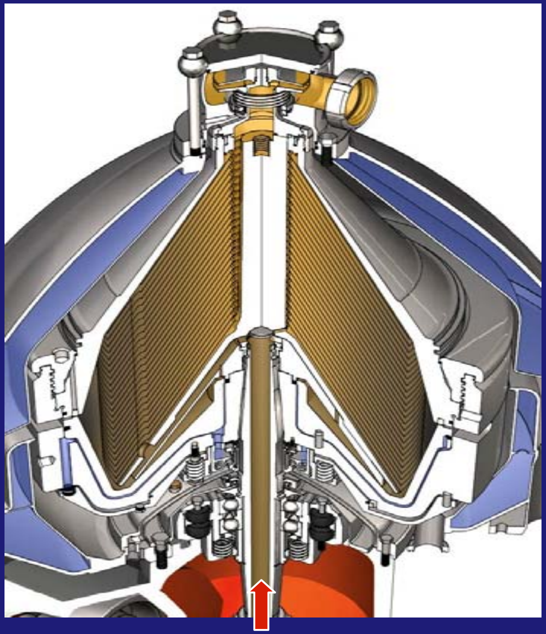
Fluid Handling

Gentle inlets

- Increase capacity
- No emulsion formation



Disc inlet working principle



Hermetic inlet

Lab tests

Optimising Separation Performance

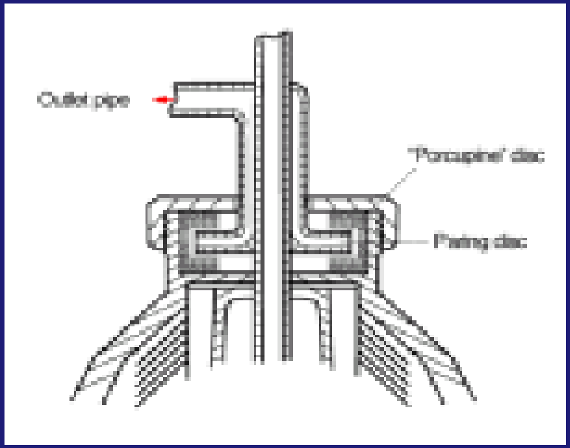
Fluid Handling

Porcupine outlet

•Reduced cavitation

•Reduced air entrainment

•Reduced break-up of particles



Optimising Separation Performance

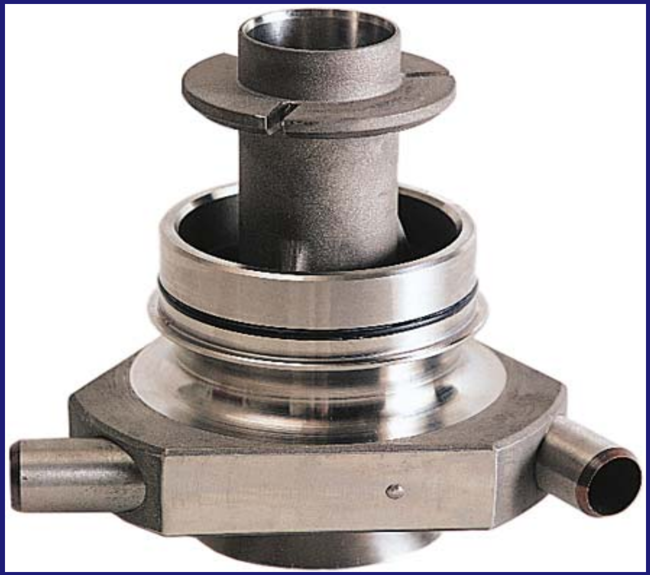
Fluid Handling

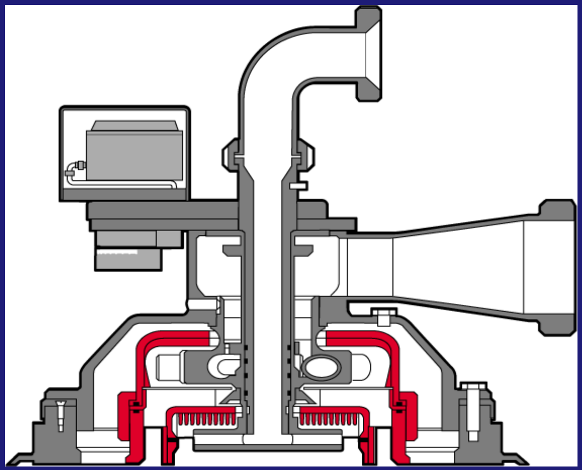
Adjustable paring disc

•Adjustable during operation

•Flexible

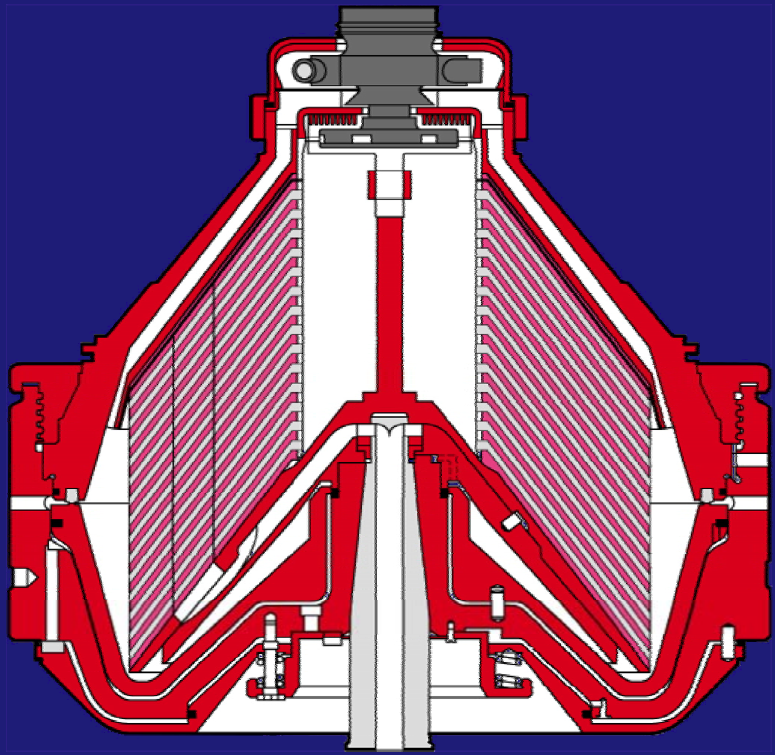
•Reduced energy consumption



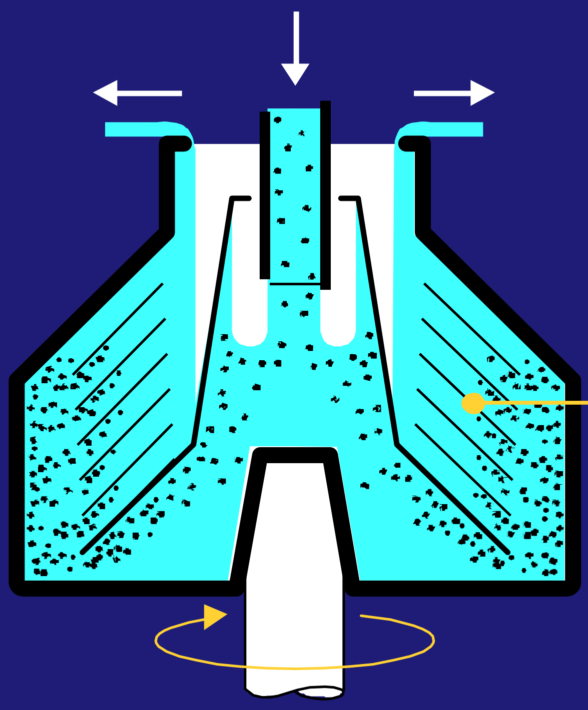


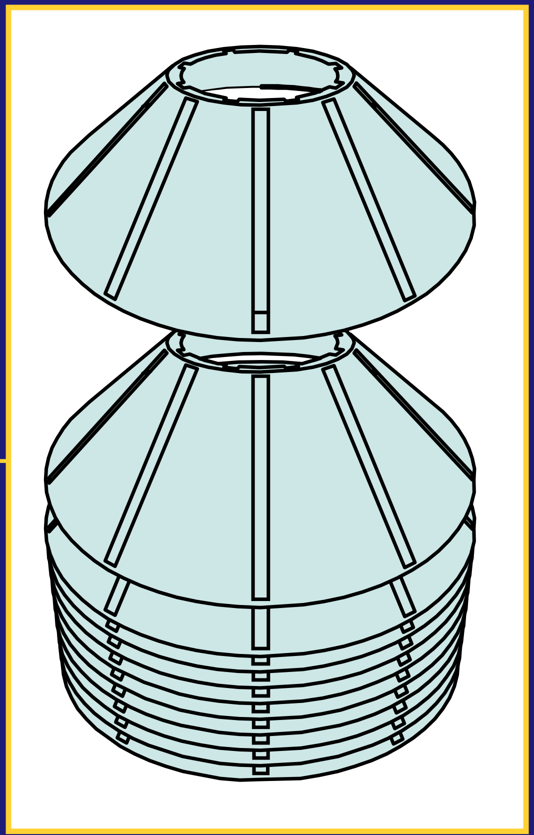
HSS Optimization - bowl design

- Optimized bowl and disc stack improve separation and reduce product loss.
- High capacity for handling sticky and viscous gums and soaps.
- Improved design and new high-performance stainless steel give the bowl optimal resistance to metal fatigue.

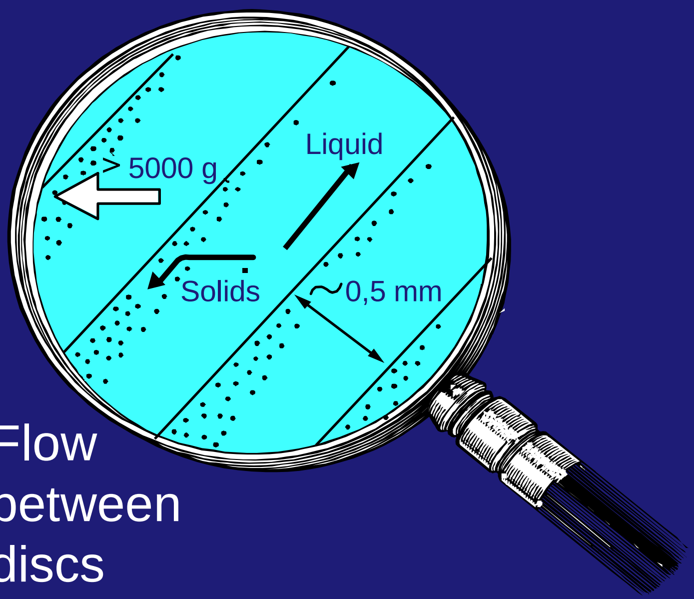


HSS Optimization - disc stack





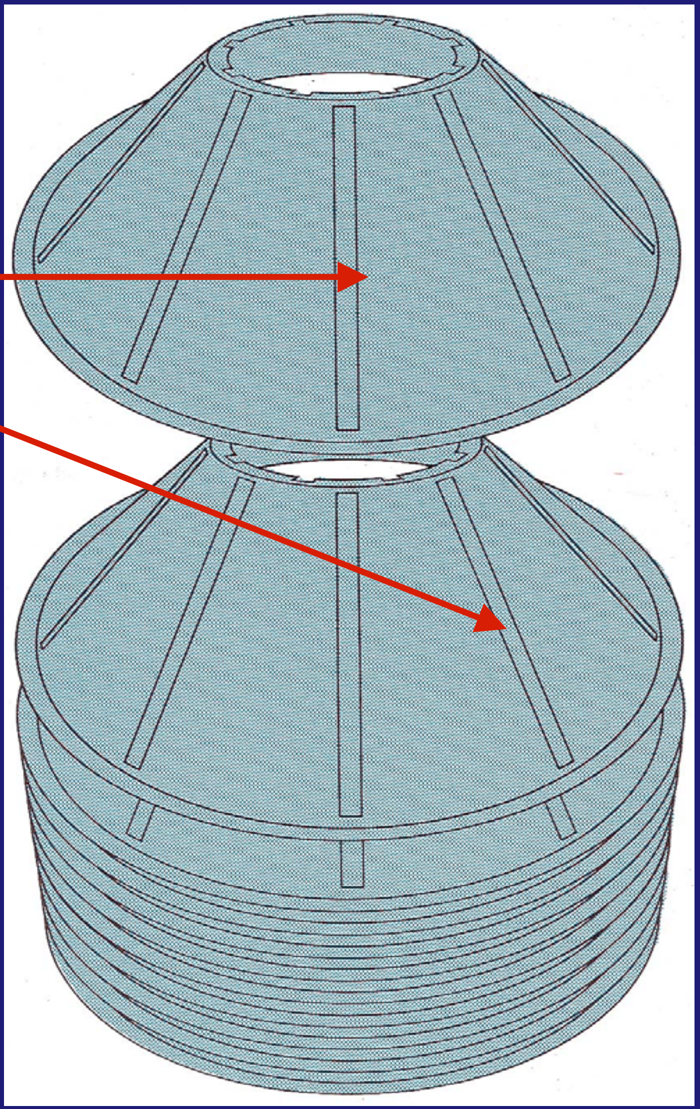
The disc-stack



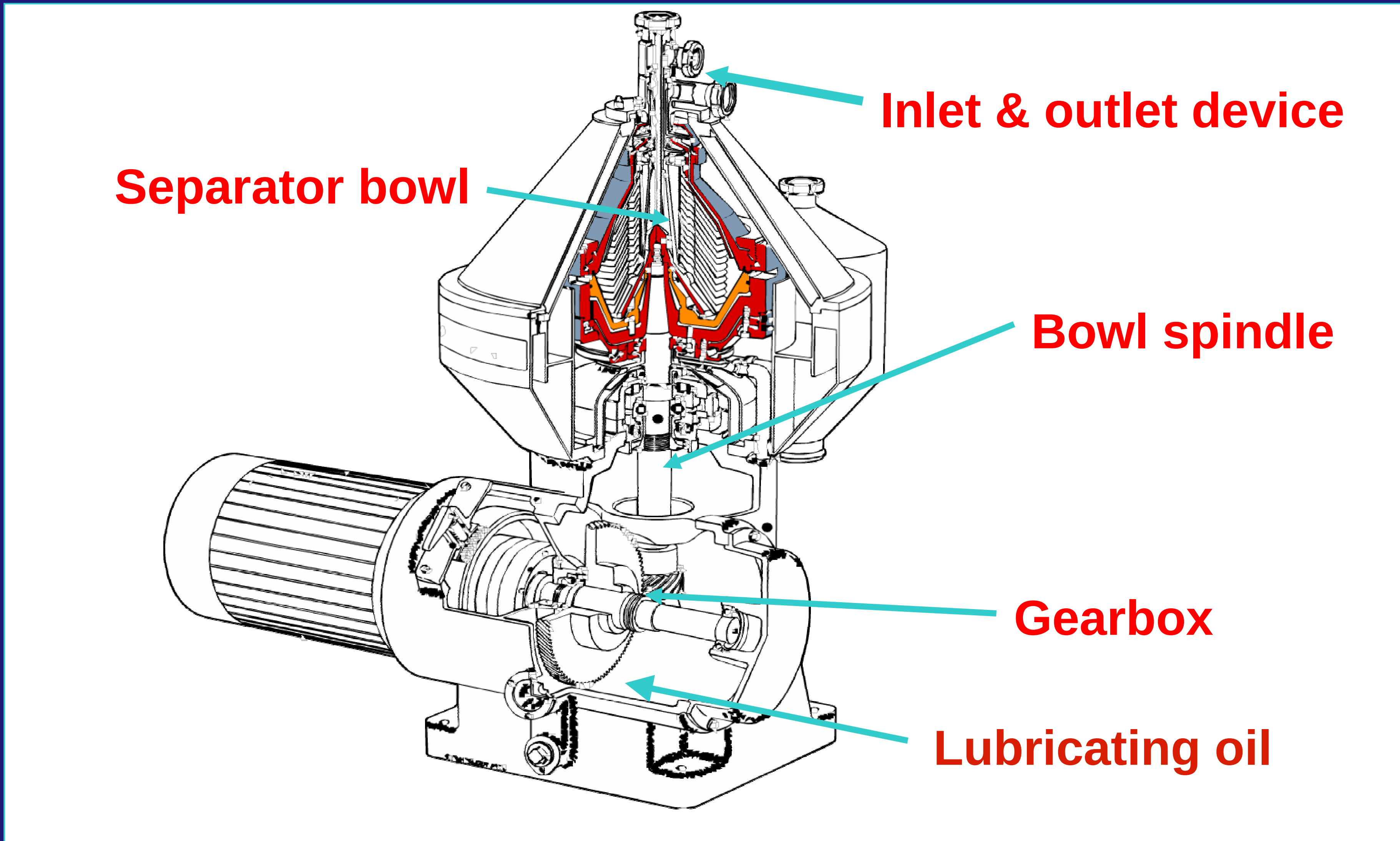
Flow between discs

Disc Stack

- **Caulks**
- **Thickness**
  - **0.4 - 2 mm**
- **Number**
  - **From 30 on small separators to more than 200 on large**



HSS Maintenance



Recommended Maintenance Intervals

- Lubricating oil change every 1500 hours
- Intermediate service every 2000 hours

  - overhaul of bowl and inlet/outlet device
- Major service every 8000 hours

  - overhaul of complete separator

Intermediate Service

- Outlet

  - clean and inspect. Renew o-rings

- Bowl

  – clean and inspect. Check for signs of corrosion or erosion
  Renew o-rings

- Drive system

  – check worm and worm wheel. Renew lubricating oil

- Monitoring equipment

  - check function of vibration and speed sensors

Major Service

- Inlet

  – clean and inspect. Renew o-rings

- Outlet

  - as per Intermediate Service

- Bowl

  - as per Intermediate Service

- Drive system

  - clean and inspect worm, worm wheel and spindle. Renew bearings, rubber buffers, gaskets, o-rings and lubricating oil

Why Planned Maintenance

- Reduced risk of unplanned stops.
- Resource allocation.
- Higher ROI by prolonged service intervals.
- Planned service.
- Pre-ordering of parts.
- Increased service quality by status check after service.
- Increased safety.

Maximize uptime and minimize operating cost !

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