University of Jordan

School of Engineering

Department of Chemical Engineering

Solid Particulate Operations Lab.

(0905364)

Experiment Number -1-

Mixing of Powders

Objective:

To study the process of mixing and see how the properties of ingredients - the particle size distribution as example - will affect the process. Also investigate the effect of mixing time, and mixing speed on the state of mixing.

Equipment:

The unit is composed of a double-cone mixer, with a timer, and with a speed controller.

Samples can be analyzed by an ionselective meter, or by titration method.

Theory:

The mixing index is a measure of how far mixing has proceeded toward equilibrium.

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For granular solids, the mixing index is defined as $\frac{\sigma_e}{S}$ the equilibrium standard deviation for complete mixing over standard deviation

$$I_s = \frac{\sigma_e}{S} = \sqrt{\frac{\mu_p.\left(1-\mu_p\right).(N-1)}{n\sum_{i=1}^{N}(x_i-\bar{x})^2}}$$

where:

μ_p: is the overall fraction, by number of particles, of sand in the total mix.

N: is the number of spot samples.

n: is the number of particles in the sample.

x_i : Fraction of sand in each spot sample.

$\bar{x}$: Average fraction of sand in all spot samples.

Procedure:

1. Weigh certain amount of salt and sand as instructed, and load the material to the mixer.
2. Fix the speed of the mixer and run it.
3. After 5 minutes of running, stop the mixer and take 3-5 samples from different locations of the mixed material and place in sample bottles.
4. Start running the mixer again and repeat taking samples after 10, 15, 20, 30, 45, and 60 minutes.
5. Using the ionselective meter (or any analytical method), the weight of salt as well as sand in each sample taken can be found.
6. Repeat using one of the variables below:
    a. Speed of rotation.
    b. Moisture or liquid content of solids.
    c. Relative amounts of components.

Calculation:

1. Calculate the mixing index for each spot sample.
2. Draw graph of mixing index against the variable selected.

References:

1. Coulson and Richardson," Chemical Engineering ", Vol.II,Pergamon Press
2. McCabe and Smith," Unit Operation of Chemical Engineering ", 3rd edition.

Mixing of Powder Data Sheet

Weight of salt: _____ Particle size of salt: _____

Weight of sand: _____ Particle size of sand: _____

Time	Sample Location	Sample wt(g)	Vol. of $AgNO_3$ (ml)
5 min	Top		
	Bottom		
	Right		
	Left		
10 min	Top		
	Bottom		
	Right		
	Left		
15 min	Top		
	Bottom		
	Right		
	Left		
20 min	Top		
	Bottom		
	Right		
	Left		
30 min	Top		
	Bottom		
	Right		
	Left		
45 min	Top		
	Bottom		
	Right		
	Left		
60 min	Top		
	Bottom		
	Right		
	Left		

Instructor signature:
Date:

Experiment Number -2-

Fluidization unit

Objective:

To show the effect of fluid velocity on pressure drop through the fluidized bed.

Equipment:

The equipment consists of a glass cylinder through which a controllable flow of air is passed. It is mounted vertically with a diffuser/ filter at the lower end. A further filter at the upper end prevents solid particles suspended in the air stream from escaping. Air from a blower fan is produced controlled by a bleed control valve. This valve is progressively closed causing air to pass through two flow meters in turn and then the chamber at the lower end of the glass cylinder below the diffuser/filter before passing through the solid particles held above the filter.

Two flow meters is used, one having approximately one tenth the range of the other. This ensures that both the initial onset of fluidization can be measured as well as the full range which exceeds the Fluidization velocity. An electric heating element in mounted in such a manner that it can be held at any height within the glass cylinder, the surface area of the heating element is 20 cm^2. The power input is controlled by a variable transformer and the surface temperature of the element is measured by a thermocouple located close under the surface of the thin copper cylinder which surrounds the heating element. By this means the cooling effect of the air and solid particle can be accurately measured.

Additional thermocouples are placed, one under the diffuser to measure air entry temperature and the other one on a movable probe to enable temperature measurement at any part in the cylinder. The thermocouple marked "X" is located close under the surface of the copper cylinder and is coupled directly to a high temperature cut out.

Pressure drop through the fluidized bed of solid particles is measured by tubular pressure probe which can be adjusted vertically to sense pressure just above the diffuser/filter. See figure (1).

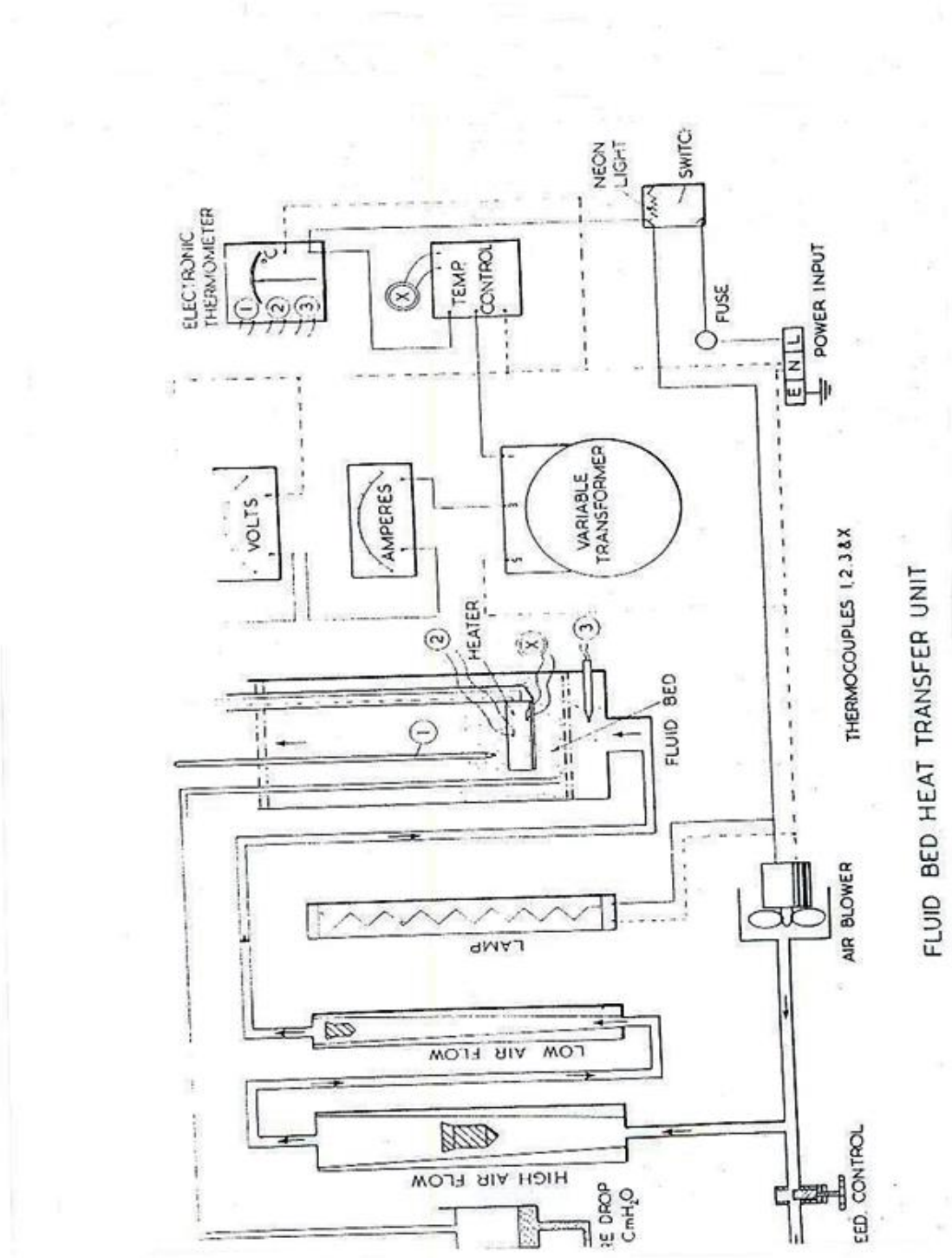


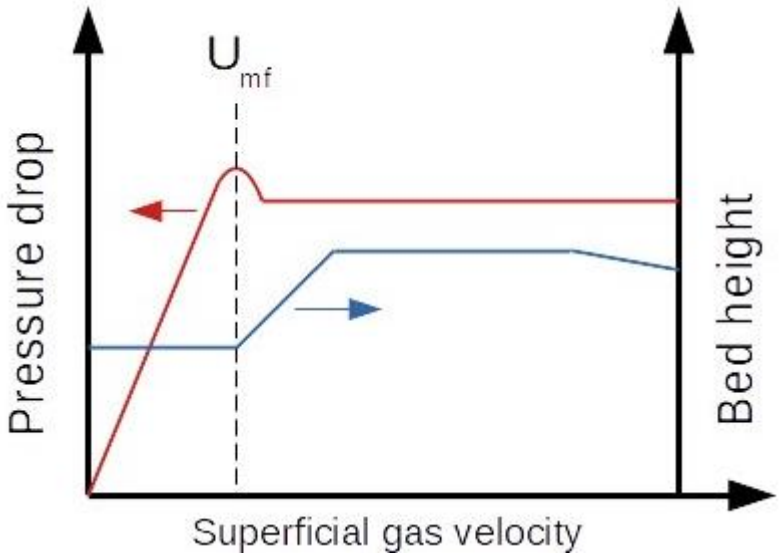
Figure (1): Schematic diagram for fluid bed heat transfer unit.

Theory:

Fluidization is a process in which a solid particulate material is transformed into a fluid like state through the introduction of a fluid (usually a gas or liquid) flowing upward through the solid bed. As the fluid velocity increases, it lifts and suspends the solid particles, causing them to behave like a boiling liquid.

This technique is widely used in chemical and process engineering for operations such as mixing, drying, combustion, and catalytic reactions. One of the key advantages of fluidization is the excellent heat and mass transfer it provides, making it highly efficient for industrial applications like fluidized bed reactor.

Fixed bed can is converted to fluidized bed with increasing the velocity according to the following curve**:**



Figure(2):Pressure drop and bed height as a function of the superficial gas velocity in a fluidized bed [

Procedure:

1. With the air bleed control opened fully, switch on the blower.
2. close the bleed control valve progressively so that the air is induced through the bed material causing the pressure to rise across the bed.
3. Record the flow rate, bed pressure drop, air temperature, element temperature, voltage and current at each air flow rate, and also record your observation.

Calculation:

Plot the bed pressure drop against air flow rate.

References:

1. J.M. Coulson and J.F. Richardson, "Chemical Engineering", Vol.2, Third Edition, 1978, Pergamon Press.
2. D.Q. kern, "Process Heat Transfer ", McGraw Hill, 1982.

Fluidized Bed Heat Transfer Unit Data Sheet

Flow rate	T_1 (°C) Bed Temp.	T_2 (°C) Heater Temp.	T_3 (°C) Air Temp.	Voltage (V)	Current (A)	ΔP(cmH_2O)	Observation

Instructor signature:

Date:

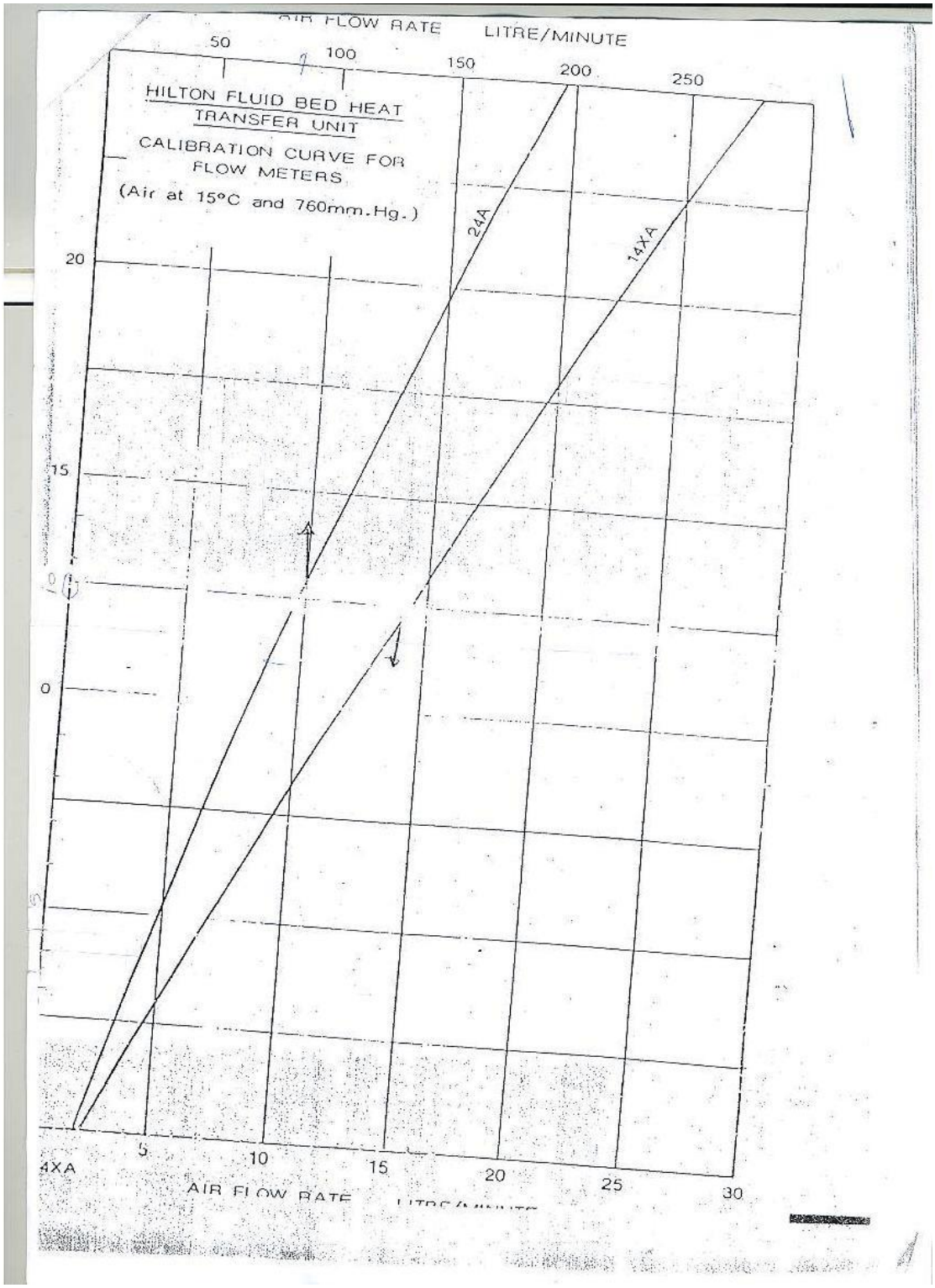


Figure (3): Calibration curve for flow meters for fluid bed heat transfer unit.

Experiment Number -3-

Jaw Crusher

Objective:

To study the comminutionbehavior of different materials, using a primary crusher (Jaw crusher), under various condition; taking in consideration power requirements.

Equipment:

The unit consists of a laboratory scale Jaw crusher of fixed speed. The gap between the two jaws can be altered using a hand wheel.

A sieve shaker is also available with a set of test sieves.

Theory:

A number of empirical laws have been put forward to estimate the energy required to effect a size reduction of a given material:

a. Rittinger's law:

$$\frac{P}{m} = K_R \left(\frac{1}{L_2} - \frac{1}{L_1}\right) \dots\dots\dots (1)$$

b. Kick's law:

$$\frac{P}{m} = K_c . ln \frac{L_1}{L_2} \dots\dots\dots (2)$$

c. Bond's law:

$$\frac{P}{m} = 0.3162 . W_i . \left(\frac{1}{\sqrt{L_2}} - \frac{1}{\sqrt{L_1}}\right) \dots\dots\dots (3)$$

Where:

L_1, L_2: Particles size of product and feed (mm).

P: Power required for crushing and grinding(Kw).

m: Feed rate (tons/hr).

W_i: Bond's work index (Kw.hr/ton).

K_R,K_c: Rittenger's constant and Kick's constant.

Procedure:

1. Prepare the material to be tested and sort according to the size.
2. Choose three samples of different sizes and weigh the required amount as instructed by supervisor of each sample.
3. Adjust the jaw gap setting as required, and tighten the hand wheel.
4. Switch on the jaw crusher.
5. Put the weighed sample into the crusher and immediately start the stop watch.
6. Once the crushing is complete, stop the stop watch and record the time.
7. Arrange the test sieves according to the size of the aperture, noting that the biggest aperture should be at top, and the smallest at the bottom and then the pan.
8. Put the crushed sample on the top sieve, and put the sieves on the sieve shaker.
9. Switch on the shaker and allow the screen process to proceed for about 15 minutes.
10. Weigh the collected solid on each sieve and record the weight.
11. Repeat using the other samples.
12. The process can be repeated using one of the following variable:
    a. Initial material size.
    b. Jaw gap setting.
    c. Type of material

Calculation:

1. Draw graphs of accumulative weight percent of product passed against screen opening and find d_{80}.
2. Using Bond's law, find the power required for grinding.
3. Find a graphical relation between the power required and the variable selected.

References:

McCab,W.L.,andSmith,J.C.,Unit Operation of Chemical Engingeering,McGraw-Hill,Inc,3rd ed.,(1976).

Jaw Crusher Data Sheet

	Coarse size	Intermediate size	Fine size
Dimensions of feed particle			
Weight of sample			
Time need for crushing			

	Mass collected on sieve (g)		
Sieves size	Coarse size	Intermediate size	Fine size

Instructor sign:
Date:

Experiment Number -4-

Gravity Sedimentation

Objective:

To demonstrate how the data obtained from batch settling tests can be used in design purposes (e.g. thickener design). This can be achieved through studying the settling behavior of different materials having different properties under various process conditions.

Equipment:

The main items of the apparatus are:
1. Five easily-removable glass tubes, mounted in support frame.

2. Back lighting to illuminate the sedimentation tubes and metric scales mounted alongside.

To help complete the experiments:
1. A stopwatch.

2. Containers to make up slurry solutions in water.

3. Specific gravity (density) bottle.

Figure (4): Schematic diagram for Sedimentation unit.

Theory:

The total weight of the solid in the slurry is ($C_o.Z_o.S$), where (C_o) and (Z_o) represent the initial concentration and height of the suspended solid in a batch-settling test and (S) is the cross-sectional area of the cylinder in which the test is being performed. The quantity of solid passing through the limiting layer is $d.C_L.\ S.\ \theta_L(V_L+\bar{V}_L)$ where C_L is concentration of the limiting layer and θ_L is the time for this layer to reach the interface , V_L is the setting velocity and $\bar{V}_L$ is the upward velocity of the capacity-limiting layer.

$$C_L.S.\theta_L(V_L+\bar{V}_L)=C_0.Z_0.S \ldots\ldots\ldots(1)$$

If $\bar{V}_L$ is assumed to be constant and Z_L is the height of the interface at O_L:

then

$$\bar{V}_L=\frac{Z_L}{O_L} \ldots\ldots\ldots(2)$$

Substituting into equation (1) gives

$$C_L=\frac{C_0.Z_0}{Z_L+V_L.\theta_L} \ldots\ldots\ldots(3)$$

The value of V_L is the slope of the plot of height of interface versus time and is equal to:

$$V_L=\frac{Z_i-Z_L}{\theta_L} \ldots\ldots\ldots(4)$$

$$Z_i=Z_L+V_L.\theta_L \ldots\ldots\ldots(5)$$

Combining equation (3) and (5) gives:

$$C_L.Z_i=C_0.Z_0 \ldots\ldots\ldots(6)$$

Procedure:

1. Fill one of the graduated cylinders with solution to a certain height.
2. Weigh the required amount of solid and add to the water in the cylinder.
3. Shake the cylinder to make the solution homogenous.
4. Record the height of the interface between the clear liquid and the settling slurry with time.
5. The experiment can be repeated at different :
    a. Type of material.
    b. Solid concentration.

c. Particle size.
d. Diameter of the cylinder.
e. Initial height.

Calculation:

1. Plot the batch settling curves for each run.
2. Calculate the critical height, time, and concentration for each run.
3. Calculate the minimum height for each run.
4. Investigate the effect of the variable studied on the settling behaviour of solid.
5. Plot graphs of the variable studied versus critical height and concentration.
6. Calculate the minimum area of the thickener to handle 3.785×10^6 L/day with feed concentration of 200 g/liter solution and thickened sludge concentration of 700 g/ liter solution.

References:

1. Coulosn, J.M., and Richardson, J.F., "Chemical Engineering ", Vol. II, London.
2. Foust, A., et al., "Principle of Unit Operation", John Wiley, New York.
3. Svarovsky , L., ed. "Solid-Liquid Separation" , Butterworhts.

Gravity Sedimentation Data Sheet

	Conc.=	Conc.=	Conc.=
Height	Time	Time	Time

	Conc.=	Conc.=	Conc.=
Height	Time	Time	Time

Instructor signature:
Date:

Experiment Number -5 -

Ball Mill

Objectives:

1. To grind the given material to a smaller size using a ball mill.
2. To obtain the size distribution of the final mixture by sieving.
3. To analyze the results using the available theories.

Equipment and materials:

The unit consists of:

- A laboratory scale rotary ball mill, as shown in Fig (1).
- Metal balls (various sizes).
- A sieve shaker with a set of test sieves.(Appendix A)

Unit description

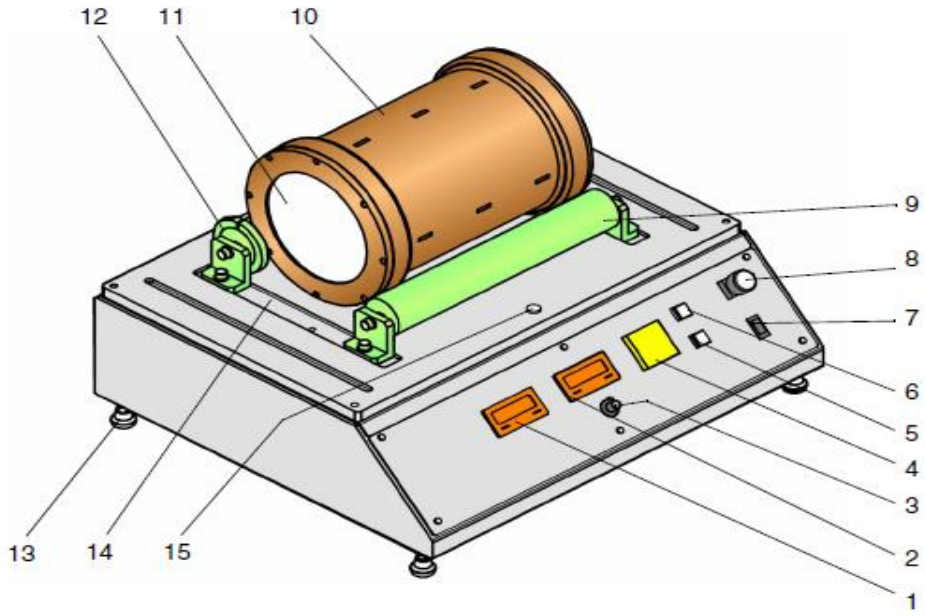
Ball Mill is a kind of grinder used for intermediate or fine grinding materials like ores, chemicals, ceramic raw materials and paints. The coarse material charged along with grinding medium,which fall onto the material and mill itby the effects of mechanicalforces. Different materials are used as media, including ceramic balls, flint pebbles and stainless steel balls. The size reduction leads to an increase in surface area per unit volume that enhances the rate of the reaction by allowing more sites for the reaction to take place,release valuable substances contained inmixtures for further processing. Moreover improve the packaging, storage and transport conditions of materials.

Unit layout

The unit consists of:

1. Digital display of power consumption in W.
2. Digital display of speed in min-1
3. Speed adjustment of drive roller controller.
4. Timer adjustment of the milling process duration.
5. The OFF button used to stop the drive, resetting the timer to zero.
6. The ON button used to switch on the drive.
7. The master switch used to switch the unit on and its readiness for service is indicated by the lamp.

8. Emergency stop switch.
9. Loose roller.
10. The milling drum, containing 50-70% of milling balls made of stainless steel and the materialto be ground .
11. Inspection window.
12. Drive roller.
13. Height-adjustable feet(Align unit to horizontal level)
14. Guide rail
15. Box level



1	Digital display power consumption in W	9	Loose roller
2	Digital display Speed in min^{-1}	10	Milling drum
3	Adjuster Speed drive roller	11	Inspection window
4	Timer	12	Drive roller
5	OFF button	13	Height-adjustable feet
6	ON button	14	Guide rail
7	Master switch	15	Box level
8	Emergency stop switch		

Fig.(5) : Ball mill layout

Theory:

Physical principles of milling

In various processes, solids frequently need to bereduced for subsequent processing. They are
normally reduced by mechanical force. Dependingon the mechanical properties of the materials,
e.g. hardness, brittleness etc., reduction is carried out using different load types.

Reduction always produces mixtures of coarseand fine material in a range of different grain
sizes. Graders are therefore connected downstreamto separate this material.The choice of reduction method for a particularmaterial depends particularly on the followingproperties:

– Particle size of basic material
– Properties of material to be ground (hardness, brittleness, viscosity)
– Required reduction.

Reduction principle

Ball mills are primarily used for fine grinding and pulverizing of dry hard to medium-hard materials.A ball mill consists of a rotating drum, which is filled 50-70% with wear-resistant milling bodiesmade of steel or hard porcelain and the materialto be ground as shown in Fig(2) .When the drum rotates, milling balls are liftedagainst the inside wall and fall back onto thematerial to be ground, crushing it through friction,shearing and impact.If the speed is low, there is a wobbling motion, andreduction is achieved mainly through friction.

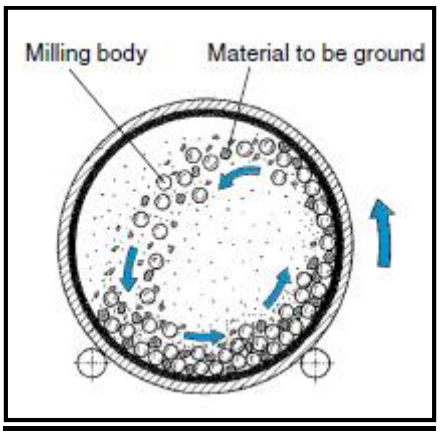


Fig. (6): The working principle of ball mill

Ball mills operate discontinuously via batch-processing. The drum size depends on the product volume.There are wet and dry milling processes. Drumscan be cooled or heated and operated under aspecial atmosphere, e.g. nitrogen.

Empirical laws:

Bonds law has been used to estimate the energy required to effect a size reduction of a given material:

Bonds law:

$$\frac{p}{m} = 0.3162\ W_i \left(\frac{1}{\sqrt{L_2}} - \frac{1}{\sqrt{L_1}}\right) \ldots\ldots\ldots(1)$$

Where:

L_1,L_2	: Particles size of product and feed (mm)
p	: Power required for grinding(kW)
m	: Feed rate (tons/hr)
W_i	: Bond's work index (kW.hr/ton).

1. Procedure:

1. Weigh about 100 g of the material to be tested with particle size (500-1000 **μ**m).
2. Add the balls and material fraction to the drum.The volume share of material and balls is 50-70% of drum volume.
   The volume share of the three balls diameters in the total ball volume is as follows:

   ⌀5mm = 25% volume share
   ⌀10mm = 50% volume share
   ⌀15mm = 25% volume share

3. Set master switch to ON position.
4. Set the required time and speed.
5. Push ON button on the drive roller, the milling process was started for required minutes with the appropriate speed.
6. Switch OFF position.
7. Separate the grounded material from the balls to prepare for the grain size analysis. A sieve with a mesh size of 1.4 mm is useful here.
8. Arrange the test sieves according to the size of the aperture, noting that the biggest aperture should be at top, and the smallest at the bottom and then the pan. (The grain size was made using an analysis sieve with the following mesh size 500,350, 250, 125, and 90**μ**m).
9. Put the grinded sample on the top sieve, and put the sieves on the sieve shaker.
10. Switch on the shaker, set the vibrating intensity (H=55), sieving time (T=10).

11. Weigh the products from the sieves, and classify them according to the size range.
12. The process can be repeated using one of the following variable:
    a. Speed of cylinder.(150, 250, 350, 450 min^{-1})
    b. Filling level of cylinder.
    c. Ball size and volume share.
    d. Duration of milling process. (5, 10, 15, 20 min)

Calculation:

1. Draw graphs of accumulative weight percent of product passed against screen opening.
2. Find a graphical relation between the power required and the variable selected.
3. Calculate the bonds work index and compare it with theoretical value.

References:

McCab,W.L.,andSmith,J.C.,Unit Operation of Chemical Engingeering,McGraw-Hill,Inc,3rd ed.,(1976).

Ball Mill Data Sheet

	Sample #1	**Sample #2**	**Sample #3**
Feed particle size (**μ**m)			
Weight of sample (g)			
Time (min)			
Rotation speed (rpm)			
Power consumption (W)			

	Mass collected on sieve (g)					
Sieves size	Sample #1	Mass fraction %	Sample #2	Mass fraction %	Sample #3	Mass fraction %
Total						

Instructor sign:
Date:

Experiment Number(6)

Angle of Repose

Objective:

1. To determine the angle of repose of two granular materials (sand& kcl salt), and to compare their flow properties.
2. To determine the effect of particle size variation of the two materials on the angle of repose.

Equipment & materials required:

1. Dry sand (sieved, in 3 different particle size)
2. Dry kcl salt (sieved, in 3 different particle size)
3. Funnel with a discharge spout opening(6-12mm) according to ASTM specifications.
4. Ring stand, with one ring to hold the funnel.
5. Stopper, sized to fit the funnel discharge spout.
6. Baseplate, flat, rigid at least 12in (30.5 cm) by 12in (30.5cm).
7. Calculator with trigonometric function.
8. 2 rulers or measuring tape (for measuring height & radius).
9. Different sieves, sieve shaker apparatus.
10. White paper.
11. Balance.

Experimental setup:

1. Sieve analysis: use sieve set to classify the sand and kcl salt into 3 distinct size ranges (125-250), (250-355), (355-500).
2. Prepare materials: ensure that all materials are completely dry, and separated into labeled containers for each size category.
3. Set up the funnel.

Theory:

A rapid method of assessing the behavior of a particulate mass is to measure its angle of repose. If a solid material is poured from a nozzle on to a plane surface, it will form an approximately conical heap, and then the angle between the sloping side of the cone and the horizontal is the angle of repose.

Angles of repose vary from 20° with free flowing solids, to about 60°with poor flow characteristics or low flow ability. In extreme cases of highly agglomerated solids then the angle of repose up to nearly 90°can be obtained.

We will use the fixed funnel method to find the angle of repose where the powder is poured through a funnel and placed onto a flat surface, forming a cone then the angle of repose will be the angle between the the sloping side of the pile and the horizontal plane.

We will find the angle of repose through the relation according to **ASTM** as follows:

$$\textbf{Angle of repose} = \tan^{-1}(2h/D) \quad \text{…… …. (1)}$$

Where:

h= height of the pile(cm).

D= the average cone diameter (cm).

Procedure:

The experiment follows the guidelines provided in ASTM C1444, which outlines the procedure for determining the Angle of Repose the steps are as follow:

1. Samples preparation: the materials will be dried if needed and sieved using the sieve shaker apparatus.
2. Weigh the sample 200g.
3. Mount the funnel on a stand so that the tip is a known, fixed height above the base (e.g. 10-15) let's say 13 cm above a flat horizontal surface.
4. Ensure that the samples free flowing at an angle of 60°.
5. Block the funnels orifice and fill the funnel with the sample without compacting it.
6. Unblock the orifice to allow the material to flow freely and form a conical pile on the base.
7. Place the funnel at a fixed height 13 cm above a flat horizontal surface and use a blank white paper to help you draw rough sketch of diameter of the base of the cone of your pile will be formed.
8. The samples are placed inside the funnel gradually until the material no longer accumulates forming a cone- shaped pile, measure the height (h) of the pile from the base to the apex using two rulers and the radius from the average diameter (d).
9. Calculate the Angle of Repose (Θ) using the formula:
   Θ = arc tan (2h/d)
10. Repeat the procedure multiple times through 3 trials, and the average is calculated to ensure the accuracy.

Calculations:

1. Calculate the angle of repose for each particle size through three trials, for each material and find the average value
2. Draw graphs of angle of repose against the particle size for each

References:

1. Coulson and Richardson “chemical engineering” volume 2, fifth edition, 2002.
2. ASTM C1444, ASTM international, 100Harbor drive, United States.

Angle of repose data sheet

Sand data sheet

Trial (1)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Trial (2)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Trial (3)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Kcl salt sheet

Trial (1)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Trial (2)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Trial (3)			
Particle size(micrometer)	**125-250**	**250-355**	**355-500**
D (average diameter)			
h (height)			

Experiment Number -7-

Coagulation - Flocculation in solid-liquid separation

Objective:

To study the process of coagulation and flocculation for removing suspended particles from a colloidal suspension and to determine the optimum conditions (pH, and coagulant dose) of the process.

Equipment:

Jar test device

Figure(7) :jar test apparatus

Theory:

Coagulation and flocculation are essential process in water and wastewater treatment , they involve:

- Coagulation : the addition of chemicals (coagulants) to destabilize colloidal particles by neutralizing charges.
- Flocculation : gentle mixing to form large aggregates (flocs) from destabilize particles

These flocs can then settle under gravity, allowing the separation of solids from liquid, figure (8).

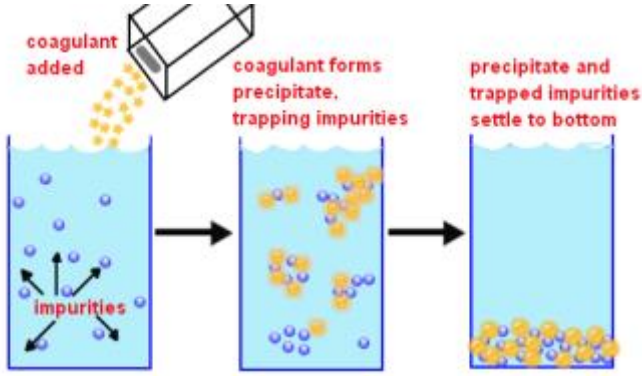


Figure (8): Coagulation and flocculation of a colloidal suspension

The most common coagulants used in water and wastewater treatment are aluminum and ferric salts such as, alum (Al2(SO4)3.14H2O),ferric chloride and ferric sulfate.

Treatment of water by coagulation involves determination of optimum dose of coagulant by **jar test**. It is important to determine the optimum dose to avoid charge reversal and resuspention colloids.(Optimum coagulant dose is consider as the amount of coagulant which produces water with lowest turbidity).

The first step of jar test involves adding coagulant to the source water and mixing the water rapidly to completely dissolves the coagulant in water. Then the water is mixed more slowly for a longer time period, allowing the forming floc particles to cluster together. Finally the mixer is stopped and the floc is allowed to settle out, as it would in the sedimentation basin.

Procedure:

Part A: Determination of optimum alum dose

1. Measure and record the initial pH and turbidity of the water sample.
2. Fill 5 beackers with 250ml of kaolin suspension
3. Add (1, 2, 3, 4, 5 ml) of 10 g/L alum solution
4. Subject the samples to one min of rapid mixing(about 100-120 rpm) followed by 15 min of slow mixing (about 40 rpm) .
5. Allow to the samples to settle for 30-60 min without disturbance
6. Measure final turbidity and pH.
7. Observe the floc characteristics.

Part B: Determination of optimum pH

1. Measure and record the initial pH and turbidity of the water sample.
2. Fill 5 beakers with 250ml of kaolin suspension
3. Adjust each sample to different pH using 0.1M NaOH or 0.1M HCl (target pH values: 4, 5, 6, 7, and 8)
4. Add optimum alum dose (from part A) to all 5 beakers.
5. Subject the samples to one min of rapid mixing(about 100-120 rpm) followed by 15 min of slow mixing (about 40 rpm) .
6. Allow to the samples to settle for 30-60 min without disturbance
7. Measure final turbidity and pH
8. Observe the floc characteristics

Calculation:

1. Plot alum dose vs final turbidity ,then find the optimum dose
2. Plot pH vs final turbidity , then find the optimum pH.

References

1. Coulson, J.M.; and Richardson, J.F., "Chemical Engineering ", volume two. Pergamon Press Inc. fifth edition, 2002.
2. Ladislav S,"Sloid – Liquid Separation", fourth edition ,2000.

Coagulation – Flocculation Data Sheet

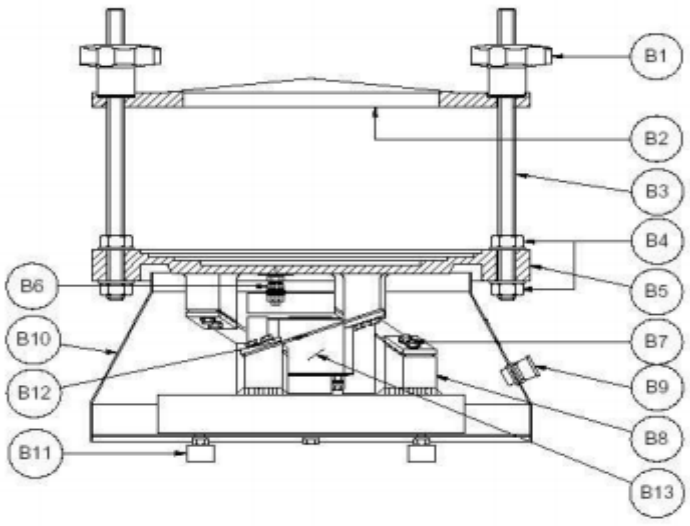
Sample number	pH(initial)	Turbidity (initial)	Alum dose (mg/L)	pH(final)	Turbidity (final)	observatuion

Appendix (A)

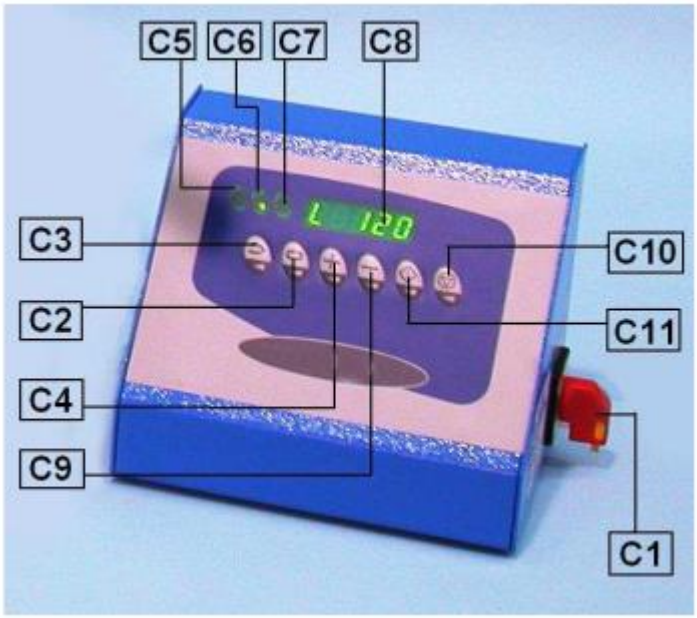
Sieve shaker

Sieves shakers can be used to sieve all the range of materials with variable intensity. They can handle many sieves at the same time.

Unit description



B1	**BLOCKING KNOBS**	They secure the upper bar (**B2**) to the sieves, blocking them firmly to the receiver (**B5**).
B2	**BAR**	It secures the sieves to the specimen receiver (**B5**).
B3	**THREADED BARS**	They allow to regulate the bar height (**B2**).
B4	**FIXING NUTS**	They fix the threaded bars (**B3**) to the specimen receiver. **In the shaker** A059-01 KIT **is present only one pair of data and the bars** B2 **are screwed into the sieve holder B5**
B5	**SIEVE HOLDER**	It can hold several sieves according to the operator's needs.
B6	**ADJUSTMENT SCREWS**	They allow to fix and to adjust the specimen receiver (**B5**) to the electromagnet (**B13**). In this way, the vibrations produced by the electromagnet are transferred to the sieves placed on the receiver (**B5**).
B7	**FIXING SCREWS**	These screws fix the springs (**B12**) to the support columns (**B8**).
B8	**SUPPORT COLUMN FOR SPRINGS**	It allows connecting the base to the specimen receiver (**B5**) by means of the springs (**B12**).
B9	**CABLE FIXING DEVICE**	It fixes the feeling cable to the sieve shaker base, avoiding its incidental pull during the normal working procedures.
B10	**GUARD**	It allows reaching the inside components of the sieve shaker base. The guard is fixed to the base by some screws.
B11	**SUPPORTING FEET**	They allow laying the sieve shaker steadily on any surface.
B12	**SPRINGS**	They transfer the vibrations from the electromagnet (**B13**) to the specimen receiver (**B5**).
B13	**ELECTROMAGNET**	It generates the vibrations, which are necessary for a sieving test. Using the Control Panel (**C**) it is possible to modify the vibrating intensity according to the user's needs. (See Chapter "USE" of this manual for further details).



C1	**MAIN SWITCH**	It allows switching on and off the machine.
C2	**"SELECTION" BUTTON**	By pressing this key it is possible to select one by one the figures on the right of the numeric display (**C8**).
C3	**"MODE"" BUTTON**	By pressing this key it is possible to select the working mode of the sieve shaker. This mode is shown by the first figure of the numeric display (**C8**); See the Chapter **"OPERATING MODE"** of this manual for further details.
C4	**"INCREASE" BUTTON**	By pressing this key it is possible to increase the figure shown on the numeric display (**C8**) in that moment.
C5	**LED "SIEVING WORKING"**	The lighting of this led means that the machine is vibrating.
C6	**LED "CONTINUOUS SIEVING"**	The lighting of this led means that the sieve shaker is vibrating in the "continuous mode". For further details, see Charter "**SETTING UP**" of this manual.
C7	**LED "DATA STORING"**	The lighting of this led means that the data shown by the display is being modified (**C8**). Once the data is stored, the led stops lighting.
C8	**NUMERIC DISPLAY**	Using this display it is possible to see all the information referred to the sieve shaker working procedures and also to modify the operating parameters; See the Chapter "**USE**" of this manual for further details.
C9	**"DECREASE" BUTTON**	By pressing this key it is possible to decrease the figure shown by the numeric display in that moment (**C8**).
C10	**"STOP" BUTTON**	By pressing this key, the sieving procedure is stopped.
C11	**"START" BUTTON**	By pressing this key, the sieving procedure is activated according to the setting up made by the operator.