

## II. Leaching (Solid-liquid extraction)

Extraction of a soluble constituent from a solid by means of a solvent.

e.g.: extraction of sugar from beet

There is only one liquid phase; there is no distribution equilibrium.

End of process: equalisation of concentration.

- Aim:
- production of a valuable matter in a concentrated solution or
  - to free an insoluble solid from soluble contamination (e.g.: pigment)

### Parts of the process

1. Dissolution of the solute in the solvent (change of phase)
2. Diffusion of solute through the solvent in the pores to the outside of solid particles
3. Transfer of the solute to the main bulk of the solution

### Factors determining the method of extraction

- Proportion of the soluble constituent
- Its distribution throughout the solid
- Nature of the solid (granulator or cellular)
- Particle size (coarse or fine solid)

If the soluble material is in small isolated packets in a material impermeable to the solvent, the solid must be crushed before the extraction.

e.g.: gold dispersed in rock

Sugar beet has cellular structure. Cell walls impede the extraction of high molecular weight contaminations. Beet is cut in long strips. (The cell walls are not destroyed.)

Extraction of oil from seeds: The solute is liquid, it may diffuse towards the solvent

### Factors influencing the rate of extraction

- Particle size
  - ↳ Greater specific surface area (+)
  - ↳ Smaller distance within the solid (+)
  - ↳ Lower settling velocity
    - ↳ separation sol./liq. is more difficult(-)
    - ↳ particles can be maintained in solution by agitation (+)
- Solvent Requirements:
  - selectivity
  - low viscosity

- Temperature
- Higher T  $\begin{cases} \nearrow \text{higher solubility} \\ \rightarrow D_{AB} \text{ increases} \\ \searrow \text{lower viscosity} \end{cases}$

- Agitation of the fluid
  - It increases the turbulence
  - It prevents the settling of solid particles
  - It promotes mass transfer

### Steps of extraction process

- 1- Dissolving of the soluble material
- 2- Separation of the solution from the insoluble solid residue
- 3- Washing of solid residue

↳ Goals:

- Increase of the recovery
- To free the solid residue from contaminants

## Equipment (for leaching)

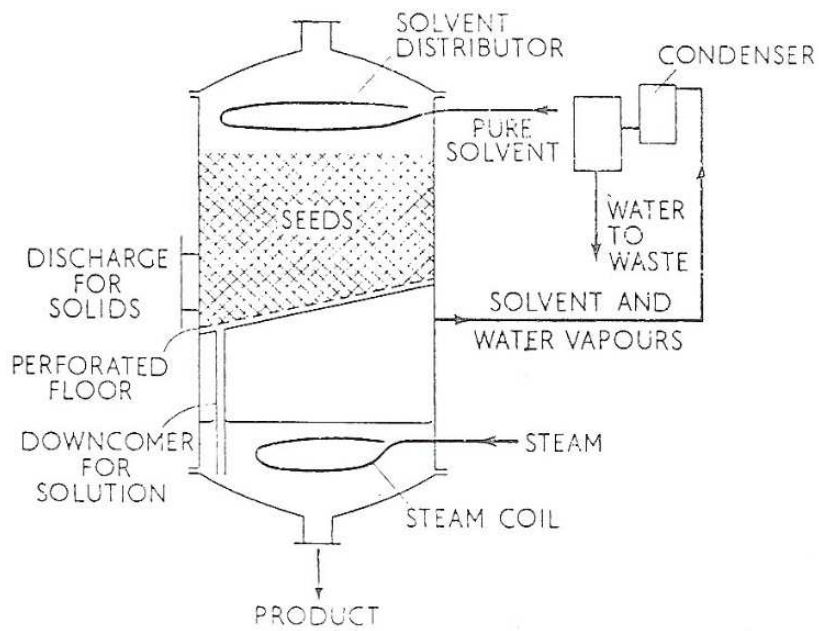
### 1. Extraction from cellular materials

e.g. oil from seeds

#### a. Batch plant for extraction of oil from seeds

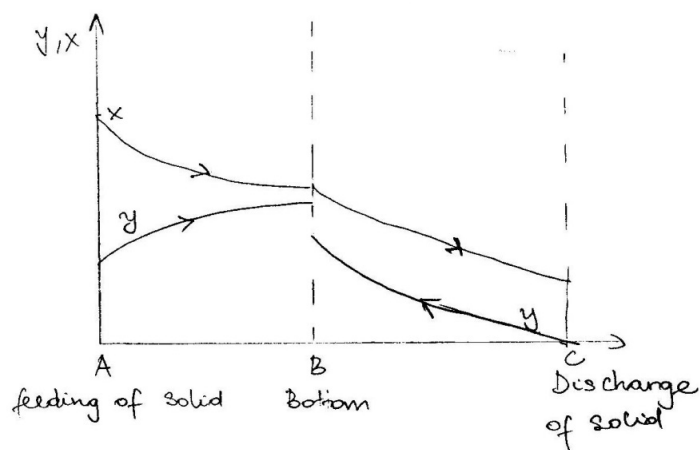
e.g. from soya beans containing only ~15 mass% of oil

- Solvents: light petroleum fraction or trichloro-ethylene or acetone/ether
  - (where fire risk is serious)      (for very wet materials)
- Vertical cylindrical vessel divided into two sections by a slanting partition
  - \* In the upper one: seeds sprayed with fresh solvent
  - \* In the lower one: solvent, oil, water heated by steam



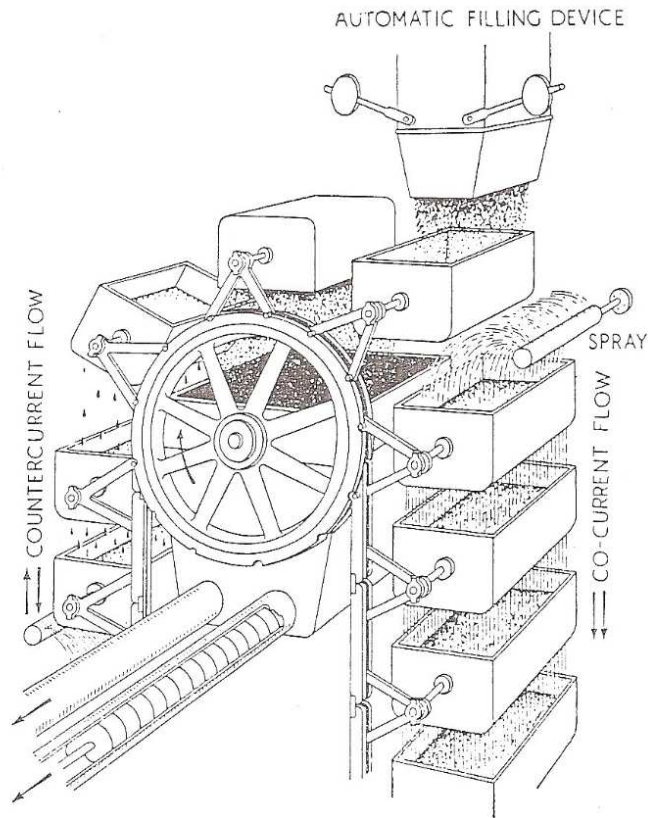
**b. Bollmann extractor**

- Continuous moving bed extractor containing a series of perforated baskets arranged as in a bucket elevator in a vapour-tight vessel
- At the left hand side (between C and B): counter-current extraction: the "half miscella" is pumped to the top of the right hand side (RHS)
- At the RHS (between A and B): co-current extraction: the final extract is the "miscella" (containing oil of ~25%)



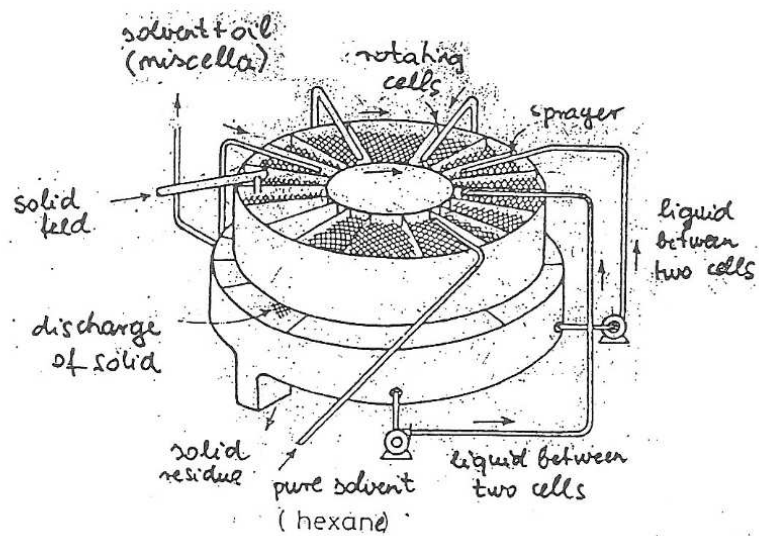
Concentration profile.

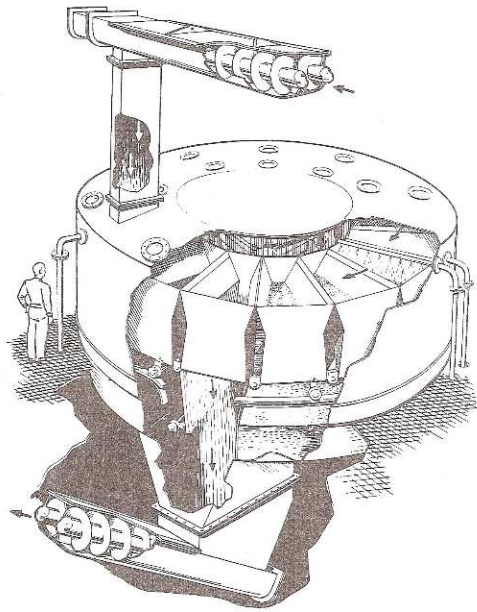
Concentration profile



c. Rotocel extractor

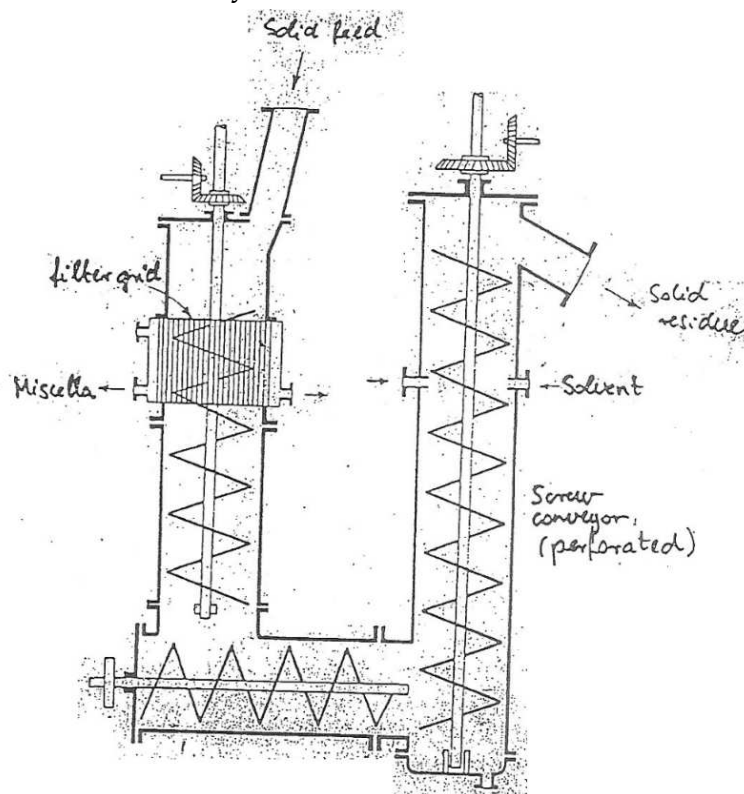
- Two parts divided into cells
  - \* The upper one is rotated, it transports the drug.
  - \* The lower one is stationary, the solvent flows down in it.
- From the lower part the solvent is pumped onto a cell containing drug less extracted (by a pump and a distributor)
- Counter-current system: the drug meets the most concentrated solvent.





#### d. Hildebrandt extractor

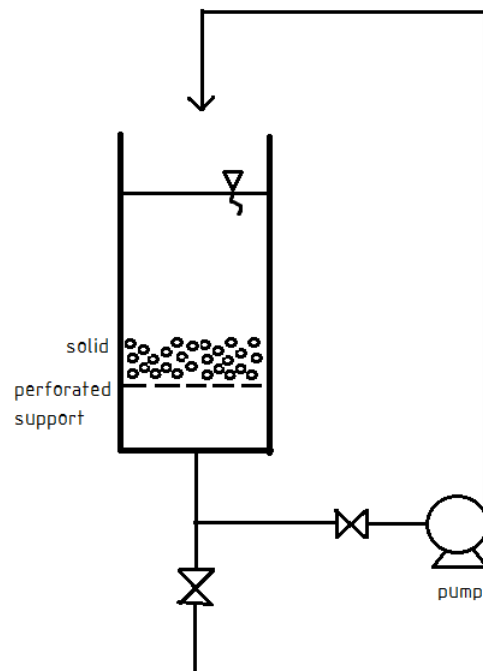
- Pipes in form of U
- Solid is transported by perforated screw conveyors having different speed of revolution → solid is accumulated in the horizontal part
- Inside the pipes, special guide rails for preventing the rotation of the solid during its transportation
- From the filter grid, the screw conveyor scrapes off the solid
- Counter-current system



## 2. Extraction of coarse solids

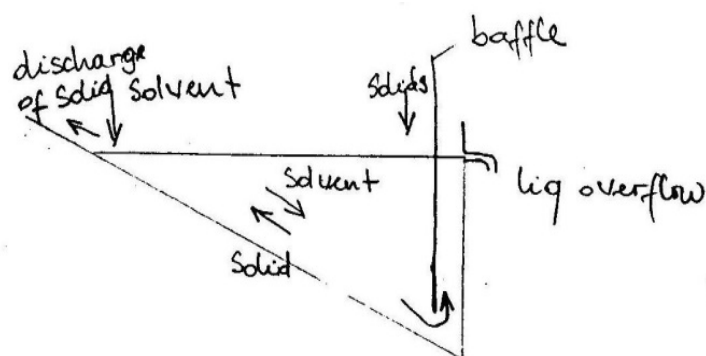
### a. Simple batch equipment

- The solvent is circulated with a pump
- The solid particles can disintegrate if a large quantity of solute is extracted. In this case the solid is treated with solvent in a tank and the solution is decanted.



### b. Dorr classifier

- Sloping tank
- The solid is gradually moved up with a rake
- The solvent flows into the opposite direction to the solid



### c. Simple counter-current system

The solid is contained in a number of tanks, the solvent flows through each in turn. The 1<sup>st</sup> vessel contains solid almost extracted, the last fresh solid. After a time the 1<sup>st</sup> tank is disconnected and a fresh charge is introduced at the far end of the battery. The solvent is generally heated before it enters each tank.

- Problems: - frequent interruption  
- no counter-current flow within the units themselves

## 3. Leaching of fine solids

$d < 0,075$  mm

In the case of fine solids, the solvent cannot pass through a bed of the material because of its high resistance.

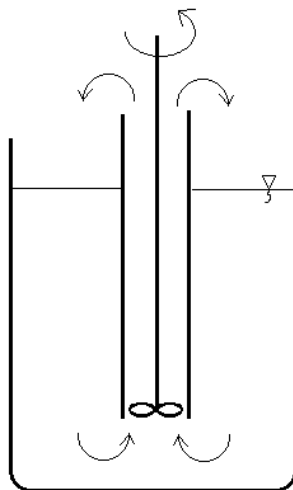
These particles

- can be maintained in suspension with slight agitation.
- provide large surface for mass transfer
- have low settling velocity → more difficult separation and washing operation

Agitation can be made by a mechanical stirrer or by compressed air

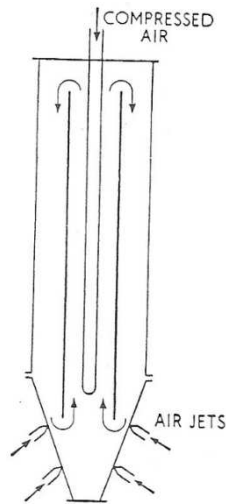
### a. Simple stirred tank

- Stirrer inside a central tube
- The liquid is lifted upwards through the tube, it discharges at the top and flows downwards outside the tube
- Continuous circulation



### b. Pachuca tank

- Stirring by compressed air
- Cylindrical tank with conical bottom
- A central pipe connected to an air supply acts as an air lift.
- Additional air jets at the bottom are applied for dislodging any material that settles out.



### c. Dorr agitator

- Stirring by compressed air
- It is a cylindrical flat-bottomed tank fitted with a central air-lift inside a hollow shaft rotating slowly.
- Rakes fitted to the bottom of the shaft drag the solid to the centre of the equipment as it settles and the solid is picked up by the air lift.
- At the top a perforated launder distributes the suspension evenly over the surface of the liquid.
- It can be used for both batch and continuous operation. In the latter case entry and delivery points are located at the opposite sides of the tank.

