X. DE-WATERING

The removal of water from solid, either partially or completely, comes under the unit operation, `Solid-Liquid Separation' which forms an integral part of several mineral processing and hydro-metallurgical processes. In recent years the importance of solid-liquid separation techniques have gained considerable importance in order to reduce the load on thermal dryers which are highly energy intensive and also for environmental protection. The economics of coal utilisation, large scale mineral processing and water treatment operations are critically dependent on the solid-liquid separation technology since any improvement in product moisture reduction techniques can result in significant cost saving.

The term, `De-watering' in solid-liquid separation is used to define two different operations:

(a) The reduction of slurry volume and production of semi-dried solid which are most commonly achieved through sedimentation. In this case separation is affected by exploiting earth's gravitational field (thickener) or centrifugal field (centrifuge or hydro-cyclone).

(b) The slurry is subsequently de-watered through filtration in which separation of solids from liquid is achieved by passing the slurry through a filtering medium on which solids build up forming cake.

Various models, such as those of Richardson & Zaki, Michaels & Bolger, Rober as well as Kynch etc. are described in the literature to understand the sedimentation kinetics. Basically the whole of settling cycle can be divided into two zones: (a) constant (or maximum) settling rate, and (b) falling rate period.

To understand the phenomenon of de-watering, it is important to define how the moisture could be associated with the solid system. Usually the moisture retention property of a solid system is influenced by the inter-particular geometry, inherent physical flaws in the solid structure, and porosity of the solid itself. For an ideal spherical particulate network moisture could be present in three distinct forms: (i) capillary, (ii) funicular, and (iii) pendular. In filtration process capillary water is partially removed, while pendular and surface water are removed by centrifugation or thermal drying. The process of filtration is often explained in terms of capillary theory which treats the pore system in a filter cake as a bundle of capillaries of changing diameters. The displacement of liquid phase will be in a tortuous way along the capillaries: the capillary with the widest diameter will de-water first after overcoming a certain pressure difference. On further increase of differential pressure the narrower capillaries will de-water subsequently.

The kinetics of de-watering can be interpreted in terms of the theory of flow through porous media and Darcy's law holds good according to which the volume flow rate (U) through a packed bed of unit area is given by:

$$U = (K * \Delta P)/(\mu * L) \qquad \text{..........................(14)}$$

where,

ΔP is the pressure difference across the filter cake having thickness L

K = permeability of the (cake) bed
m = the fluid viscosity

The conventionally available de-watering techniques are not sufficient for treating very fine particles (-325 mesh size) due to associated problems. Hence there is an increasing need to develop improved de-watering techniques. Use of flocculants and surfactants in the de-watering process has been successful in achieving this end to a considerable extent in recent years.

Filtration of fine particles has always been a difficult area of mineral beneficiation as well as coal preparation and has attracted much of R & D effort throughout the world. Traditionally de-watering of fine particles has been carried out using rotary vacuum filters, usually drum or disk filters. During recent years a variety of pressure filters such as (a) air blown filter press and (b) tube press have been developed. Extensive field trials have shown that pressure filter can reduce free moisture down to very low level. However, the widespread adoption of this equipment has been slow because of relatively high capital costs involved. Current R & D is focused on the development of a potentially low cost system, based on the use of an ultra- high speed centrifuge.

R & D effort has been made towards the use of (a) flocculants - chemical (organic) based and more recently bacteria based, and (b) surfactants as de-watering aids. Flocculants are usually linear, long chain, water-soluble polymers based on polyacrylamide. These increase the yield of filtered solid and produce a permeable filter cake amenable to rapid de-watering. In this case, the long chain polymers bridge between individual particles, to produce multi-particle aggregates. Surfactants typically consist of hydrophilic and hydrophobic grouping. Although surfactant enhanced de-watering is of technical and economic importance, the fundamental surface chemical phenomena which decide their mode of action are not fully understood. It is generally believed that these allow filter cake capillaries to drain more rapidly by reducing the surface tension, and thus reduces moisture content of the cake.