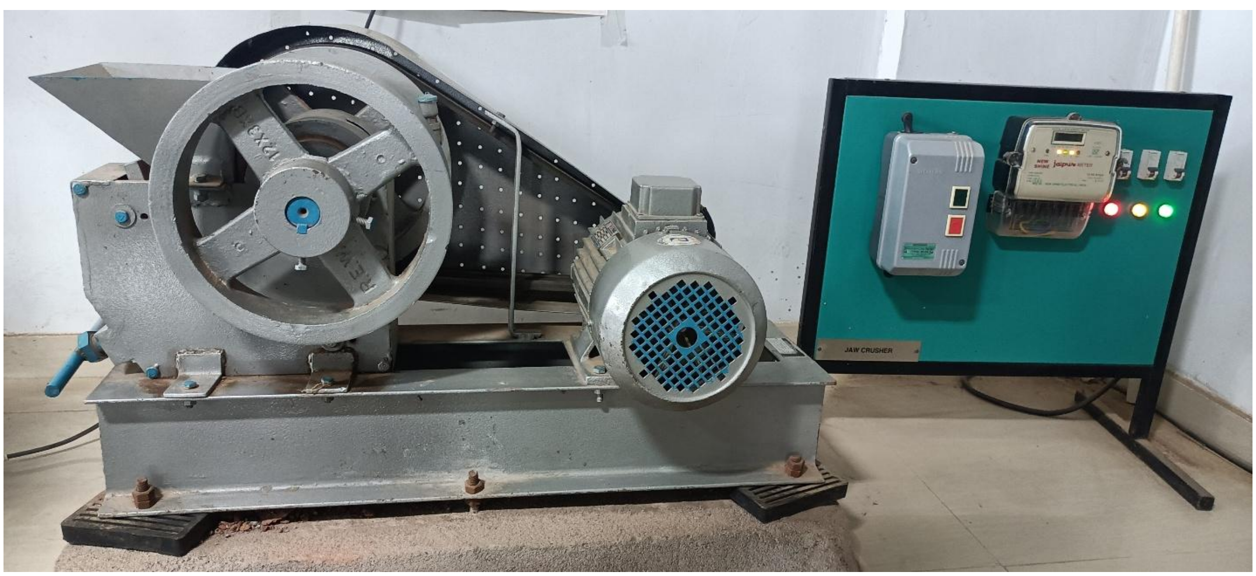
EXPERIMENT:- Jaw Crusher



AIM- To determine rittinger'sconstant,Bond's Constant and Kick's Constant.

APPARATUS:

Jaw Crusher, Sieve Shaker, Sieves, Weighing Balance, Weight Box.

THEORY:

The Crusher has a fixed jaw and a moving jaw pivoted at the top with the crushing faces themselves formed of manganese steel. Since the maximum movement of the jaw is at the bottom, there will be little tendency for the machine to clog, though some uncrushed material may fall through and have to be returned to the crusher. Further, the maximum pressure will be exerted on the large material which is introduced at the top. The machine is usually protected so that it is not damaged if lumps of metal invariantly enter, by making one of the toggle plates in the driving mechanism relatively weak so that, if any large stresses are set up, this is the first part to fail. Easy renewal of the damaged part is then possible.

Jaw Crushers are made with jaw widths varying from about 150 mm to 1.0 mm and the running speed is about 240 rpm, the smaller machines running at the higher speeds. The speed of operation should not be so high that a large quantity of fines is produced as a result of material being repeatedly crushed because it cannot escape sufficiently quickly. The angle of nip, the angle between the jaws, is usually about 30°.

Because the crushing action is intermittent, the loading on the machine is uneven and the crusher therefore incorporates a heavy flywheel. The power requirements of the crusher depend upon the size and capacity.

The Volume Surface Mean Diameter Ds:

$$Ds = 1/ (Z\ (xi/Dpi))$$

Rittinger's Law;

A crushing law proposed by Rittinger in 1867 states that the work required in crushing is proportional to the new surface created. This law can be written as

$$W = P/M = K_r * (1/Ds2 - 1/Ds1)$$

Where,

W-Energy input.

P=Power required by machine,

M= feed rate,

Kr=Rittinger's constant,

Ds1 & Ds2= Volume surface mean diameter before and after crushing

Kick's Law:

In 1885 Kick proposed another law, which states that the work required for crushing a given mass of material is constant for the same reduction ratio, that is the ratio of the Volume surface mean diameter before and after crushing.

$$W = P/m = K_k * \ln (Ds1/Ds2)$$

Where,

K_1 = Kick's constant

Bond's Crushing Law:

A somewhat more realistic method of estimating the power required for crushing and grinding was proposed by Bond in 1952. Bond postulated that the work required to form particles of size Dp from very large feed is proportion to the square root of the surface to-volume ratio of the product, Sp/Vp.

But,

$$= 6Vp/ (Dp*Sp)$$

Where

=sphericity of the particles

So,

$$P/m = Kb/\sqrt{Dp}$$

WORK INDEX:

Work Index, Wi is defined as the gross energy requirement in kilowatt-hours per ton of feed needed to reduce a very large feed to such a size that 80% of the product passes

a 100 m screen. This relation leads to a relation between Kb and Wi. If Dp is in milimeters P in kilowatts, and m in tons per hour

$$Kb (\sqrt{100*10^{-3}})Wi=0.3102\ Wi$$

If 80% of the feed passes a mesh size of Dp1 millimeters and 80% of the product a mesh of Dp2 millimeters, then

$$P/m\ 0.3162\ Wi(1/\sqrt{Dp2}-\sqrt{Dp1})$$

The work index includes the friction in the crusher and the power given by above eq is gross power

PROCEDURE:

- Start the jaw crusher and find the power consumption under no load condition with the help of energy meter and a stop watch.
- Prepare the sample you want to crush in the jaw crusher.
- Feed the above sample of coal to a jaw crusher and crush it. Measure the time for crushing.
- Take different sieves and perform sieve analysis of the product from the jaw crusher.
- Weigh the material in each size of sieve.

WORKING:

The removable jaw hits two blow every revolution thus reducing over size to minimum. A combination of forward and downward stroke with sufficient stroking action exerts pressure on the coarse material. Yet permits the finished material to pass down through the steel jaws. A convenient hand wheel provides an easy means of adjusting the jaw opening without the use of a wrench or shims. Smooth jaws insure a more uniform product and easy cleaning.

OBSERVATION

1. Feed mass =
2. Crushing time. =
3. Energy Consumed during Crushing Time. =
4. Energy Consumption for Empty Run. =
5. Energy Consumption for Crushing Period. =
6. Additional Energy used for Crushing of Material =

OBSERVATION TABLE

Mesh no.	Screen aperture	Mean dia. Dpi, mm	Mass Retained gm	Mass fraction Retained, Xi	Xi/Dpi
4	4.699	-			
6	3.327	4.013			
8	2.362	2.8445			
10	1.651	2.0065			
14	1.168	1.4095			
20	0.833	1.005			
28	0.589	0.711			
35	0.417	0.503			
48	0.295	0.356			
65	0.208	0.2515			
100	0.147	0.1775			
150	0.104	0.1255			
200	0.074	0.089			
pan					

SEIVE SHAKER

EXEPERIMENT:SIEVE SHAKER

Aim:

To determine and compare the different mean diameter of particles in given sample by differential as well as cumulative analysis.

Equipment and Material:

Sieve shaker, balance, sand /gravel/or their mixture

Theory:

Sieves are used industrially on large scale for the separation of particles according to their size, for the small scale production of closely ground material and for carrying out size analysis. Generally woven wire cloth is used for the size analysis of very small particles.

Procedure:

Take the feed sample and weigh it.

Arrange the sieves in order of the mesh no.

Place the sample on the top screen and start the operation for 10 minutes.

Weigh the particles on each screen and note it down.

Data:

1. Weight of feed = gm
2. Screening time = minutes
3. Shape factor,a = 0.95
4. Particle density C = gm/cm^3
5. For rounded sand = 0.83
6. Particle density Pp = 1.5 Gm/cm^3

OBSERVATION TABLE:

Sr. No	Mesh No	Mass retained	Screen opening Dpi Mm	Average diameter	Mass fraction (xi)	ΣXi/Dpi

Calculations:

1. Specific surface area

Aw = (6/Qs Pp) Σ(x/Dp,)

=

=

2. Mass mean diameter

Dw = Σx, Dp;

=

=

3. Volume surface mean diameter

Ds=1/Σ(x,/Dpi)

=

=

4. Number of particles

Nw = (1/ a pp) Σ(x// Dp^3)

=

=

5. Arithmetic Mean diameter

$DN = \Sigma(x, Dp,/NT)$

=

6. Volume Mean diameter

$Dv = [1/\Sigma(x,/Dp,^3)]1/3$

=

=

Graph:

For cumulative analysis:

X; Vs Dp

X, Vs 1/D x Vs 1/D

X Vs 1/Dp

Result:

Sr. No	Differential analysis	Cumulative Analysis
Sp. Surface Area		
Arithmetic Mean diameter		
Volume Surface Mean Diameter		
Mass Mean diameter		
Volume Mean diameter		
No. Of Particles		

Conclusion:

EXPERIMENT: BELT CONVEYOR

THEORY

A conveyor belt is the carrying medium of a belt conveyor system (often shortened to belt conveyor. A belt conveyor system is one of many types of conveyor systems. A belt conveyor system consists of two or more pulleys (sometimes referred to as drums), with an endless loop of carrying medium-the conveyor belt-that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward The powered pulley is called the drive pulley while the unpowered pulley is called the idler pulley There are two main industrial classes of belt conveyors Those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport large volumes of resources and agricultural materials such as grain, salt, coal, ore sand overburden and more

Today there are different types of conveyor belts that have been created for conveying different kinds of material available in PVC and rubber materials.

The belt consists of one or more layers of material. Many belts in general material handing have two layers An under layer of material to provide linear strength and shape called a carcass and an over layer called the cover. The carcass is often a woven fabric having a warp & weft. The most common carcass materials are polyester, nylon and cotton. The cover is often various rubber or plastic compounds specified by use of the belt Covers can be made from more exotic materials for unusual applications such as silicone for heat or gum rubber when traction is essential

Material flowing over the belt may be weighed in transit using a beltweigher. Belts with regularly spaced partitions known as elevator belts are used for transporting loose materials up steep inclines Belt Conveyors are used in self-unloading bulk freighters and in live bottom trucks. Belt conveyor technology is also used in conveyor transport such as moving sidewalks or escalators, as well as on many manufacturing assembly lines: Stores often have conveyor belts at the check-out counter to move shopping items Ski areas also use conveyor belts to transport skiers up the hill.

1. AIM:

To determine the energy consumption of belt conveyor with varying speed at load condition, unload condition.

2. REQUIREMENT:

- Dry sand -5 Kg

3. PROCEDURE:

- Feed the hopper with the required quantity of the sand.
- Put the collecting bin in the right position for collection of the discharge sand.
- Plug in the socket and switch on the main switch.
- Run the machine for the sometime to maintain a steady speed.
- Open the discharge plate so that sand can fall on the belt.
- Measure the weight with respect with the time.

OBSERVATION TABLE:

Sr no.	Energy Consumed KWH	Weight of Sand Collected Kg	Time Sec	Sand discharge flow rate. Kg/Hr

RESULT:

EXPERIMENT: RIBBON BLENDER

AIM: To plot the mixing index vs. mixing time curve for Ribbon Blender.

APPARATUS: Ribbon Blender.

THEORY:

It consists of a horizontal trough container having a central shaft and a helical agitator. Two counteracting ribbons are mounted on the same shaft, one moving the solid in the one direction slowly while other moving it quickly in the other. The ribbon may be continuous or interrupted. Mixing results from the turbulence induced by the counter acting agitators. Ribbon Blenders can be operated in batch or continuous manner. The effectiveness of the solid mixing equipments when both are powder is measured by statistical procedure. In the procedure various spot sample are taken at ramose from the mixture and are analyzed. The mixing index is then calculated as shown in

Is-oe/sup(1-up)(N-1))/(n(xi-x)2)

The mixing time for a given mixing index can be calculated as follows:

t-l/k In(1-1/Vn)/(1-1s)

where n-Number of particles in a given spot

Is-mixing index

T-time of mixing

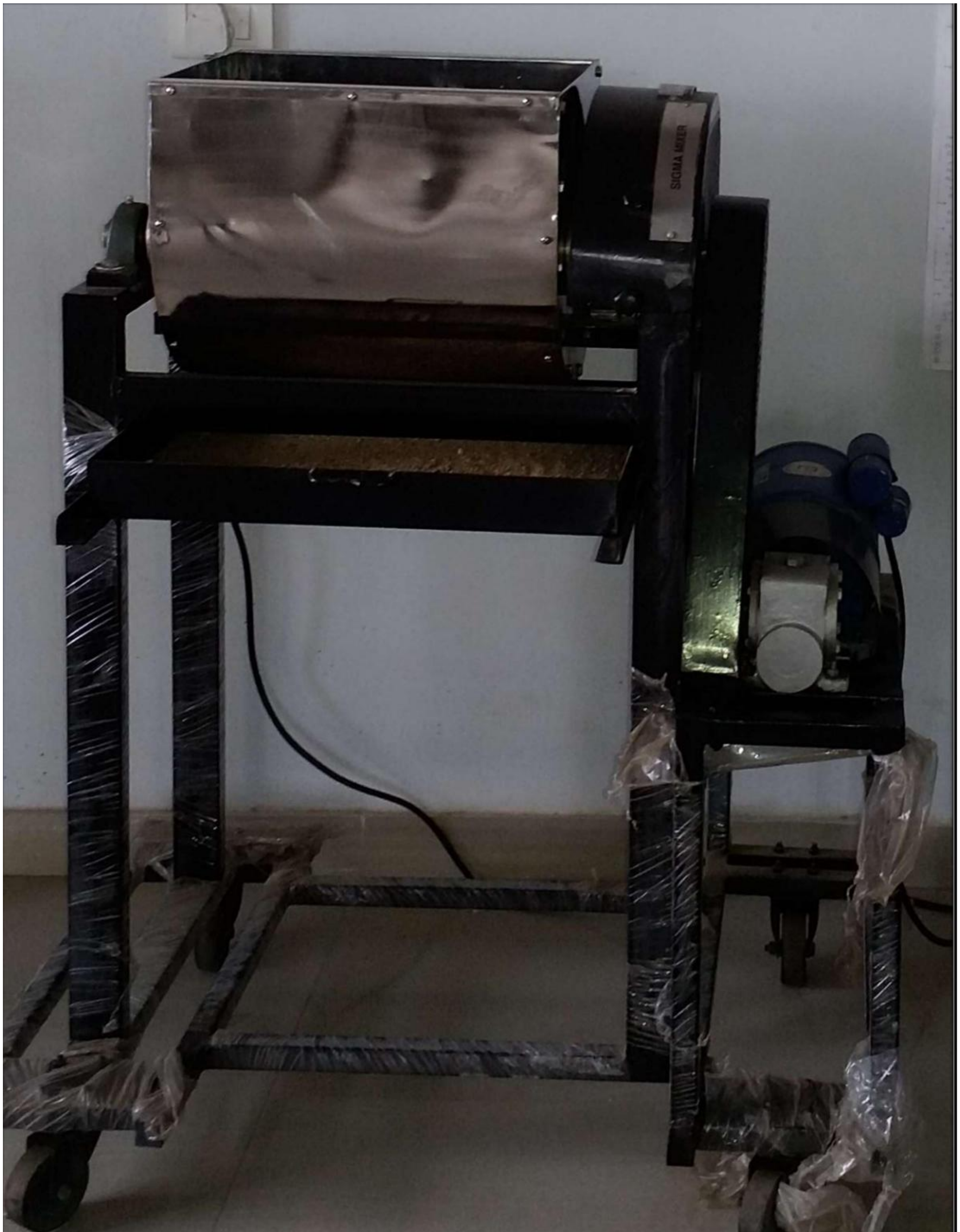
PROCEDURE

Take approximate 500 gms fine brick sample of certain mesh size which different from that of sand which is to be used. Take approximately 500 gms sand of particle size charge them in the ribbon blender. Ruin the blender for 5 minutes and take 10 samples at random. Run the blender and similarly take sample every five minutes. Plot mixing index vs. mixing time curve.

OBSERVATION:

Sr. No.	**Wt. Of Sand W (gm)**	**Wt. of Brick W (gm)**	**Concentration $W_a(W_a+W_b)$**	**Time**

CONCLUSION:



SIGMA MIXER

EXPERIMENT : SIGMA MIXER

AIM: To plot the mixing index vs. time curve SIGMA MIXER

APPARATUS: SIGMA MIXER

THEORY:

It consists of a hotzontal trough container having a central seat and a heal agitator. Two counteracting ribbons are mounted on the same shalt one moving the solid in the one direction slowly while other moving it quickly in the other. The ribbon may be continuous or interrupted. Moxing results from the turbulence induced by the counter acting agitatoes SIGMA MDCERS can be operated in batch or continuous manner. The effectiveness of the solid mixing equipments when both are powder is measured by statistical procedure. In the procedure various spot sample are taken at ramose from the MIXER and are analyzed. The mixing index is then calculated as shown in

$$Is=\sigma e/s=\sqrt{(up(1-Hp)\ (N-1))/(n(xi-x)2)}$$

The mixing time for a given mixing index can be calculated as follows

$$t-l/k\ In(1-1/n)/(1-1s)$$

where n-Number of particles in a given spot

Is = mixing index

T=time of mixing

PROCEDURE

Take approximate 900 gms fine brick sample of certain mesh size which different from that of sand which is to be used. Take approximately 100 y sand of particle size charge them in the SIGMA MIXER Rain the blender for 5 minutes and take 10 samples at random. Run the Blender and similarly take sample every five minutes Plot mixing index Vs mixing time curve

OBSERVATION

Sr. No.	Wt. of Sand W, (gm)	WL of Brick W (gm)	Concentration $W_a(w_a+w_b)$	Time

CONCLUSION:

EXPERIMENT:- BASKET CENTRIFUGE

AIM: To perform the operational characteristics of Top Driven Centrifuge.

APPARATUS: Top driven Centrifuge, Measuring Cylinders.

THEORY:

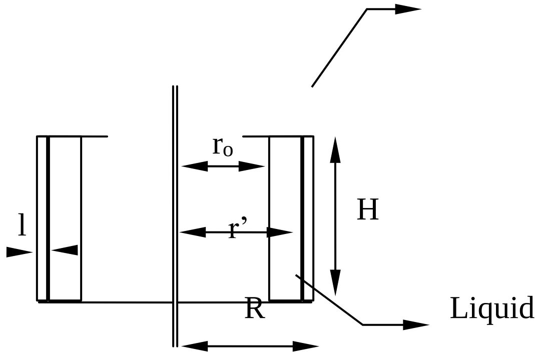
Centrifuges for the separation of solids from liquids are of two general types:

(1) Sedimenting centrifuges, which require a difference in density of the two phases (solid-liquid or liquid-liquid) and

(2) Filtering centrifuges (for solid-liquid separation), in which the solid phase is retained by the filter medium through which the liquid phase is free to pass.

When filtration is carried out in a centrifuge, it is necessary to use a perforate bowl to permit the removal of the filtrate. The driving force is the centrifugal pressure due to the liquid and suspended solids, and will not be affected by the presence of solid particles deposited on the walls. The resulting force must overcome friction caused by the flow of liquid through the filter cake, the cloth, and the supporting gauge and perforations. The resistance of the filter cake will increase as solids are deposited but the other resistances will remain approximately constant throughout the process. Considering filtration in a bowl of radius R an supposing that the suspension is introduced at such a rate that the inner radius of the liquid surface remains constant, then at some time t after the commencement of filtration, a filter cake of thickness l will have been built up and the radius of the interface between the cake and the suspension will be r'.

Filter Cake



GENERALPRINCIPLES

Centripetal and Centrifugal Acceleration. A centripetal body force is required to sustain a body of mass moving along a curve trajectory. The force acts perpendicular to the direction of motion and is directed radially inward. The centripetal acceleration, which follows the same direction as the force, is given by the kinematic relationship:

where *V*q is the tangential velocity at a given point on the trajectory and *r* is the radius of curvature at that point. This analysis holds for the motion of a body in an inertial reference frame, for example, a stationary laboratory. It is most desirable to consider the process in a centrifuge, and the dynamics associated with such, in a noninertial reference frame such as in a frame rotating at the same angular speed as the centrifuge. Here, additional forces and accelerations arise, some of which are absent in the inertial frame. Analogous to centripetal acceleration, an observer in the rotating frame experiences a centrifugal acceleration directed radially outward from the axis of rotation with magnitude:

a = W2r (18-76)

where W is the angular speed of the rotating frame and *r* is the radius from the axis of rotation.

Solid-Body Rotation When a body of fluid rotates in a solid body mode, the tangential or circumferential velocity is linearly proportional to radius: as with a system of particles in a rigid body. Under this condition, the magnitude of the centripetal acceleration equals that of the centrifugal acceleration despite the fact that these accelerations are considered in two different reference frames. Hereafter, the rotating frame attached to the centrifuge is adopted. Therefore, centrifugal acceleration is exclusively used. G-Level Centrifugal acceleration *G* is measured in multiples of earth gravity *g:*

With the speed of the centrifuge W in r/min and *D* the diameter of the bowl,

= 0.000559W2*D, D*(*m*) (18-79)

With *D* in inches, the constant in is 0.0000142.

G can be as low as 100*g* for slow-speed, large basket units to as much as 10,000*g*

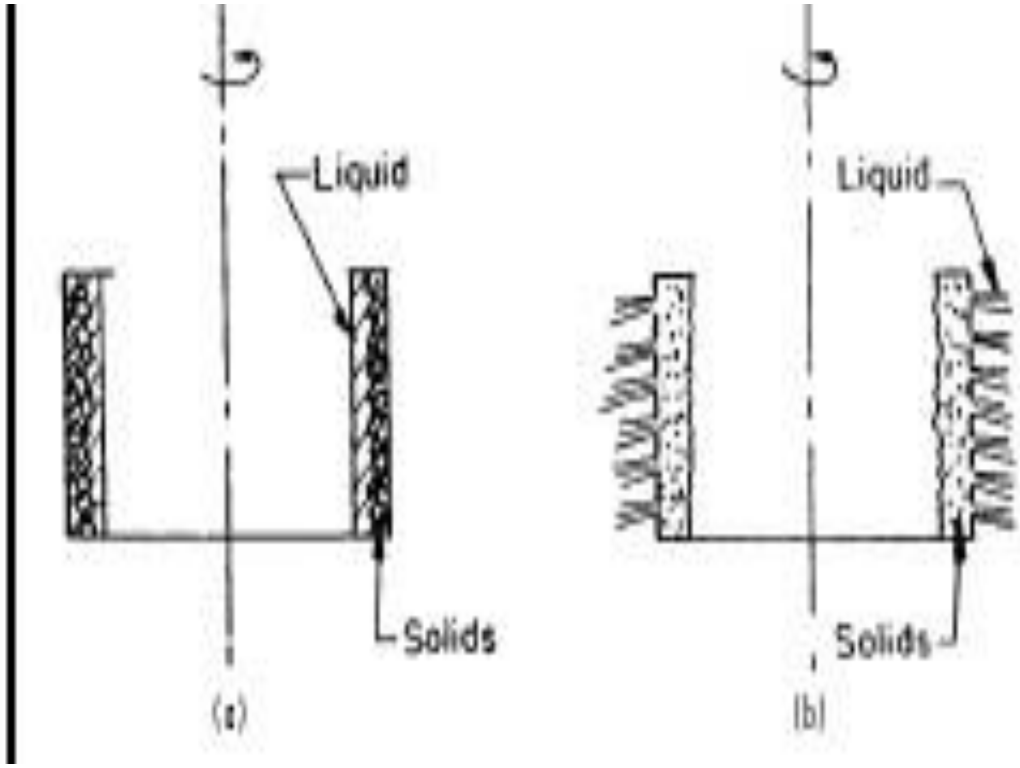
For high-speed, small decanter centrifuges and 15,000*g* for disk centrifuges.

Because *G* is usually very much greater than *g,* the effect due to earth's gravity is negligible. In analytical ultracentrifuges used to process small samples, *G* can be as much as 500,000*g* to effectively Separate two phases with very small density difference.

Principles of centrifugal separation and filtration:

(a) Sedimentation in rotating imperforate bowl

(b) Filtration in rotating perforate basket.



PROCEDURE:

1. Initially check the equipment without load.
2. Check the filter cloth, drain valve properly.
3. Prepare 30 - 50% slurry of $CaCO_3$ as feed material for centrifuge.
4. Start the motor for centrifuging & add slurry in centrifuge parrrrrtly. Also note down the time.
5. Collect the filtrate at regular interval of time and note down the readings in observation table.
6. As all the filtrate is come out stop the motor.
7. Using the brake stop the machine completely.
8. Take out the cake and weight the cake from centrifuge

PRECAUTION TAKEN FOR OPERATION:

1. DO NOT RUN THE EQUIPMENT FOR LONG TIME WITHOUT LOAD.
2. CLEAN IMMIDIATELY THE EQUIPMENT AFTER OPERATION OTHERWISE THE CLOTH WILL BE CLOOGED.

OBSERVATION:

1. Inner Radius of the Basket =

2. Outer Radius of the Basket =

3. Height of the Basket =

OBSERVATION TABLE:

Sr. No.	Filtrate collected , V (liter)	Time , t (sec)	Δt (sec)	$\Delta t / \Delta V$	Avg. Vol collected V (liter per minute)

CALCULATIONS:

(1) % Moisture in Cake = [W_1 - W_2] * 100 %

Where, W_2 = Final Wt. Of Cake after 45 min. drying.

W_1 = Initial Wt. Of cake

(2)Filtering velocity per unit time = Filtrate Collected / Time during collection

RESULT:

From above observation table

1. Top driven centrifuge is working satisfactorily.
2. Cake & Filtrate is obtained clearly.
3. During operation filtrate collected volume per time is reduced due to cake formation or cake resistance.


ET-2-28 BALLMILL ET-2-28 BALLMILL ET-2-28 BALLMILL
MAIN SWITCH
MOTOR SWITCH
MAIN ON
MOTOR ON
ENERGY METER
MFG BY :- MODERN INDUSTRIAL CORPORATION MUMBAI

EXPERIMENT: BALL MILL

THEORY:

In its simplest form, the Ball Mill consists of a rotating hollow cylinder, partially filled with balls, with its axis either horizontal or at a small angel to te horizontal. The material to be ground may be fed in through a hollow trunnion at one end and the product leaves through a similar trunnion at the other end for continuous type operation. The outlet is normally covered with a coarse screen to prevent the escape of the balls.

The inner surface of the cylinder is usually lined with an abrasion-resistant material such as manganese steel, stoneware or rubber. Less wear takes place in rubber-lined mills, and the coefficient of friction between the balls and the cylinder is greater than with steel or stoneware linings. The balls are therefore carried further in contact with the cylinder and thus drop on to the feed from a greater height. In some cases, lifter bars are fitted to the inside of the cylinder. A new type of ball mill is now being used to a increasing extent, where the mill is vibrated instead of being rotated, and the rate of passage of material is controlled by the slope of the mill.

The ball mill is used for the grinding of a wide range of materials, including coal, pigments, and felspar for pottery, and will take feed up to about 50 mm in size. The efficiency of grinding increases with the hold-up in the mill, until the voids between the balls are filled. Further increase in the quantity then lowers the efficiency again.

The balls are usually made of flint or steel and occupy between 30 and 50 per cent of the volume of the mill. The diameter of ball used will vary between 13 mm and 125 mm and the optimum diameter is approximately proportional to the square root of the size of the feed, the proportionality constant being a function of the nature of the material.

During grinding, the balls themselves wear and are constantly replaced by new ones so that the mill contains ball of various ages, and hence of various sizes. This is advantageous since the large balls deal effectively with the feed and the small ones are responsible for giving a fine product. The maximum rate of wear of steel balls, using very abrasive materials, is about 0.3 kg per mg of material for dry grinding, and 1-1.5 kg/mg for wet grinding. The normal charge of balls amounts to about 5 mg/m^3. In small mills where very fine grinding is required, pebbles are often used in place of balls.

In the compound mill, the cylinder is divided into a number of compartments by vertical perforated plates. The material flows axially along the mill and can pass from one compartment to the next only when its size has been reduced to less than that of the perforations in the plate. Each compartment is supplied with balls of a different size; the large balls are at the entry end and thus operate on the feed material, whilst the small balls come into contact with the material immediately before it is discharged. This results in economical operation and the formation of a uniform product. It also gives an improved residence time distribution for the material, since a single ball mill approximates closely to a completely mixed system.

Factors influencing the size of the product

(a) The rate of feed. With high rates of feed, less size reduction is effected since the material is in the mill for a shorter time.

(b) The properties of the feed material. The larger the feed the larger will be the product under given operating conditions. A smaller size reduction is obtained with a hard material.

(c) Weight of balls. A heavy charge of balls produces a fine product. The weight of the charge can be increased, either by increasing the number of balls, or by using a material of higher density. Since optimum grinding conditions are usually obtained when the bulk volume of the balls is equal to 50 per cent of the volume of the mill, variation of the weight of balls is normally effected by the use of materials of different densities.

(d) The diameter of the balls. Small balls facilitate the production of fine material but they do not deal so effectively with the larger particles in the feed. The limiting size reduction obtained with a given size of balls is known as the free grinding limit. For most economical operation, the smallest possible balls should be used.

(e) The slope of the mill. Increase in the slope of the mill increases the capacity of the plant because the retention time is reduced, but a coarser product is obtained.

(f) Discharge freedom. Increasing the freedom of discharge of the product has the same effect as increasing the slope. In some mills, the product is discharged through openings in the lining.

(g) The speed of rotation of the mill. At low speed of rotation, the balls simply roll over one another and little crushing action is obtained. At slightly higher speeds, they are projected short distances across the mill, and at still higher speeds they are thrown greater distances and considerable wear of the lining of the mill takes place. At very high speeds, the balls are carried right round in contact with the sides of the mill and little relative movement of grinding takes place again. The minimum speed at which the balls are carried round in this manner is called the critical speed of the mill and, under these conditions, there will be no resultant force acting on the ball when it is situated in contact with the lining of the mill in the uppermost position, that is the centrifugal force will be exactly equal to the weight of the ball. If the mill is rotating at critical angular velocity (ω_C),

$$r\,\omega_C^2 = g$$

$$\omega_C = \sqrt{g/r}$$

The corresponding critical rotational speed $N_c = \omega_C / (2 * \pi) = [1/(2 * \pi)] * \sqrt{(g / r)}$

Here r is the radius of the mill less than that of the particle. It is found that the optimum speed is between one-half and three-quarters of the critical speed.

(h) The level of material in the mill. Power consumption is reduced by maintaining a low level of material in the mill, and this can be controlled most satisfactorily by fitting a suitable discharge opening for the product. If the level of material is raised, the cushioning action is increased and power is wasted by the production of an excessive quantity of undersize material.

BALL MILL

EXPERIMENTAL MANUAL

PROCEDURE:

- Measure the diameter of the mill and the balls to be utilized.
- Take the given sample of feed balls and fill the balls in the mill.
- Turn the ball for 15 – 20 minutes and then take out the product.
- Take the product and perform its sieve analysis to find the product size.
- Repeat the above experiment with different speed and do perform necessary calculations.

OBSERVATIONS:

⇒ Number of balls =25
⇒ Radius of the mill R =30 cm.
⇒ Radius of balls r =2.54 cm.
⇒ Shape factor Constant =1.2
⇒ Weight of feed =1 kg
⇒ Number of revolution per minute =19

OBSERVATION TABLE:

Sr NO.	Mesh No.	Screen aperture diam.	Mass Retained	Mass fraction Xi	Average diam.	3Xi/Dpi
1	16	1.0				
2	25	0.6				
3	38	0.5				
4	44	0.35				
5	60	0.25				
6	85	0.18				
7	100	0.15				
8	Pan	-				

CALCULATIONS:

Specific Surface= $A_{w=} \frac{68}{P}\ 3\ \frac{\triangle \Phi}{\triangle P}$

=

=

Critical Speed= $\eta_c = 1/2\Pi \times [g/(R-r)]^{0.5}$

PLATE & FRAME FILTER PRESS

INTRODUCTION:

The mechanical separation of a solid material from a liquid in which it is suspended can be accomplished by several different methods, but the most important of these in the chemical process industries is filtration. In this method, the separation is effected by a porous medium, which permits the passage of the liquid but retains the solid particle.

Although filtration is generally regarded as an operation for the recovery of the solid, the liquid, or both, this does not constitute the only objective of filtration is to clarify a liquid that contains a small quantity of suspended matter.

Filters may be classified broadly into three general types:

(1) Gravity Filters
(2) Pressure Filters
(3) Vacuum Filters

DESCRIPTION:

The plate-and-frame filter press is one example of a variety of industrial filtering equipment. It is used particularly when the quantity of solid to be filtered is not large enough to justify the use of a continuous automatic filter or if the solids to be separated have a high value.

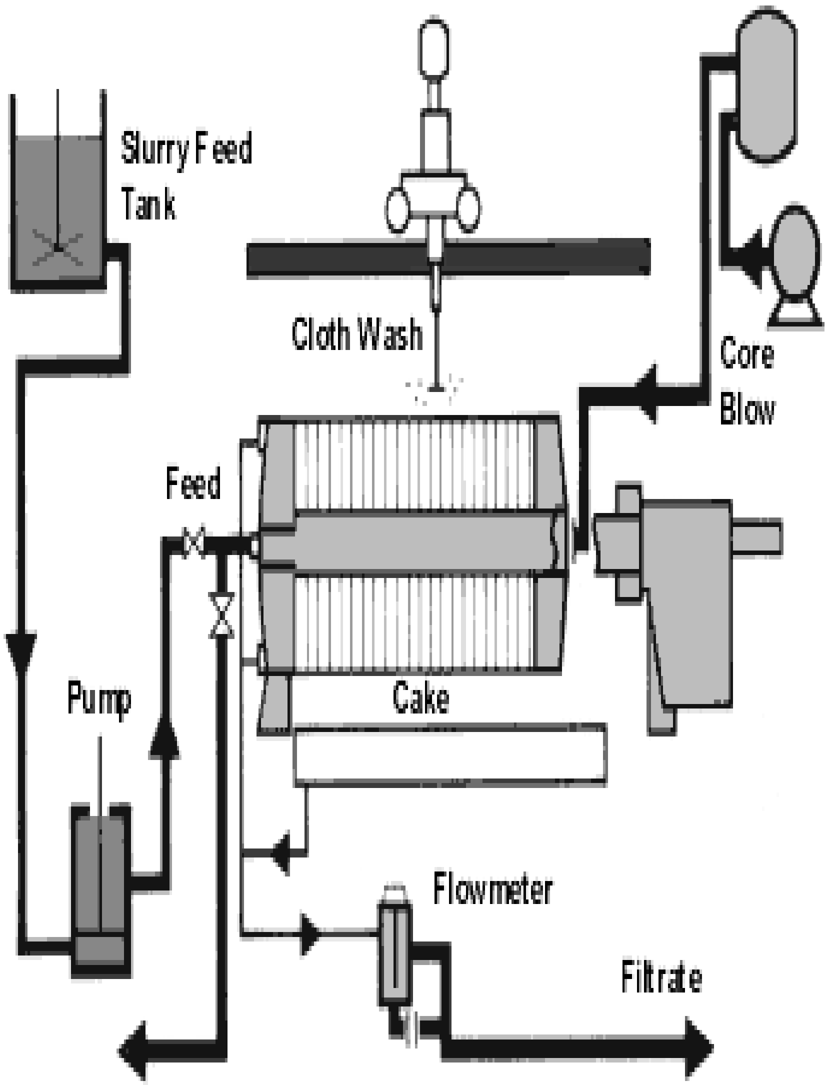
Although the plate-and-frame filter is lower in capital cost per unit of filtering surface than its competitors and requires the least floor space, the operating costs fur such a press is high and this filter is therefore not always the most economical choice.

Filter presses were introduced at the turn of the century and have been around for many years mainly dewatering waste Sludge. They were considered laborintensive machines hence they did not find much acceptance in the sophisticated and highly automated process industries. It was not until sometime in the 60's that this image has changed by the introduction of advanced mechanisms that were oriented towards obtaining low moisture cakes that discharge automatically and enable the washing of the cloth at the end of the filtration cycle.

The Filter press consists of a head and follower that contain in between a pack of vertical rectangular plates that are supported by side or overhead beams. The head serves as a fixed end to which the feed and filtrate pipes are connected and the follower moves along the beams and presses the plates together during the filtration cycle by a hydraulic or mechanical mechanism. Each plate is dressed with filter cloth on both sides and, once pressed together they form a series of chambers that depend on the number of plates. The plates have generally a centered feed port that passes through the entire length of the Filter press so that all the chambers of the plate pack are connected together. Likewise, four corner ports connect all the plates and collect the mother and wash filtrates in a "closed discharge" towards outlets that are located on the same side as the feed inlet.

Some Filter presses have plates that are fitted with cocks at their lower side so that the filtrate flows in an "open discharge" to a trough and serve as "tell tales" on the condition of the filter cloth by the clarity of the filtrate that passes through each chamber. The disadvantage of this arrangement is that it cannot be used with filtrates that are toxic, flammable or volatile.

A typical flow scheme may look like this:



The present day Filter presses, as mentioned previously, are equipped with features that enable fully automatic operation controlled by PLC's.

The main features are:

Shuttle shifters that separate the plates one by one for cake discharge at a rate of 5-6 seconds per plate. A special design of the shifting mechanism ensures that two adjacent plates are not pulled together due to sticky cakes.

- Shakers that subject the plate to vibrations and assist in discharging the cake.
- Cloth showers with movable manifolds and high impact jets for intensive cloth washing.

PRECOATING AND BODY-AID

Often special measures are taken to ease cake discharge and enhance filtration. The measures are:

- Precoating
- Addition of Body Aid

Precoating the plates prior to introducing the feed is done only in the following cases:

- When the contaminants are gelatinous and sticky it forms a barrier that avoids cloth blinding. Likewise the interface between the Precoat and the cloth departs readily so the cake discharges leaving a clean cloth.
- When a clear filtrate is required immediately after the filtration cycle commences otherwise recirculation must be employed until a clear filtrate is obtained.

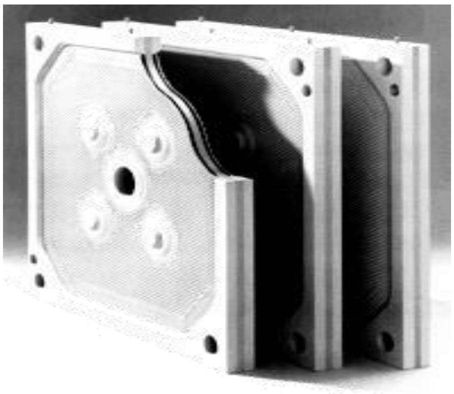
Once the Precoating stage is completed the process slurry is pumped into the filter, the forming cake is retained on the plates and the filtrate flows to further processing.

When the solids are fine and slow to filter a body-aid is added to the feed slurry in order to enhance cake permeability. However, it should be kept in mind that the addition of body-aid increases the solids concentration in the feed so it occupies additional volume between the plates and increases the amount of cake for disposal. Likewise, for all those applications when the cake is the product, Precoat and filter-aid may not be used since they mix and discharge together with the cake.

Please refer to the section on Filters for further details on Precoating and the addition of body-aid.

THE PLATES:

For many years' Filter presses, named Plate and Frame, have used flush plates with separate frames to contain the cake. These Plate and Frame Filter presses had many sealing surfaces, which were the main cause for leakages so the introduction of Recessed Plates has cut the number of surfaces in half and reduced the problem of drippings. The development of Recessed Plates has gone hand in hand with advances in cloth technology, which enabled 3 dimensional stretching as opposed to Plate and Frame where the cloth remains in one plain.



THE SPECIAL FEATURES ARE:

- Lower plate weight has reduced the downtime for shuttle shifting during the cake discharge mode.
- Effective filtration area has gone up since with the largest available plates of 2 by 2 meters, having a 20 mm recess and 150 chambers, the area is about 1000 m2 with a cake capacity of 20 m3.
- The introduction of water, or air to a lesser extent, from the backside of flexible membranes reduces chamber volume and squeezes the cake yielding a further lowering of the moisture content. The Filter press may be arranged as a mixed pack of flush and membrane plates, full flush or full membrane pack depending on the application.

Typical membrane plates are shown in the photo to the above.

Most plates are extruded in polypropylene, which withstands temperatures of 8085C. Operating at higher temperatures will warp the plates and leakage or even squirts can be dangerous at such high temperatures.

SELECTION CRITERIA

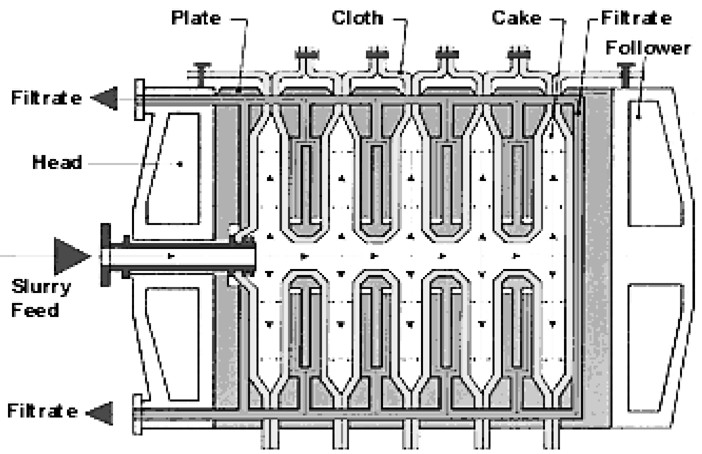
Filter presses are best selected in the following instances:

- When very low moisture content is required for thermal cake drying or incineration.
  When high filtrate clarity is required for polishing applications.
- When good cake release assisted by squeezing is required.
- When the cake is disposed as land fill for spreading with a bulldozer provided it is hard enough to carry its weight.

- When large filtration areas are required in a limited space.

They should be selected with care:

- When filtering saturated brines since the plates cool-off during cake discharge and require preheating prior to feeding the process slurry. For such brines autoclaved filters such as **Horizontal Plates,Vertical Leaf**or **Candle Filters**are better suited as they can be steam jacketed.
- When there is a risk of environmental hazard from toxic, flammable or volatile cakes when the plates are opened for discharge at the end of each cycle. Again, the autoclaved filters are better suited.
- When efficient washing is required since with a chamber filled with cake the wash water may not reach its entire surface causing an uneven displacement. This, however, should present no problem when a gap is left between the formed cakes within a chamber so that the wash water is distributed evenly over the cake and reaches its entire surface.



OPERATIONAL SEQUENCE

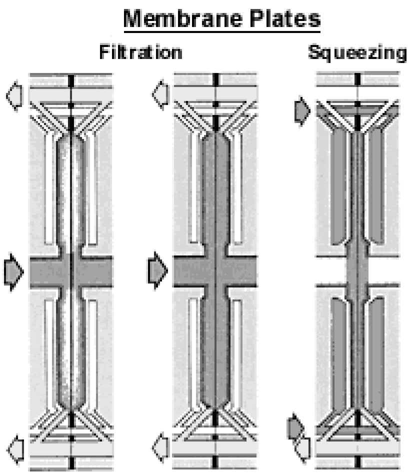
The basic design of the following configurations may be viewed in both figures to the above.

Filter press without membrane plates:

Slurry is pumped and fills the chambers at a high flow rate and low pressure, which gradually builds-up, as the cake gets thicker. The drip trays, which are positioned below the Filter press for the collection of drippings, closed.

- When pressure reaches 6-7 bars wash water is pumped through the filter cake at a predetermined wash ratio to displace the adhering mother solution.
- Air blowing is applied to reduce cake moisture.
- The wet core that remains in the feed port is blown back with air for 20-30 seconds to ensure that the discharged cake is completely dry.
- The drip trays open and are ready for cake discharge.

- The hydraulic plate-closing piston retracts together with the follower.
- The shuttle shifter moves the plates one by one towards the follower and the cake discharges.
- The drip trays close and are ready for the next cycle.
- The shuttle shifter moves the plates back one by one towards the fixed header. When each plate parks the cloth is washed at 100 bar with a mechanism that lowers and lifts a pair of symmetrical manifolds with high impact nozzles.



Filter press with membrane plates:

- Slurry is pumped and fills the chambers at a high flow rate and low pressure, which gradually builds-up as the cake gets thicker. The drip trays are closed.
- The membranes, of empty chamber type plates, are pressed back to allow cake formation.
- When pressure reaches 6-7 bars the cake is presqueezed for even distribution by pumping water to the backside of the membranes.
- Wash water is pumped through the filter cake at a predetermined wash ratio to displace the adhering mother solution.
  Air blowing is applied to reduce cake moisture.
- More water is pumped to the backside of the membranes for final squeezing up to 15 bars to further reduce moisture.
- The wet core that remains in the feed port is blown back with air at 6-7 bars for 20-30 seconds to ensure that the discharged cake is completely dry.
- The drip trays open and are ready for cake discharge.
- The hydraulic plate-closing piston retracts together with the follower.
- The shuttle shifter moves the plates one by one towards the follower and the cake discharges.
- The drip trays close and are ready for the next cycle.
- The shuttle shifter moves the plates back one by one towards the fixed header. When each plate parks the cloth is washed at 100 bar with a

mechanism that lowers and lifts a pair of symmetrical manifolds with high impact nozzles.

CAKE DISPOSAL:

Cakes may be discharged into bins that are trucked away or transported with a belt conveyor. With very large Filter presses a well-formed cake may weigh 200-300 Kg per chamber and when it falls into a bin or onto a belt conveyor in one solid piece the impact is very high. Hence, special measures are required to break and de-lump the sole hard cake and, for belt conveyors, it is also recommended to increase the number of belt support rollers below the discharge chute at the point of impact.

MAINTENANCE:

The Filter press by itself requires little maintenance however the automation features that accompany modern Filter presses should be checked regularly and with particular attention to safety devices such as:

- The infrared curtain that protects the operator during the closure of the plate pack should stop the hydraulic pump within 2 milliseconds.
- The switch that warns when a loss of pressure in the hydraulic plate closing system detects leakage between the plates.
- The filtrate flow meter microswitch that stops the slurry feed pump when the chambers are full.
- The microswitch that is attached to the drip trays is interlocked so that the doors are fully open during cake discharge.
  The pressure switch that permits squeezing of the membranes only when the plate pack is compressed with the hydraulic closing system.
- The zippered bellows that protect the hydraulic piston against drippings should be checked for wear and tear.
- The two manifolds that wash the cloth on both sides of the plate have high impact nozzles at a pressure of 100 bar. When some nozzles of one manifold are plugged the jet impact is uneven and the plates tend to swing.
- The cloth must be checked for holes and the optional cocks on the filtrate port of each plate help in identifying damaged cloths.

The impregnated edges that surround the cloth and seal between adjacent plates should be checked for leakage.

ANALYSIS OF CONSTANT PRESSURE FILTRATION DATA:

The resistance offered to the passage of the filtrate consists of:

(1) The resistance of the filter press leads and channels
(2) The resistance of the cake, and
(3) The resistance of the filter medium.

The sum of these resistances may be related to the differential rate for the filtrate flow in the following manner:

The resistance offered to the passage of the filtrate consists of:

(1) The resistance of the filter press leads and channels

(2) The resistance of the cake, and

(3) The resistance of the filter medium.

The sum of these resistances may be related to the differential rate for the filtrate flow in the following manner:

$$\frac{dV}{d\theta} = \frac{A}{\mu}\frac{P}{R}$$

Where

V	=	Volume of filtrate collected up to time θ
θ	=	Elapsed time
A	=	Total filtering area
μ	=	Viscosity of the filtrate
P	=	Pressure drop through the press
R	=	Total resistance to the flow of the filtrate

If the press is designed properly, the resistance of the leads and channels will be negligible and, therefore, the resistance to the flow of filtrate may be considered to be made up of the resistances offered by the cake and the filter a medium. The total resistance offered by the cake increases as the cake increases in thickness, and depends upon the character of the slurry, the filtration rate, and the pressure. Furthermore, the resistance of the filter medium is not constant but also depends upon the rate, the pressure, and the character of the slurry.

Walker, Lewis, MxcADams and Gilliland give the following filtration equation:

$$\frac{dV}{d\theta} = \frac{P * A^2}{\mu(r'' vP^s V + \rho' AP^m}$$

$$\frac{P\theta}{(V / A)} = \frac{r'' v\mu}{2} P^s \left(\frac{V}{A}\right) + \rho' \mu P^m$$

When integrated for constant pressure, it becomes

Where

P	=	pressure drop across cake, filter medium, and press channels
θ	=	Time
V	=	weight of filtrate up to time θ
A	=	filtering area
r”	=	cake resistivity
v	=	volume of cake per unit of filtrate
μ	=	Viscosity of filtrate
s	=	cake resistivity exponent
ρ’	=	Cloth resistivity
m	=	cloth resistivity exponent

When carrying out an experiment, the quantity of filtrate collected is not ordinarily equal to the total weight of filtrate V because of the holdup in the filtrate line. If the filtrate hold up is V_c and the filtrate collected in up to time θ is V’, the total weight of filtrate up to time θ is V’ + V_c, and the above equation becomes

$$\frac{P\theta}{(V'+V_c / A)} = \frac{r'' v\mu}{2} P^s \left(\frac{V'+V_c}{A}\right) + \rho' \mu P^m$$

Furthermore, because there is usually a time lag before the constant pressure is reached, an additional correction must be applied. If this time lag is equal to

θ_r and the quantity of filtrate collected during this period is V_r, the integration of equation (1) for the period after the constant pressure is reached as follows:

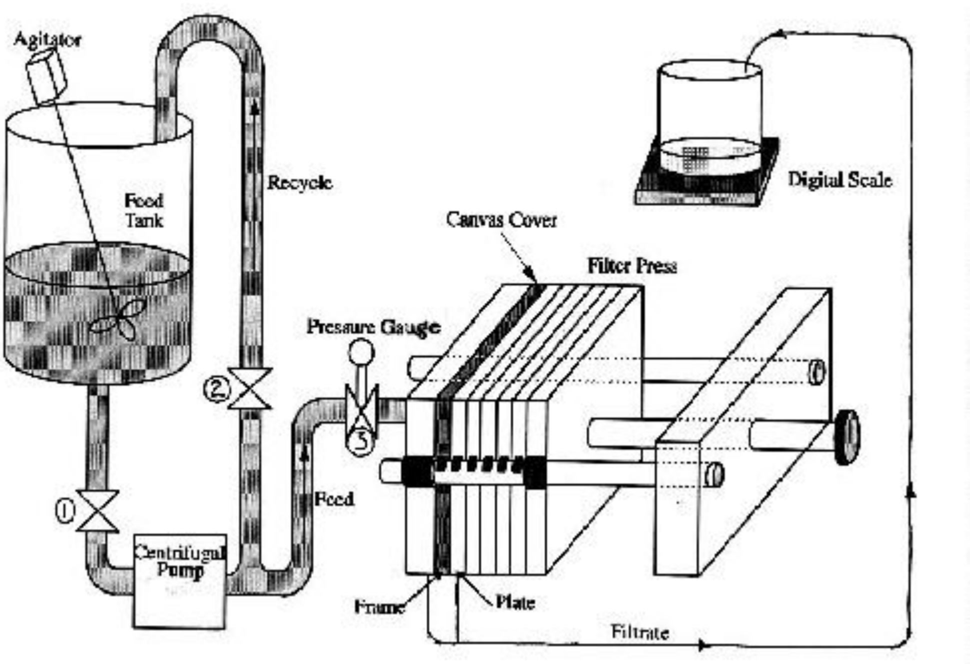
$$\frac{PA(\theta - \theta_r)}{(V' - V_r)} = \frac{r'' \nu \mu P^s (V' + V_r + 2V_c)}{2A} + \rho' \mu P^m$$

PLATE & FRAME FILTER PRESS

EXPERIMENTAL MANUAL

Description of Equipment:

⇒ Plate and Frame Filter Press
⇒ Slurry Tank
⇒ Filter Medium
⇒ Agitator
⇒ Slurry Pump
⇒ Pressure Gauge
⇒ Ball Valve
⇒ Recycle Gate Valve



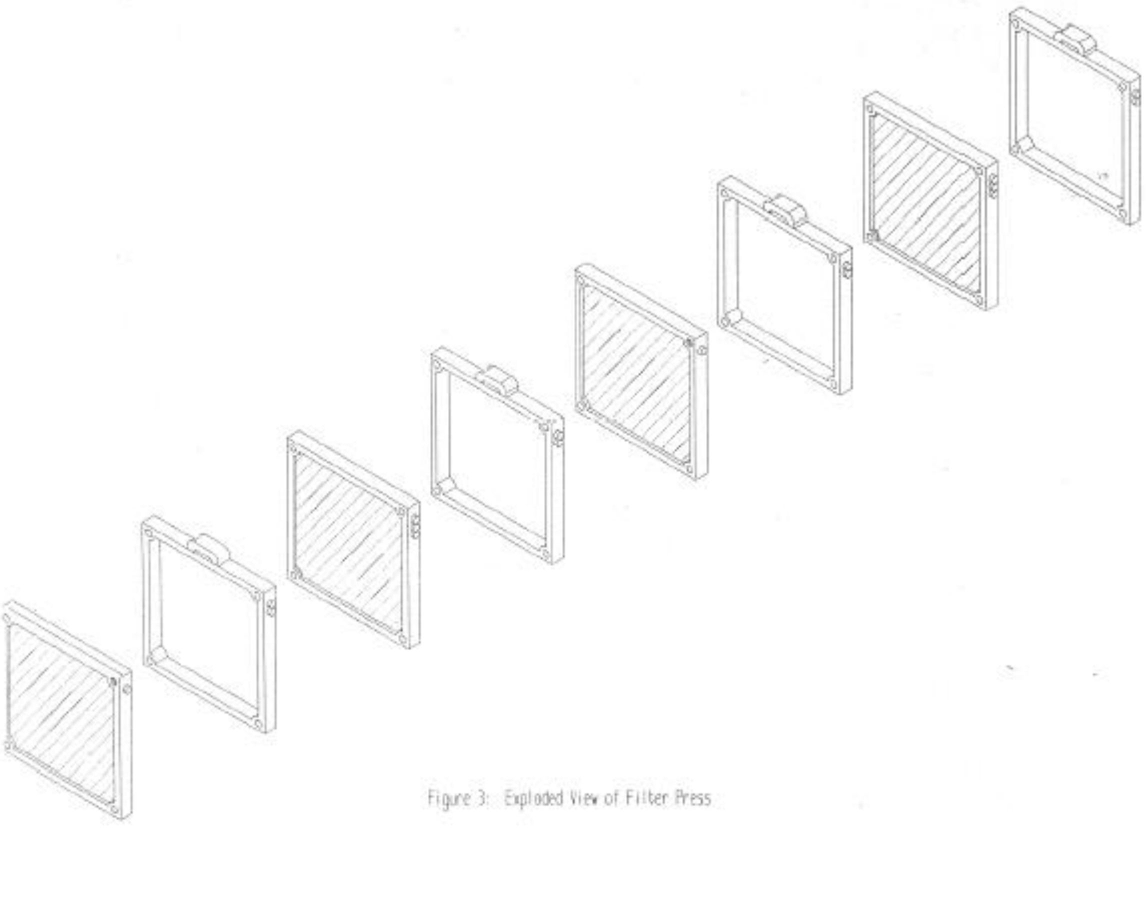


Figure 3: Exploded View of Filter Press

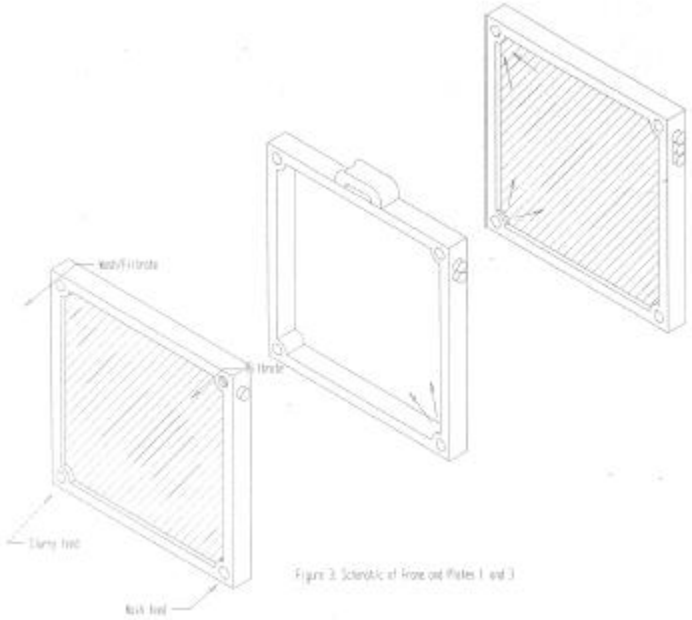


Figure 3. Schematic of Frame and Plates 1 and 3

PLATE & FRAME FILTER PRESS

OPERATIONAL MANUAL

Objectives:

⇒ To study the filtration processes and determine which are the major contributing factors to its operation.

⇒ To determine the flow rates through the filters and into the tank

⇒ To determine the following values at constant (various) filtration pressures.

- Specific Cake Resistance, (α)
- Filter Medium Resistance, R_m
- Cake Compressibility, S

Theory of Filtration:

Filter presses operate under pressure using the process of cake filtration. This involves sending slurry through the press, which is equipped with filter cloths. The cloths pick up the particles in the slurry and allow the solvent (water) to pass through. As more slurry moves through the press, the cake builds up and assists the filtration process. The rate at which the slurry moves through the press depends on the viscosity of the liquid, the thickness and resistance of the cake,

$$\frac{t}{V} = \left(\frac{\mu c \alpha}{2 A^2 \Delta p g_c}\right) V + \left(\frac{\mu R_m}{A \Delta p g_c}\right)$$

where α = specific cake resistance (ft/lb$_m$)
Δp_c = pressure drop across the cake (lb$_f$/ft^2)
g_c = Newton's gravitational proportionality constant (lb$_m$ ft / sec^2 lb$_f$)
A = area of the filter (ft^2)
μ = viscosity of the filtrate (lb$_m$ / ft sec)
c = concentration of the feed slurry (lb$_m$ / ft^3)
V = the volume of the filtrate at any time (ft^3)
R_m = filter medium resistance (ft^{-1})
t = time

By plotting the straight line of time / volume versus volume, the specific cake resistance and the filter medium resistance can be determined by the slope and the intercept of the line respectively.

$$\alpha = \frac{2\ slope\ A^2\ \Delta p\ g_c}{\mu c} \qquad R_m = \frac{intercept\ A\ \Delta p\ g_c}{\mu}$$

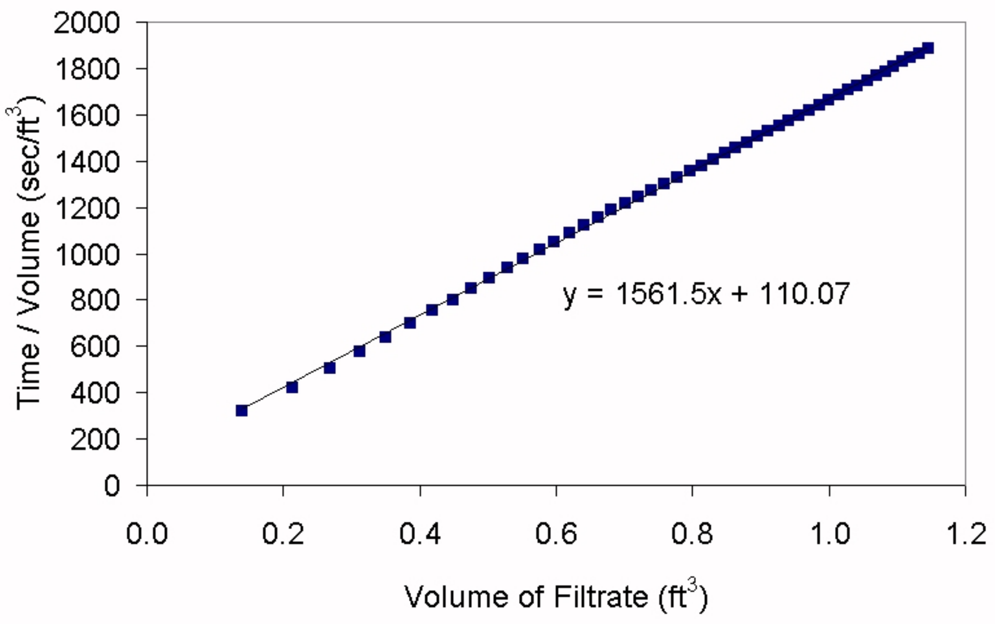


Figure 1: Filtration at 25 psig

Compressible cake will compress to a greater extent at higher pressures. Since the more compact a filter cake is the more resistance to flow there is, the specific cake resistance, a , is a function of the total pressure drop over the filter. The most prevalent function used to model the dependency is as follows.

$$\alpha = \alpha_o \, \Delta p^s \qquad \Rightarrow \qquad Ln(\alpha) = Ln(\alpha_o) + s \, Ln(\Delta p)$$

Where

a_o	=	empirical constant
s	=	the cake compressibility coefficient

A linear plot of Ln(a) versus Ln(Dp) will have a slope that is equal to the cake compressibility coefficient (s).

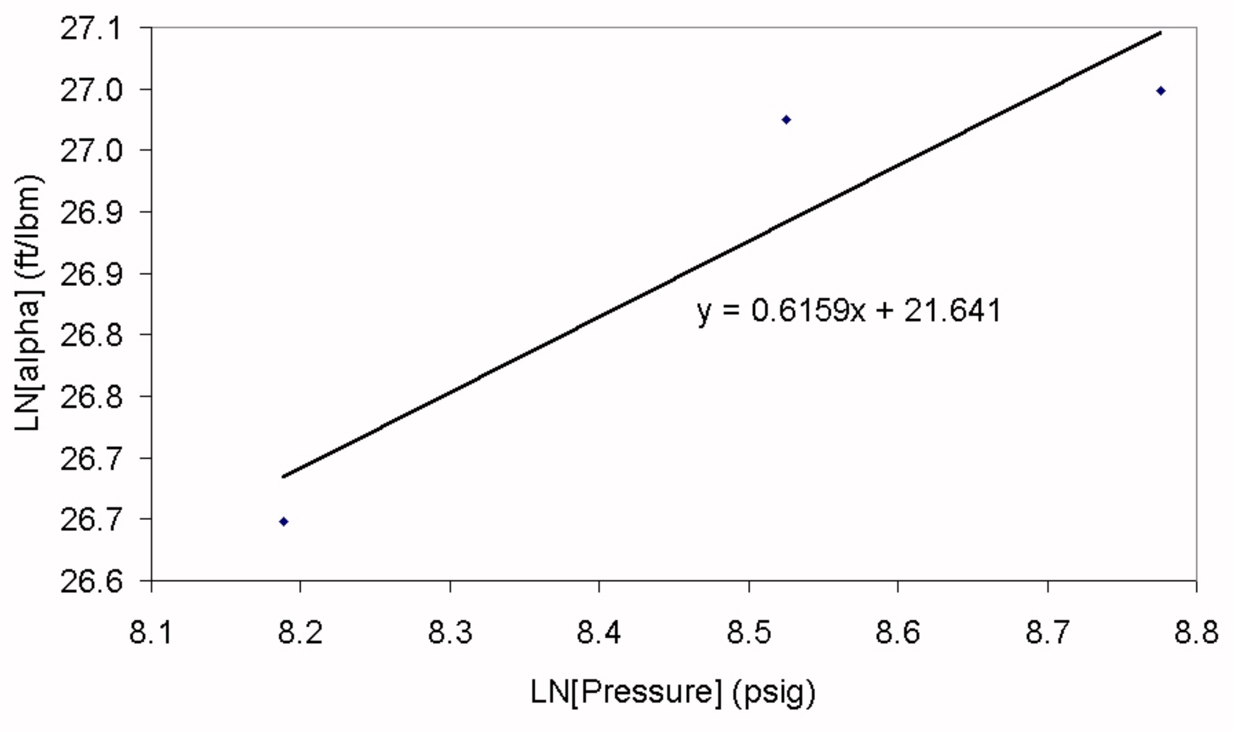


Figure 2: Cake Compressibility Coefficient

Procedure:

- ⇒ Weight a known quantity of the $CaCO_3$ powder (5 kg) and add measured quantity of the water (50 liters) to it. Prepare slurry of it by mixing it together in the slurry tank.
- ⇒ Fill the slurry tank with the help of the slurry prepared.
- ⇒ The agitator was switched on.
- ⇒ The recycle valve was opened, and the inlet valve to the filter press was closed
- ⇒ The slurry pump was switched on
- ⇒ A volumetric sample of the slurry was taken and weighed
- ⇒ The filtrate collection beakers' scale was set to a reference of zero
- ⇒ The pre-wetted filter medium was placed over a frame, and the press was tightly sealed
- ⇒ Simultaneously, the inlet valve to the filter press was opened.
- ⇒ The pressure drop across the filter press for a trial was kept constant by continually adjusting the inlet valve and the recycle valve
- ⇒ The slurry was filtered until approximately _______ liters of filtrate was collected
- ⇒ Simultaneously, the inlet valve to the filter press was closed.
- ⇒ The pump and the agitator were both switched off
- ⇒ The wet filter cake and remaining slurry in the frame were weighed
- ⇒ Five samples of the wet filter cake were weighed
- ⇒ The five cake samples and the slurry sample were then dried and re-weighed
- ⇒ The temperature of the filtrate was measured

OBSERVATION:

Pressure drop	=
Filtering Area	=
Weight of wet cake	=
Weight of dry cake	=
Weight of wet cake sample	=
Viscosity	=
Density of filtrate	=
Density of $CaCO_3$	=
Density of dry $CaCO_3$	=

Observation Table:

Run Number	1	2	3
No. of plates used			
Pressure gauge Reading (kg/ cm^2)			
Temperature (°C)			
Viscosity of filtrate (gm/ cm sec)			
Density of filtrate (g/ cm^3)			

Reading Number	Filtering Time θ (sec)	Weight of filtrate V (gm)	Filtering Time θ (sec)	Weight of filtrate V (gm)	Filtering Time θ (sec)	Weight of filtrate V (gm)
1						
2						
3						
4						
5						
6						
7						

For Water:

	Run No.		Average of Runs 1 & 2	Run No.		Average of Runs 3 & 4
Temperature (°C)						
Viscosity of Water (gm/ cm sec)						
Pressure (kg/ cm^2)						
Time for 10 kg of water, sec						

Cloth Resistance P^m						

Calculation:

To determine the flow rate at any time through the press, a simple differential equation is used:

$$A\frac{\partial h}{\partial t} = F_{in} \qquad (1)$$

Where,

F_{in} = flow into the tank.

A = cross-sectional area of tank

h = height of liquid in tank at time t

However, taking a closer look, the flow rate of the filtrate can be approximated by expressing it in terms physical properties of the slurry:

$$\frac{\partial t}{\partial V} = \frac{\mu}{A(\Delta P)}\left(\frac{\alpha CV}{A} + R_m\right) \qquad (2)$$

Where:

t = time (sec)

V = volume filtered (m^3)

μ = viscosity of water (Pa2s)

A = total area of all filtration cakes in system (m^2)

ΔP = Pressure differential across filter (Pa)

C = Slurry concentration of solids per volume (kg / m^3)

α = Specific cake resistance (m/kg)

R_m = Filter medium resistance (m-1)

Equation 2 may be rewritten with symbolic values to represent the larger terms:

$$\frac{\partial t}{\partial V} = K_1 V + K_2 \qquad (3)$$

Where: $K_1 = \frac{\mu \alpha C}{A^2 (\Delta P)}$ and

$$K_2 = \frac{R_m}{A(\Delta P)}$$

Graph:

A plot of dt/dV vs. V should give a straight line with a slope of K1, which will allow the calculation of the specific cake resistance, a. Also, the intercept will be K2, which will allow the calculation of Rm.

Result:

Conclusion:

Results:

CYCLONE SEPRATOR

EXPERIMENT:-CYCLONE SEPARATOR

INTRODUCTION:

Centrifugal Separating devices consist of cyclone separators, rotational flow dust precipitators, and mechanical centrifugal separators, the cyclones being most widely used. The smallest particle size removable is about 5 μm, although smaller sizes as low as 0.1 μm have been separated in case where particle agglomeration takes place.

The cyclone separator is uniquely conceived so that the solid particles are separated from gases under centrifugal flow path conditions to produce much greater separation forces than obtained by gravitational methods. The flow path is patterned so that gases and solids are discharged separately and with no appreciable entrainment.

Probably the most conspicuous property of centrifugal flow is the velocity distribution as examined radially across the flow. If the wall boundary, where the velocity is zero (from Prandtl) is omitted, the effect of viscous shear in the fluid will tend to give higher velocities near the inside of a centrifugal path. In fluid mechanics this is called irrotational condition of flow and is a two dimensional conditions. It may also be described as quasi representation of flow.

This radial flow distribution may be represented, as expression that states the tangential component of velocity will vary in inverse as the radial distance.

In a qualitative description, the cyclone may be said to produce favorable separation forces, if its particle paths are of relatively short distances, and the inner walls of the cylindrical and conical sections also provides impingement area.

Here, as when many small diameter baffles are used in preference to fewer larger units, the use of more cyclones in parallel arrangement at the same pressure drop will give better efficiency of particle removal for a given flow. This is reasonable, since an increase in the number of cyclones results in separation at smaller radial distances in the centrifugal flows produces, and shorter particle travel distances, before impingement on the inner walls of the cyclones.

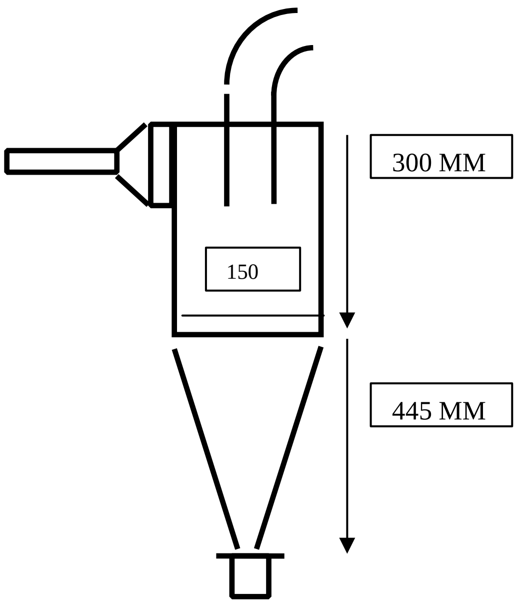
The entering gas at the rectangular inlet first enters an annular space, tangentially to the inner wall of the cylindrical section at the top, and is also bounded inside the centrifugal path by the outside of theoretical gas outlet pipe, which is concentric with the cylinder.

Although the inlet gas flow after entrance is only bonded on the sides and top, and is free to pass downward (which it does, following a spiral path on the outer diameter similar to the upward directed center vortex), it is of some value to note possible gross velocity changes o f flow according to the approximate cross section area presented. It should be noted that inner and outer spiral paths of flow have the same sense of rotation and that the inner flow of the clean gas enters the outlet gas pipe below the lowest level of the rectangular inlet.

The rectangular inlet provides the lowest cross sectional area of flow. In the downward direction, the annular space is pi times the area, and the gas outlets, presumably even at some lowers static pressure, and has only half the area for upward flow. The exact boundary conditions between the slow rotating outer vortex and fast rotating inner vortex, moving in their downward and upward directions respectively, do not tend to contaminant the outgoing gases, since the inner vortex rotation is reported to pass, to some extent, the residual small particles back into the outer vortex, resulting in final entrainment of some very small solids.

DESCRIPTION :

Proportional dimensions are shown in the figure.



D_c = 150 mm

The following statements summarize the essential mechanical characteristics of cyclones:

- Vertically cylindrical top section is a typical case, but variations with top and middle conical sections are possible. Slanted installations are also possible.
- Lower conical section below cylindrical section tapering downward into the solids discharge outlet in a typical case.
- Tangential inlet for dust laden gas of rectangular cross section shape.
- Gas outlet pipe vertical and concentric with top cylindrical section starting below the rectangular inlet where dust-laden gas enters, partially separating the two vortex flows of gas downward and upward.
- The cone supplies volume to hold a solids bed that may be continuously or intermittently removed.

Preventions are necessary in the prevention of leakage of air into the cyclone and leakage of dust and gas out of the cyclone; either will reduce collection efficiency. For intermittent withdrawal of dust, an airtight receiver is used; for continuous, a star valve or special types of locking gate valves are used.

Fans are usually required with cyclones and may be placed to handle the dustladen gas or the cleaned gas from either upstream or downstream installations.

EXPERIMENTAL MANUAL
CYCLONE SEPARATOR

AIM:

To determine the

a) Terminal Velocity
b) Collective efficiency

EQUIPMENT &MATERIAL REQUIRED: Cyclone Separator,

THEORY:

Most centrifugal separators for removing particles from the gas stream contain no moving parts. The cyclone consists of a vertical cylinder with a conical bottom, a tangential inlet near the top and an outlet for the dust at the bottom of the cone. The inlet is usually rectangular. The outlet pipe is extended into the cylinder to prevent the short-circuiting of air from inlet to outlet. The incoming dust-laden air travels in a spiral path around and down the cylindrical body of the cyclone. The centrifugal force developed in the vortex tend to move the particle radially towards the wall, and particles that reach the wall, slide down in to the cone and are collected. The cyclone is basically a settling device in which a strong centrifugal force, acting radially is used in place of the relatively weak gravitational force acting vertically.

PROCEDURE:

- Take the mixture of solid particles (about 0.5-1 kg) of different sizes (preferably less than 0.01 mm in diameter) and sieve analyze them.

  Tabulate the cumulative values.
- Charge this mixture of solid particles to the hopper and start the blower set the velocity above (10 m/sec) as calculated at the rectangular inlet.
- Operate the cyclone separator till the charge is exhausted.
- Stop the blower and open the Collection Jar provided at the bottom of the cyclone separator. Sieves analyze the mixture of solid collected and tabulate the cumulative values.
- Perform the calculations.

CALCULATION:

1. Terminal Velocity $V_t = D_p^2\, g\, (\rho_p - \rho) / 18\mu$
2. Collective Efficiency: For a given Dia. of particle the mass fraction of the size particles collected.

From the division of cumulative percent data on the incoming dust to the cyclone, and the collection efficiency at each 5% step taken as a mid percent point, the overall collection efficiency η is obtained either from the direct calculation or from a plot. Fractional weight collection efficiency η vs. Cumulative fraction larger than size (Perry and Chilton "Chemical Engineers' Handbook, McGraw Hill New York). Find the mean ordinate in such a way that area on enclosed on either side is equal. The intersection of this mean ordinate with y axis will give overall collection efficiency.

Graph:

Collective Efficiency % Vs D_{pi}

RESULT:

- Minimum size of the particles separated =
- Cut size of particles for calculation of separation efficiency =
- Separation Efficiency (for individual size particles) =
- Overall collection efficiency =
- Terminal Velocity V_t =

CONCLUSION: