**SRI SHANMUGHA COLLEGE OF ENGINEERING AND TECHNOLOGY**

**(Approved By AICTE, Accredited by NAAC, Affiliated to Anna University)**

*Tiruchengode – Sankari Mani Rd, Pullipalayam, Morur (PO), Sankari (Tk), Salem 637304.*

# AI8512 – POST HARVEST ENGINEERING LABORATORY

# DEPARTMENT OF AGRICULTURE ENGINEERING

## Anna University - Regulation: 2017

## B.E AGRICULTURE ENGINEERING – V SEMESTER

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# RECORD NOTE BOOK

REGNO. ______________________

Certified that this is a bonafide observation of Practical work done by Mr/Ms/Mrs……………………………………of the…………………………………… Semester………………………………………………. Branch during the Academic year……………in the………………………………laboratory.

**Staff–in–Charge** **Head of the Department**

**Internal Examiner** **External Examiner**

# GENERAL INSTRUCTIONS

- All the students are instructed to wear protective uniform and shoes before entering into the laboratory.
- Before starting the exercise, students should have a clear idea about the principles of that exercise
- All the students are advised to come with completed recorded and corrected observation book of previous experiments, defaulters will not allowed to do their experiment.
- Don't operate any instrument without getting concerned staff member's prior permission.
- All the instruments are costly. Hence handle them carefully, to avoid fine for any breakage.
- Almost care must be taken to avert any possible injury while on laboratory work. In case, anything occurs immediately report to the staff members.
- One student from each batch should put his/her signature during receiving the instrument in instrument issue register.

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**Ex No:1 Determination of Moisture Content by Oven Method and Moisture Meter**

**AIM**

To determine moisture content of given agricultural materials by direct and indirect methods.

**APPARATUS**

Hot-air oven, PSAW universal digital moisturemeter, balance, grain, etc.

**THEORY**

Moisture content of a substance is expressed in percentage by weight on wet basis, but the moisture content on dry basis is simpler to use in calculations as the quantity of moisture present at any time is directly proportional to the moisture content on dry basis.

The moisture content (*M*), per cent wet basis is

$$M = \frac{W_m}{W_m + W_d} \times 100\ (\%)$$

Where,

$W_m$ = Weight of moisture (g)

$W_d$ = Weight of bone dry material (g)

The moisture content (*M*), per cent dry basis is

$$M = \frac{W_m}{W_d} \times 100\ (\%)$$

There are several methods for determination of moisture content of agricultural products. For determination of moisture content of a particular product, the choice of method depends on many factors, they are

(1) The form in which water is present in the product.
(2) The relative amount of water present.
(3) The rapidly of determination.
(4) Accuracy of method.
(5) Products nature whether easily oxidized or decomposed and
(6) The cost of equipment used.

Moisture content is determined mainly by two methods (i) direct, also called as primary method and (ii) indirect, also called as secondary method. The accuracy of moisture content determination by direct method is high; hence these methods are used by research workers. The moisture content values obtained by direct methods reused to calibrate all the indirect type moisture measuring devices. The direct methods of moisture determination are time consuming therefore such methods are not very much useful for determination of moisture in field or ware houses. Indirect methods are faster and mostly employ the electrical properties of the grains.

## DIRECT METHOD

## HOT-AIR OVEN METHOD

The air-oven drying method can be accomplished in a single stage or double stage in accordance with the grain samples containing less than 13 per cent or more than 13 per cent moisture content.

## PROCEDURE

In the single stage method, 2 – 3 grams sample is powdered or ground and kept in the oven for 1 hour at 130±2$^{o}$ C. Then the sample is kept in desiccators and weighed. The sample should check within 0.1 per cent.

In the double – stage method 25 – 30 grams whole grain sample is kept in air-oven at 130±2$^{o}$ C for 14 – 16 hours, so that its moisture content is reduced to about 13 per cent. Then the same procedures followed as in single-stage method.

## INDIRECT METHOD

PSAW universal moisture meters are designed for quick and accurate determination of per cent moisture content of a wide range of organic and many inorganic materials. The instrument is specially designed for apparently dry granular substances, such as, food grains, seeds, pulses, spices and dehydrated fruits. The rugged mechanical construction of the instrument to withstand high applied pressure coupled with latest electronic technique for reliability and accuracy of results, makes it indispensable for grain and seed houses. For a given temperature the percent moisture content in the material is directly read from correlator dial without making use of any chart or mathematical calculations. PSAW universal moisture meters are, therefore, best suited for quick and accurate determination of per cent moisture content in food grains, pulses, oil seeds, vegetable seeds and other granular materials such as, coffee beans, cotton seeds, oats, water melon seeds, etc.

The operation of PSAW universal moisture meter is based on the fact that the electrical conductivity of a moist material is directly proportional to the amount of moisture contained in it. Electrical conductivity also varies with the temperature. A built-in thermometer and a set of correlator dials on the front panel of the instrument compensate for these variations. For uniformity, accuracy and reliability of results the materials under examination is compressed to a particular thickness in order to annul the porosity effect on the electrical conductivity.

**PROCEDURE**

The cup containing the sample is placed under the plunger. The cup is so placed that its bottom key fits in the base socket and the lower surface of the cup settles in the cup mounting place. The cup is raised by rotating the hand wheel till the surface of the sample touches the plunger. Now for applying high pressure the ratchet spanner is used and the sample is compressed to proper thickness (ex. paddy – 0.55”).

1. The sample to be tested is taken from a representative sample of the entire lot and thoroughly mixed before testing.
2. A measuring cup of the proper volumes (A, B and C) is filled with the test material up to its brim. The material need not be pressed in the measuring cup rather it should be properly shaken and leveled to avoid superfluous empty spaces in between the grains. The test material is then transferred into the test cup.
3. Place the test cup containing the sample in its housing in such a manner that the guide stems of the cup snuggly fits into the hole in the body base.
4. Select the proper compression thickness required for the given test sample from

the thickness setting chart.

5. Rotate the smaller handle in anti-clockwise direction until the plunger is snuggly compressed against the sample.

6. Now fit the Ratchet handle into the open end of bevel pinion and compress the sample until the reading on the main scale and the circular scale divisions together give the correct thickness reading.

7. Press the push type switch on the moisture meter to take the reading after count down from 10 to 1 and temperature correction automatically. The three digits display will give direct moisture percentage after count down.

8. To remove the sample, release the pressure between the plunger and the test cup by using ratchet handle in clockwise direction, till movement is free. Remove the rachet handle. Use small handle till the pointer goes to the upper most position. Lift the test cup upwards. Remove the test material from the test cup and clean the cup and plunger with a soft piece of cloth. Replace the cup in its position.

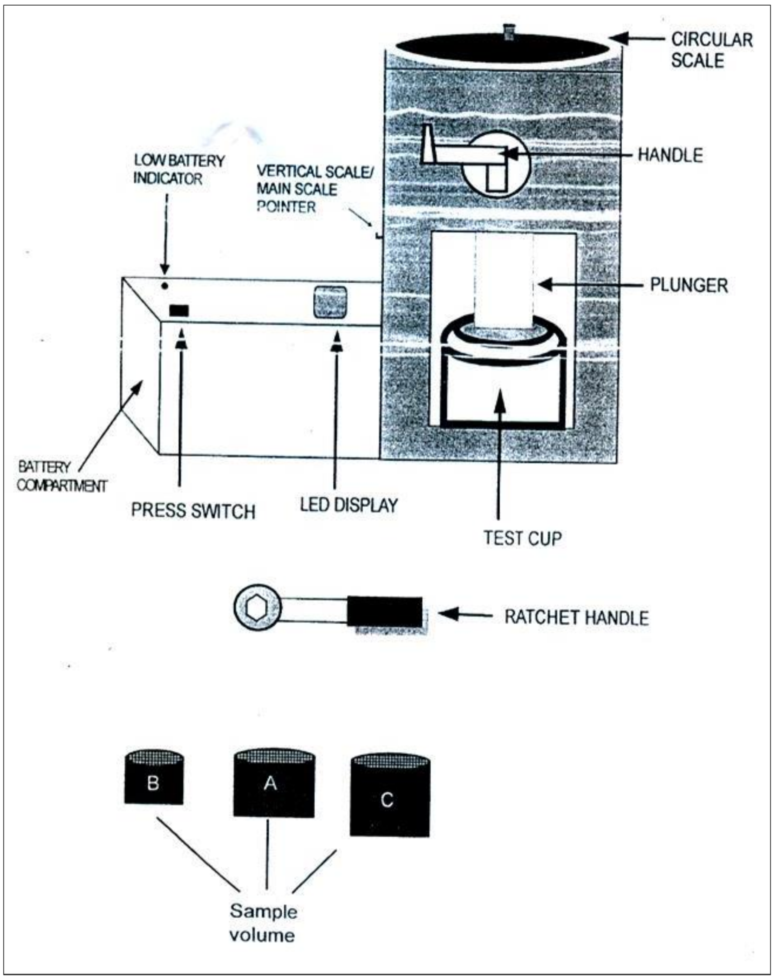



**Fig.1 Digital moisture meter**

## RESULTS

The moisture content of the given grain is

1) Direct method = % (w.b.)

= % (d.b.)

2) Indirect method = % (w.b.)

## Ex No 2 Estimation of Porosity of Grains

**AIM:**

To determine the porosity of the given rice sample

**PRINCIPLE**

Porosity is defined as the percentage of pore space in food materials.

**TERMS INVOLVED**

***Bulk density***

It is defined as the ratio of bulk weight of the material to the volume of the same material. It is expressed in $Kg/m^3$.

***True density***

It is defined as the ratio of weight of the material to its true volume (i.e) excluding the pore space.

***Porosity***

Porosity is the amount of voids or pore space present in the bulk grain expressed in present of whole mass. To overcome this air is used to fill the voids or pores and the porosity is determined.

According to the perfect gas law, the equilibrium pressure P is read by

$$\mathbf{P_1V_1 = m\,R_1T_1}$$

Where, P1= absolute pressure

V1= volume of tank 1 M=mass of air, g

R1= gas constant for air T1= absolute temperature K

**MATERIALS REQUIRED**

Measuring cylinder, Graduated beaker, Rice sample water

**FORMULAE**

% Porosity = [1- (Bulk density/true density)] X 100

**PROCEDURE**

**Bulk density:**

The bulk density is found by taking container is found by measuring the length, breadth and height of cubical container and measuring diameter, height for cylinder container. The weight of the grain in the container is found separately.

**True density:**

Known volume of water is taken in a measuring cylinder 'N' no of grains uniform size are taken weighed. These grains are then transferred to the measuring cylinder and increased volume of water is noted.

**Porosity:**

It consists of two identical glass tanks connecting the tube with the manometer. A hand is provided to fill the tank with air.

Fill the tank no 2 with the grain for which the porosity is to be found out. Also the orientation of the grains be formed naturally as the pore space varies with the factors. Assemble the grain tank setup and close the other valves except the inlet valve to the air tank. Blow air into the air mouth.

Note the head difference (P1) in U-tube manometer. Now open the connecting the valves and let the air flow from air tank to grain tank. Note the change in head difference (P2) in the manometer. Repeat the experiment for minimum three times.

## CALCULATION

Weight of the rice sample =

Total volume of water taken =

Initial level of sample in measuring cylinder =

Radius of the measuring cylinder amount of water consumed =

Volume = $\pi r^2 h$

Bulk density = bulk weight of grain (g)/ bulk volume of grain ($cm^3$)

True density = true weight of grain (g)/ true volume of grain ($cm^3$)

Porosity = [1- (Bulk density/true density)] X 100

$$\textbf{Porosity} = \mathbf{P_1 - P_2 / P_2}$$

**RESULT:**

Porosity of the given sample =

Bulk density of the given sample =

True density of the given sample =

## EX.No:3 Determination of Angle of Repose and Coefficient of Friction

**AIM**

To determine the angle of repose and coefficient of friction of the given sample

**APPARATUS**

Sample, angle of repose apparatus, coefficient of friction apparatus

**THEORY FOR ANGLE OF REPOSE**

The angle of repose is the angle between the base and the slope of the cone formed on a free vertical fall of the granular material to a horizontal plane. The size, shape, moisture content and orientation of the grains affect the angle of repose. There are two angle of repose

***Static Angle of Repose***

It is the angle of friction taken upon by the material to just slide up upon itself.

***Dynamic Angle of Repose***

It is the angle formed when the grain is in motion like discharge of grain from bins and hopper.

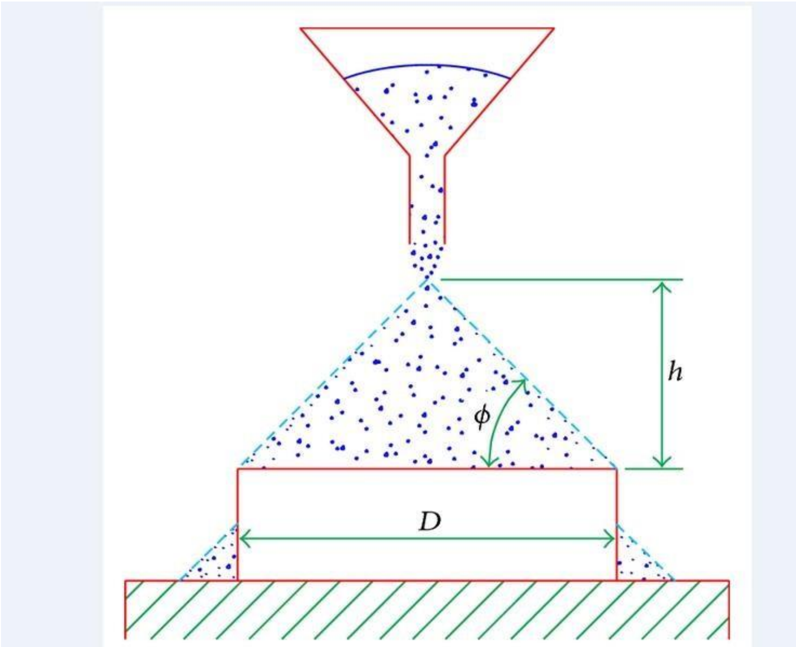
**PROCEDURE**

Measure the diameter of the circular plate on which the rice sample is to be heaped by using a scale. From the diameter of the plate, the radius can be calculated. Now naturally heap the given rice sample through the hopper on the circular plate. The height of the heap can be noted by adjusting the scale pointer and corresponding reading can be seen on the scale. By using the height of the natural heap and the radius of the circular plate, the angle of repose can be calculated. Repeat the procedure for plates of different diameters and calculate the angle of repose accordingly.

**OBSERVATION AND CALCULATIONS**

| S.l. No. | Diameter of the circular plate | Radius of the circular plate (r) | Height of heap (h) | Angle of repose |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Angle of Repose = $\tan^{-1}(h/r)$




**THEORY FOR COEFFICIENT OF FRICTION**

Friction may be defined as the forces acting between the surfaces of contact at rest with respect to each other or the frictional forces existing between the surfaces in relative motion. If F is the force of friction and W is the force normal to the surface of contact, then the coefficient of friction 'f' is given by the relationship

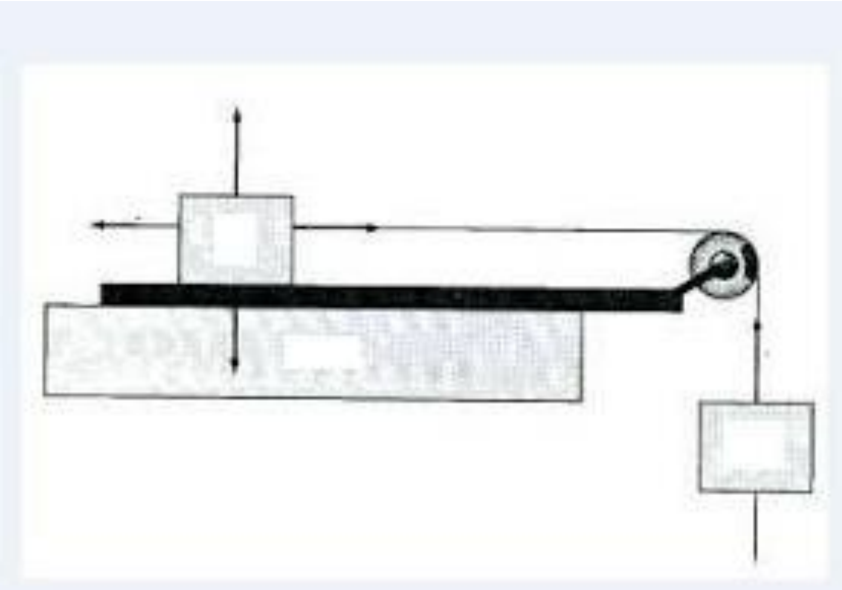
$$\mathbf{f = F/W}$$

The coefficient of friction may also be given as the tangent of angle of the inclined surface upon which the friction force tangential to the surface and the component of the weight normal to the surface are acting.

**PROCEDURE**

Fill the grains up to the rim of the container which is connected to the pulley. Weigh the grains inside the container. Place the container on the surface under study (steel, wood, cardboard etc). Ensure the stability of the container. Now add weights to the other side of the rope connected to the container. Note at which point of addition of weight the container starts to move. Record the sum of weights added. Calculate the coefficient of friction using the formulae.

Coefficient of friction (f) = F/W



**Coefficient of Friction Apparatus**

## OBSERVATION AND CALCULATIONS

| S.l. No. | Surface | Weight of the grains (W) | Weights added (F) | Coefficient of Friction (f) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Coefficient of friction (f) = F/W

**RESULT**

Angle of repose of the given sample =

Coefficient of friction of the given sample on

i) On surface =

ii) On surface =

iii) On surface =

iv) On surface =

## Ex.No: 4 Testing of Paddy Thresher and Paddy Winnower

**AIM:**

To test the paddy thresher and winnower

**APPARATUS REQUIRED:**

Paddy thresher, paddy, weighing machine

**THEORY:**

Threshing is an operation of detaching the grains from the ear heads, cobs and pods. Thresher is a machine to separate grains from the harvested crop and provide clean grain without much loss and damage. During threshing, grain loss in terms of broken grain, un- threshed grain, blown grain, spilled grain etc. should be minimum. Bureau of Indian Standards has specified that the total grain loss should not be more than 5 per cent, in which broken grain should be less than 2 per cent

**COMPONENTS**

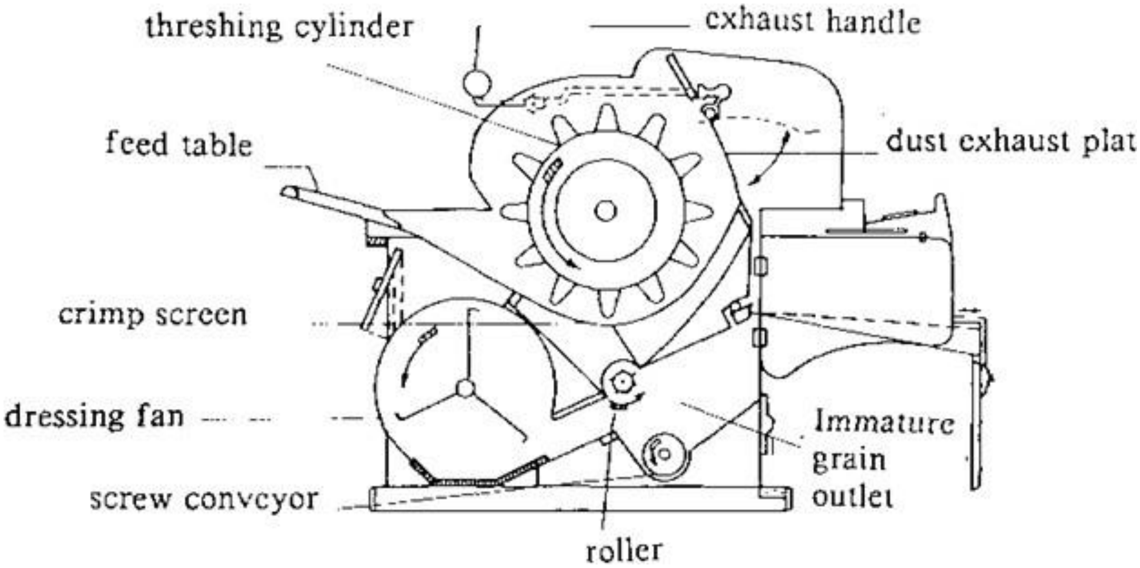
A mechanical crop thresher mainly consists of the following component/ devices:

a) Feeding device (chute/tray/trough/hopper/conveyor)
b) Threshing cylinder (hammers/spikes/rasp-bars/wire-loops/syndicator)
c) Concave (woven-wire mesh/punched sheet/welded square bars)
d) Blower/aspirator
e) Sieve-shaker/straw-walker.

**WORKING PRINCIPLE**

The crop is fed from the feeding tray into the threshing cylinder. The threshing cylinder is fitted with spikes/bars/hammers or wire-loops around its periphery according to the type of thresher. During operation, the crop material is slightly pushed into the threshing cylinder through the feeding chute, which gets into the working slit created between the circumference of the revolving drum having attached spikes and the upper casing. The speed of the spikes is greater than the plant mass due to which they strike the latter which results in part of the grain being separated from straw. Simultaneously, the drum pulls the mass through the gap between the spikes and the upper casing with a varying speed. The angle iron ribs on the other hand, restrain the speed of the travelling of stalks clamped by the spikes. Due to this the spikes move in the working slit with a varying speed in relation to the shifting mass of material, which is simultaneously shifted, with a varying speed with respect to the upper casing. As a result, the material layer is struck several times by the spikes against the ribs, causing threshing of the major amount of grains and breaking stalks into pieces, and also accelerating them into the inlet of the lower concave.

As the material layer shifts towards the progressively converging slit of lower concave, its size reduces. The vibration amplitudes, therefore, decrease, whereas the speed of the layer increases. This causes mutual rubbing of the ear stalks, as well as rubbing of the ears against the edges of the concave bars and causes breaking of stalks depending on the concave clearance. Since the system is closed, the thicker stalk, which cannot be sieved through the concave, again joins the fresh stalk and the same process is repeated until the stalk size is reduced to the extent that it compass through the concave apertures. Thus fine bruised straw is produced. The entire or a portion of threshed material falls from the concave on to top sieve of the cleaning system. Due to reciprocating motion of top sieve lighter accumulate at the top and grain falls on to the bottom sieve. In case of spike tooth thresher, an aspirator blower sucks out the lighter material from the top sieve and throws it out from blower outlet. The sieves help in further cleaning of the grain by allowing heavier straw to overflow.




**Power Thresher**

## PROCEDURE

Feed weighed quantity of unthreshed paddy into the thresher at a constant rate. Allow complete threshing of paddy. After the threshing operation apply the following formulas and calculate the threshing efficiency, cleaning efficiency and the percentage loss.

***Threshing efficiency (TE)*****:** It is the ratio of the mass of threshed millet to the total mass of the millet panicle expressed in percentage and is given as

$$T_E = (M_t/M) \times 100$$

Where,

$T_E$ = the threshing efficiency (%)

$M_t$ = mass of threshed paddy (g)

$M$ = total mass of paddy panicle (g)

***Cleaning efficiency (CE):*** It is the ratio of mass of separated impurities to the total mass of impurities in the millet expressed in percentage and is given as:

$$\mathbf{CE = (M_{si}/M_{usi}) \times 100}$$

Where,

CE = the cleaning efficiency (%)

$M_{si}$ = mass of separated impurities (g)

$M_{usi}$ = mass of un-separated impurities (g)

***Percentage loss (PL):*** It is the ratio of quantity of millet loss to the total quantity of the millet panicle expressed as a percentage and is given as:

$$PL = \quad (M_{rg}/M_{rg}+M_{lg}) \times 100$$

Where,

PL= the percentage loss (%)

$M_{rg}$ = the mass of recovered paddy (g)

$M_{lg}$ = mass of paddy losses (unthreshed loss+ separation loss+ scattering Loss+ blower loss) (g)

**OBSERVATION AND CALCULATION**:

| | |
|---|---|
| Total mass of paddy panicle | = |
| Mass of threshed paddy | = |
| Mass of separated impurities | = |
| Mass of un-separated impurities | = |
| Mass of recovered paddy | = |
| Unthreshed loss | = |
| Separation loss | = |
| Scattering Loss | = |
| Blower loss | = |
| Threshing efficiency | = |
| Cleaning efficiency | = |
| Percentage loss | = |

**RESULT**

Threshing efficiency =

Cleaning Efficiency =

Percentage loss =

## Ex.No: 5 Testing of Groundnut Decorticator and Maize Sheller

**AIM**

To find out the shelling efficiency, percentage of broken and capacity of groundnut Decorticator (hand operated).

**APPARATUS**

Groundnut decorticator (hand operated), groundnut pods, balance etc.

**DESCRIPTION**

Hand operated groundnut decorticator consists of curved ‘L’ angle frame and four legs. A perforated sieve in a semi-circular shape is provided. Seven cast iron peg assemblies are fitted in an oscillating sector. The groundnut pods are shelled between the oscillating sector and the perforated concave sieve. The kernels and husk are collected at the bottom of the unit. The clearance between the concave and oscillating sector is adjustable to decorticate pods of different varieties of groundnut. The sieve is also replaceable according to the variety of groundnut pods.

**PROCEDURE**

The clearance between the concave and oscillating sector was adjusted according to the size of the groundnut pod. One kg of groundnut is weighed and fed into the unit. The pods are shelled by operating the oscillating sector. Time taken for shelling one kg of pods is noted. The kernels, husk and unshelled pods are collected at bottom. From the product, kernels, broken and unshelled pods are separated and weighed.

$$\text{Capacity} = \frac{W_f}{T} kg/h$$

Where,

$W_f$ = Weight of feed ( kg)

$T$ = Time taken for shelling (h)

$$\text{Shelling efficiency, } S = \frac{(1 - W_u)}{W_f} \times 100(\%)$$

Where,

$S$ = Shelling efficiency, %

$W_u$ = Weight of unshelled pods, kg

$W_f$= Weight of sample taken, kg

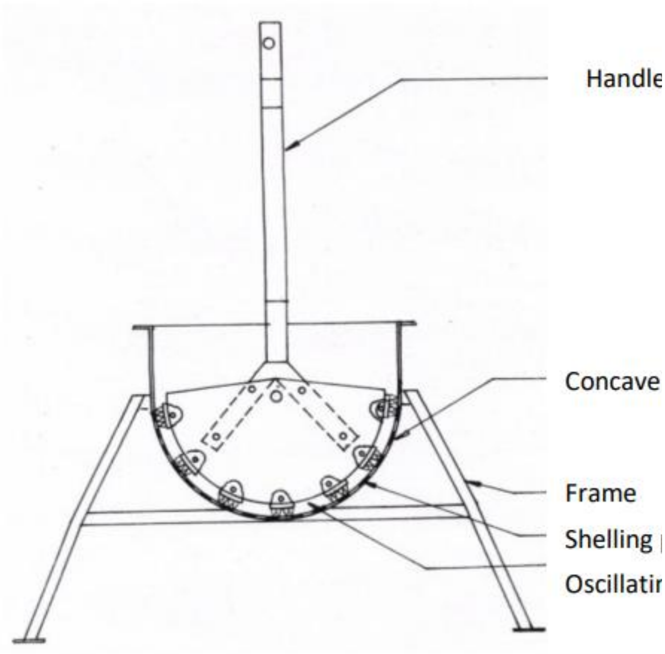
$$\text{Percentage broken } (P_b) = \frac{W_{bk}}{W_{tk}} \times 100(\%)$$

Where,

$P_b$ = Percentage of broken (%)

$W_{bk}$ = Weight of broken kernels (kg)

$W_{tk}$ = Weight of total kernels (kg)




**Groundnut Decorticator**

## OBSERVATIONS AND CALCULATION:

Weight of Groundnut taken ($W_f$) = kg

Weight of unshelled pods ($W_u$) = kg

Time taken for shelling (T) = Hr

Weight of good Kernels ($W_{gk}$) = kg

Weight of Broken Kernels ($W_{bk}$) = kg

Weight of total Kernels ($W_{tk}$) = $W_{gk}$+ $W_b$k = kg

1. Capacity = $W_f$ / T (kg/hr)
2. Shelling Efficiency, S = (1-$W_u$/ $W_f$) x 100 (%)
3. Percentage Broken ($P_b$) = ($W_{bk}$/ $W_{tk}$) x 100 (%)

## RESULT

1. Capacity of Groundnut Decorticator (Hand Operated) = (kg/hr)
2. Shelling Efficiency of Groundnut Decorticator = (%)
3. Percentage of Broken = (%)

# Ex.No:6 Evaluation of Thin Layer Drier

**AIM**

i. To draw the drying characteristic curves for the given grain

ii. To determine the drying constant for the given grain

**APPARATUS**

Lab model thin layer grain dryer, grain sample, thermometer, oven, balance, etc.

**THEORY**

Drying of agricultural commodities like cereal grain is an essential processing operation for extending storage life. Drying can be performed in two ways namely thin layer drying and deep bed drying. In thin layer drying, a layer of grain is exposed to hot dry air for removal of moisture. In deep bed drying a drying front steadily propagates through the deep grain mass removing moisture.

Drying characteristics include plots drawn between residual moisture or rate of moisture removal against drying time. The process of drying is described by the following equation:

$$\frac{M - M_e}{M_o - M_e} = e^{-kt}$$

Where,

$M$ - Moisture content at time't' % (d.b.)

$M_0$ - Initial moisture content % (d.b.)

$M_e$ - Equilibrium moisture content % (d.b.)

$t$ - Drying time in hours

$k$ - Drying constant

On a graph sheet, the residual moisture removal rate is plotted against the time to get the drying constant '*k*'

## DESCRIPTION

The lab model thin layer dryer consists of a blower heater assembly, plenum chamber and holding bin. The blower used is a built in type run by single phase electric motor and has provision to adjust the air flow rate at the suction side. The delivery end is connected to the heater assembly. The heater assembly is made in the cylindrical shape and 3 numbers of heating coils of 1000 W rating have been provided and connected in series. The other end of the heater assembly is connected to plenum chamber.

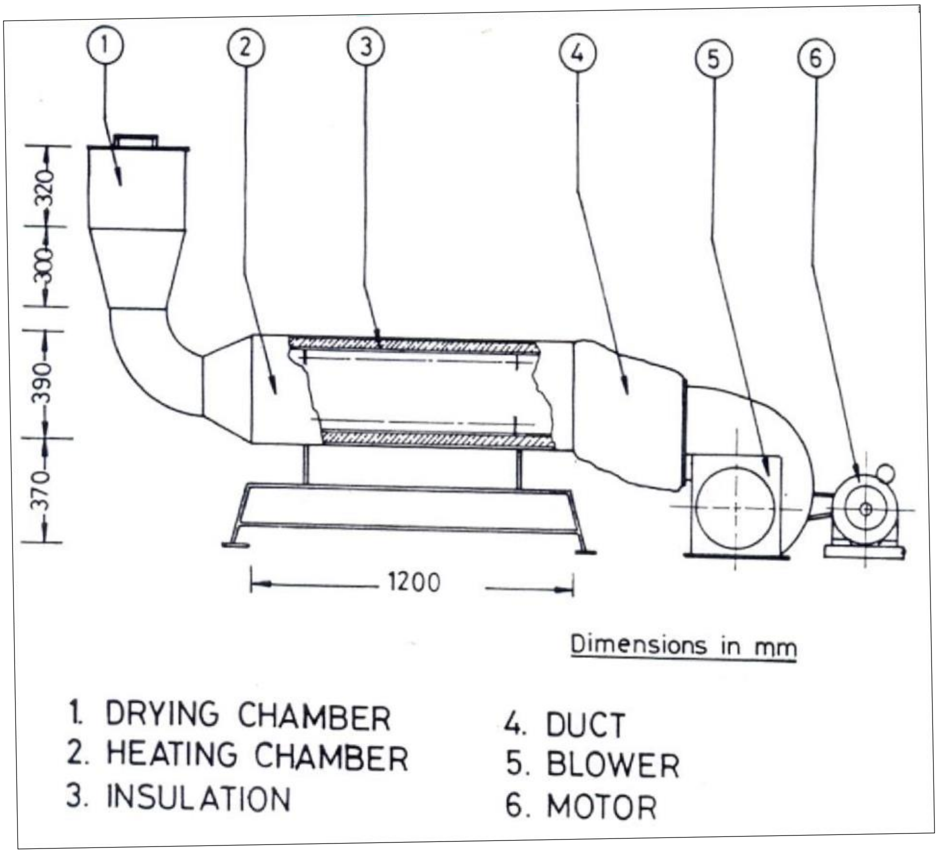
At the inlet of the heater assembly an orifice is provided to measure the airflow rate with the help of a U-tube manometer in terms of velocity head. In the plenum chamber a container is provided to hold the grain to be dried. This container can be removed at periodical intervals for weighing the grain along the bin to avoid spilling of grain during handling / transferring.

A stem type thermometer is provided in the ‘Plenum chamber’ and connected in the circuit to control the temperature of hot air. Timer switch is also provided, in the circuit to put off the complete equipment at desired time interval of drying.

## PROCEDURE

The empty mass of the grain holding container and the mass of sample taken for drying are noted. To determine the initial moisture content of grain, a minimum of three samples each of 10 g are taken and kept in the oven at $130 \pm 2^0C$ for one hour.

The container with grain is placed in the plenum chamber and drying process is started at desired airflow rate and air temperature. The timer switch can be set at desired time interval in steps of 10 minutes. For every 10 minutes interval temperature of air at inlet (suction), hot air and exhaust air from container are recorded. The change in mass at every 10 minutes is also recorded, until a constant value is reached.




**Thin layer dryer**

**OBSERVATIONS**

**Table 1. Moisture content and Temperature measurements**

| **Sl. No.** | **Time (min)** | **Initial weight (g)** | **Final weight (g)** | **Initial temp. of air $^oC$, ($t_0$)** | **Temp. of hot air $^oC$, ($t_1$)** | **Temp. of exhaust air $^oC$, ($t_2$)** |
|---|---|---|---|---|---|---|
| 1 | 10 | | | | | |
| 2 | 20 | | | | | |
| 3 | 30 | | | | | |
| 4 | 40 | | | | | |
| 5 | 50 | | | | | |
| 6 | 60 | | | | | |
| 7 | 70 | | | | | |
| 8 | 80 | | | | | |
| 9 | 90 | | | | | |
| 10 | 100 | | | | | |

**CALCULATIONS**

1. Initial moisture content of grain = % (d.b.)

2. Moisture content of grain at time '*t*' min of drying

$$= \frac{\text{Initial mass of grain} - \text{Final mass of grain at 't' min}}{\text{Bone dry material}}$$

3. Drying rate at '*t*' min $= \frac{\text{Mass of water removed at time '}t\text{' min in kg}}{\text{Time in hours}}$

4. The equilibrium moisture content of grain for the ambient conditions needs to be taken from published data and used in the calculations.

**Table 2. Estimation of drying constant and drying rate**

| S.No. | Time (min) | Initial moisture content ($M_0$) | Final moisture content ($M$) | $(M-M_e)/(M_0-M_e)$* | Drying rate (kg/h) |
|---|---|---|---|---|---|
| 1 | 10 | | | | |
| 2 | 20 | | | | |
| 3 | 30 | | | | |
| 4 | 40 | | | | |
| 5 | 50 | | | | |
| 6 | 60 | | | | |
| 7 | 70 | | | | |
| 8 | 80 | | | | |
| 9 | 90 | | | | |
| 10 | 100 | | | | |

* On a graph sheet, the residual moisture removal rate is plotted against the time to get the drying constant '*k*'

**RESULTS**

(i) Drying constant ($k$) =

(ii) Drying characteristic curves for the given grain were drawn.

# Ex.No: 7 Evaluation of LSU Drier

**AIM**

i) To draw the drying characteristic curves for the given grain

ii) To determine the drying constant for the given grain

**APPARATUS**

Lab model LSU dryer, grain sample, thermometer, oven, balance, etc.

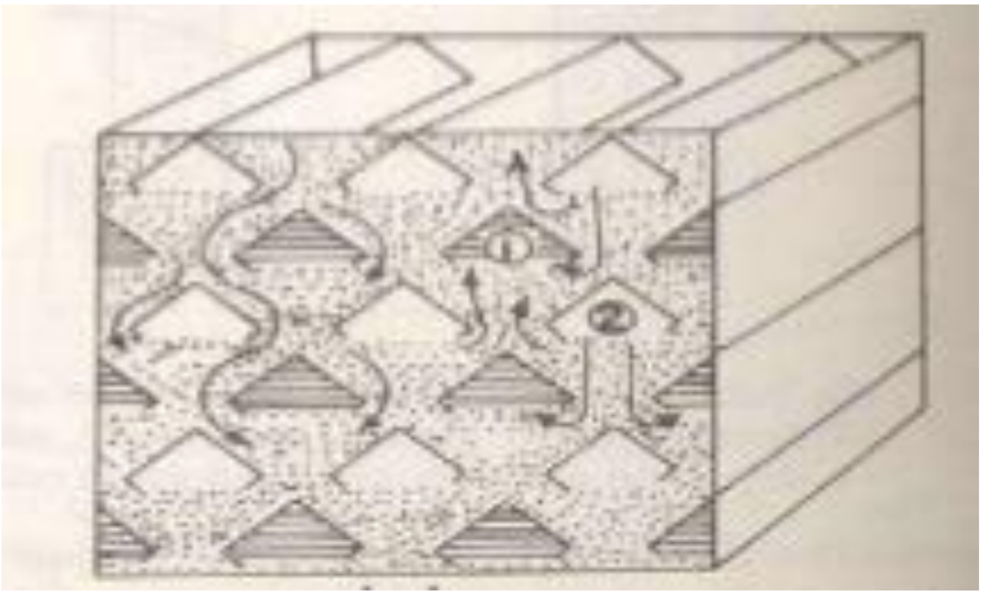
**DESCRIPTION**

The design of this continuous dryer was developed in Lousiana State University in the mid-1950s called the L.S.U. dryer. This design was developed specifically for rice to ensure gentle treatment, good grain mixing and good air to grain contact. It is a mixing type continuous flow dryer, in which layers of inverted V-shaped channels are installed. The layers alternate between hot air intake and exhaust air outlets and are staggered to provide mixing.

**PROCEDURE**

The empty mass of the grain holding container and the mass of sample taken for drying are noted. To determine the initial moisture content of grain, a minimum of three samples each of 10 g are taken and kept in the oven at 130± $2^0$C for one hour.

The container with grain is placed in the plenum chamber and drying process is started at desired airflow rate and air temperature. The timer switch can be set at desired time interval in steps of 10 minutes. For every 10 minutes interval temperature of air at inlet (suction), hot air and exhaust air from container are recorded. The change in mass at every 10 minutes is also recorded, until a constant value is reached.




**LSU dryer**

**OBSERVATIONS**

**Table 1. Moisture content and Temperature measurements**

| **Sl. No.** | **Time (min)** | **Initial weight (g)** | **Final weight (g)** | **Initial temp. of air $^oC$, ($t_0$)** | **Temp. of hot air $^oC$, ($t_1$)** | **Temp. of exhaust air $^oC$, ($t_2$)** |
|---|---|---|---|---|---|---|
| 1 | 10 | | | | | |
| 2 | 20 | | | | | |
| 3 | 30 | | | | | |
| 4 | 40 | | | | | |
| 5 | 50 | | | | | |
| 6 | 60 | | | | | |
| 7 | 70 | | | | | |
| 8 | 80 | | | | | |
| 9 | 90 | | | | | |
| 10 | 100 | | | | | |

**CALCULATIONS**

1. Initial moisture content of grain = % (d.b.)

2. Moisture content of grain at time '*t*' min of drying

$$= \frac{\text{Initial mass of grain – Final mass of grain}}{\text{Bone dry material}}$$

3. Drying rate at 't' min = $\frac{\text{Mass of water removed at time '}t\text{' min in kg}}{\text{Time in hours}}$

4. The equilibrium moisture content of grain for the ambient conditions needs to be taken from published data and used in the calculations.

**Table 2. Estimation of drying constant and drying rate**

| SI.No. | Time (min) | Initial moisture content ($M_0$) | Final moisture content ($M$) | $(M-M_e)/(M_0-M_e)$* | Drying rate (kg/h) |
|---|---|---|---|---|---|
| 1 | 10 | | | | |
| 2 | 20 | | | | |
| 3 | 30 | | | | |
| 4 | 40 | | | | |
| 5 | 50 | | | | |
| 6 | 60 | | | | |
| 7 | 70 | | | | |
| 8 | 80 | | | | |
| 9 | 90 | | | | |
| 10 | 100 | | | | |

* On a graph sheet, the residual moisture removal rate is plotted against the time to get the drying constant '*k*'

**RESULTS**

(i) Drying constant ($k$) =

(ii) Drying characteristic curves for the given grain were drawn.

**Ex No 8**

# Determining the Efficiency of Bucket Elevator and Screw Conveyor

**AIM**

To determine the conveyance efficiency of bucket elevator and screw conveyor

**APPARATUS**

Bucket elevator, Screw conveyor, tachometer, balance, stop-watch, grain, etc.

**THEORY**

Bucket elevator is an important grain handling equipment, which can be found in modern mills and storage silos. It is used to convey material vertically. It consists of a series of buckets / cups arranged to an endless belt rotated by a power source. The bucket is filled with grains during upward movement and discharged at the top due to centrifugal force. The capacity depends on the bucket size and speed of operation. For proper discharge of the material, the weight of the material in each cup should be equal to the centrifugal force created due to rotation.

The theoretical capacity of the bucket elevator is derived as follows:

Let

$v_c$ = Volume of each cup in $m^3$

$V$ = Linear velocity of belt

$= \pi DN/60$

$D$ = Diameter of pulley (m)

$N$ = Speed of rotation (rpm)

$S$ = Spacing between 2 cups in m

$\omega$ = Bulk density of grain ($kg/m^3$)

The velocity of belt is $= \pi DN/60$

No. of cups delivering grain per meter length of the belt is 1 per second.

Mass rate of grain delivered = $\boldsymbol{\pi D N v_c \omega / 60S}$ $kg/s$

Volume rate of grain delivered= $\boldsymbol{\pi D N v_c / 60S}$ $kg/s$

Theoretical capacity of bucket elevator = ($\pi DNv_c\,\omega / S$ ) x 60 kg/f

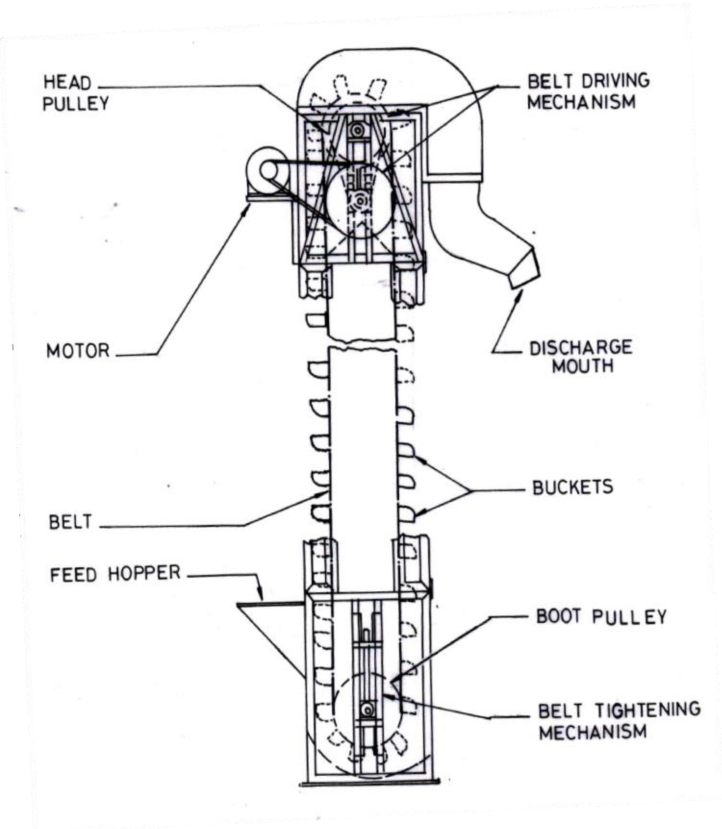
**DESCRIPTION**

The lab model bucket elevator consists of small trapezoidal steel buckets mounted on an endless flat belt. The belt drive runs on two pulleys. The header pulley is driven by a motor of 0.5 hp. The belt with the cups runs vertically for about a height of 2 m. The cups are placed at a particular interval in the belt. The belts, cups and pulleys are mounted on a steel frame.

The grain from the hopper reaches the pulley and taken by the cups during the upward movement and is discharged at the top by the centrifugal force. An outlet is provided at the top to collect the discharged grain.

**PROCEDURE**

The footer is filled with sufficient grain and the unit is switched on. The grain will be collected by the incoming cups in the footer and will be carried on vertically over the belt. The cups will deliver the grain as it leaves the header. The grain delivery is due to the centrifugal force acting on the pulley. The speed of rotation of the header pulley is noted. The mass of grain delivered for a given time period is also noted.



## OBSERVATIONS AND CALCULATIONS

| | | |
|---|---|---|
| Volume of each cup ($v_c$) | = | $m^3$ |
| Distance between two consecutive cups ($S$) | = | m |
| Speed of the rotation ($N$) | = | rpm |
| Diameter of the pulley ($D$) | = | m |
| Velocity of belt ($V=\pi DN/60$) | = | m/s |
| Mass of Grain Collected ($M_g$) | = | kg |
| Time taken (t) | = | hr |
| Actual Capacity ($Ac=M_g/T$) | = | kg/hr |
| Theoretical Capacity ($T_c = (\pi DN\omega\upsilon_c / S) \times 60$) | = | kg/hr |

Conveying Efficiency = **Actual Capacity ($A_c$)/ Theoretical Capacity ($T_c$) x 100**

## THEORY OF SCREW CONVEYOR

Screw conveyor is one of the grain handling equipment. Helical screws mounted on a shaft is used to convey the material horizontally and upto a slope of $15^0$. The material held between two screws (pitch) will be conveyed in rotation in helical paths taken by the screw.

If,

| | | |
|---|---|---|
| $D$ | = | Diameter of screw (cm) |
| $d$ | = | Diameter of shaft (cm) |
| $P$ | = | Pitch of the screw (cm) |
| $N$ | = | Speed of rotation (rpm) |
| $\omega$ | = | Bulk density of grain in kg/m$^3$ |

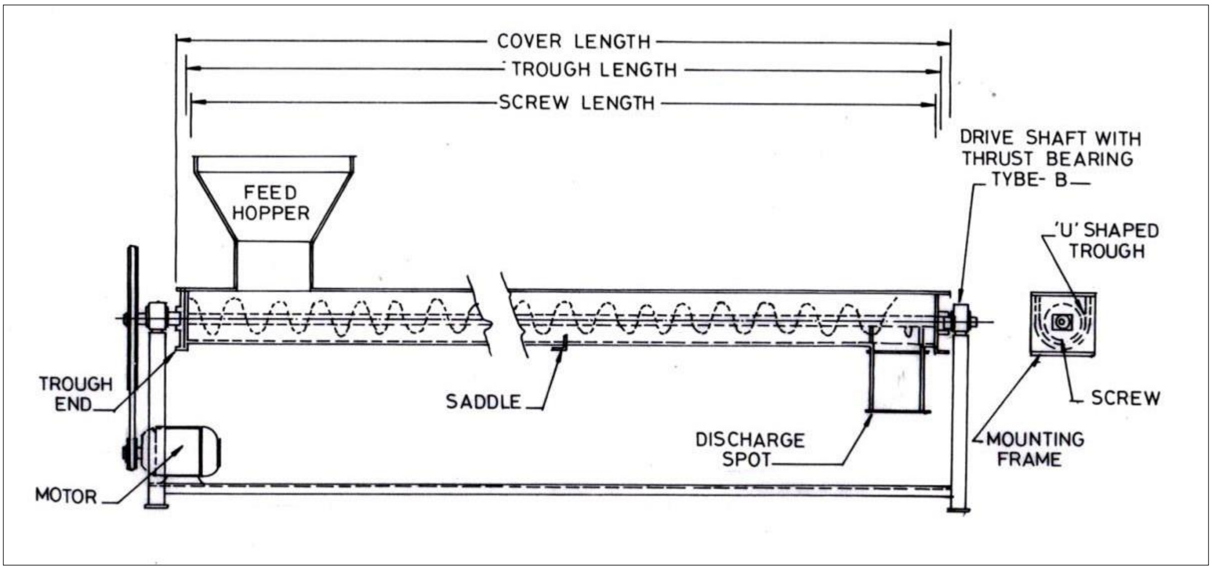
$$\text{Quantity of material held in one pitch} = \frac{\pi}{4}(D^2 - d^2)P\frac{\omega}{10^6}\ kg$$

$$\text{Quantity of material conveyed in one hour} = \frac{\pi}{4}(D^2 - d^2)P\frac{\omega}{10^6} \times N \times 60\ kg$$

**PROCEDURE**

The feed hopper is loaded with grain and the screw conveyor is made to run idle for 5 minutes. The diameter and pitch of the screw and the length of the conveyor are measured using a measuring tape. The speed of rotation of the shaft is measured by a tachometer. The feed hopper is opened and material is allowed to convey by the screw. Time taken for collecting known volume of grain is noted at the other end. By using the formula, the conveying efficiency of screw conveyor is calculated by

Conveying Efficiency = **Actual Capacity ($A_c$)/ Theoretical Capacity ($T_c$) x 100**



## CALCULATION

| | | |
|---|---|---|
| Diameter of the screw ($D$) | = | cm |
| Diameter of the shaft ($d$) | = | cm |
| Speed of the screw ($N$) | = | rpm |
| Pitch of the screw ($P$) | = | cm |
| Bulk density of the grain ($\omega$) | = | kg/m$^3$ |
| Quantity of the grain collected ($W_g$) | = | kg |
| Time taken ($T$) | = | kg |

Actual capacity ($A_c$) $= \dfrac{W_g}{T} =$ kg/h

Theoretical capacity ($T_c$) $= \dfrac{\pi}{4}(D^2 - d^2)P\dfrac{\omega}{10^6} \times N \times 60$ kg/h

Conveying efficiency $= \dfrac{\textit{Actual capacity}\,(A_c)}{\textit{Theoretical capacity}\,(T_c)} \times 100$ %

**RESULT**

The conveyance efficiency of the bucket elevator is %

The conveying efficiency of the screw conveyor is %

# Ex.No: 9 Evaluation of Shelling Efficiency of Rubber Roll Sheller

## AIM

To evaluate the following parameters:

i) Capacity of the sheller

ii) Shelling efficiency

iii) Total rice yield

iv) Head rice recover

v) Percentage of brokens

## APPARATUS

Paddy, rubber roll sheller, sample divider, balance, tachometer etc.

## THEORY

The paddy grain deformation is caused by shearing and compression of the two rotating rubber surfaces, which is sufficient to separate the rice from husk. Paddy is passed through the clearance between the two rubber rollers rotating at opposite direction at different speeds. The clearance between rollers is smaller than the mean thickness of the paddy. One part of the husk is subjected to shear force whereas the other part in contact with slower roller is under compression.

## PROCEDURE

Two kilogram of paddy is weighed and transferred to the feed hopper of the rubber roll sheller. The motor is switched on and the rollers are allowed to attain the rated speed. The feed hopper is opened and the paddy is passed through the roller. The stopwatch is used to note the time taken for dehusking the paddy. The tachometer is fixed at the center of the roller shaft and the speed of each roller is calculated. Three samples each weighing 50 grams is taken from feed and the brown rice and husk are separated manually. Three samples each weighing 50 grams of dehusked sample is taken using the sample divider and unshelled paddy, shelled rice, broken rice and husk are separated manually.

## OBSERVATION AND CALCULATIONS

Weight of paddy taken for shelling ($W_f$) = kg

Time taken for shelling ($t$) = h

i. Capacity of the rubber roll sheller $= \dfrac{W_f}{t}$ kg/h

**From the feed**

Weight of paddy sample taken ($a$) = g

Weight of rice present in the paddy ($b$) = g

Rice-husk ratio ($A = b/a$) =

Percentage of rice present in the paddy ($B = (b/a) \times 100$) =

**From the dehusked sample**

Weight of paddy sample taken ($c$) = g

Weight of unshelled paddy ($d$) = g

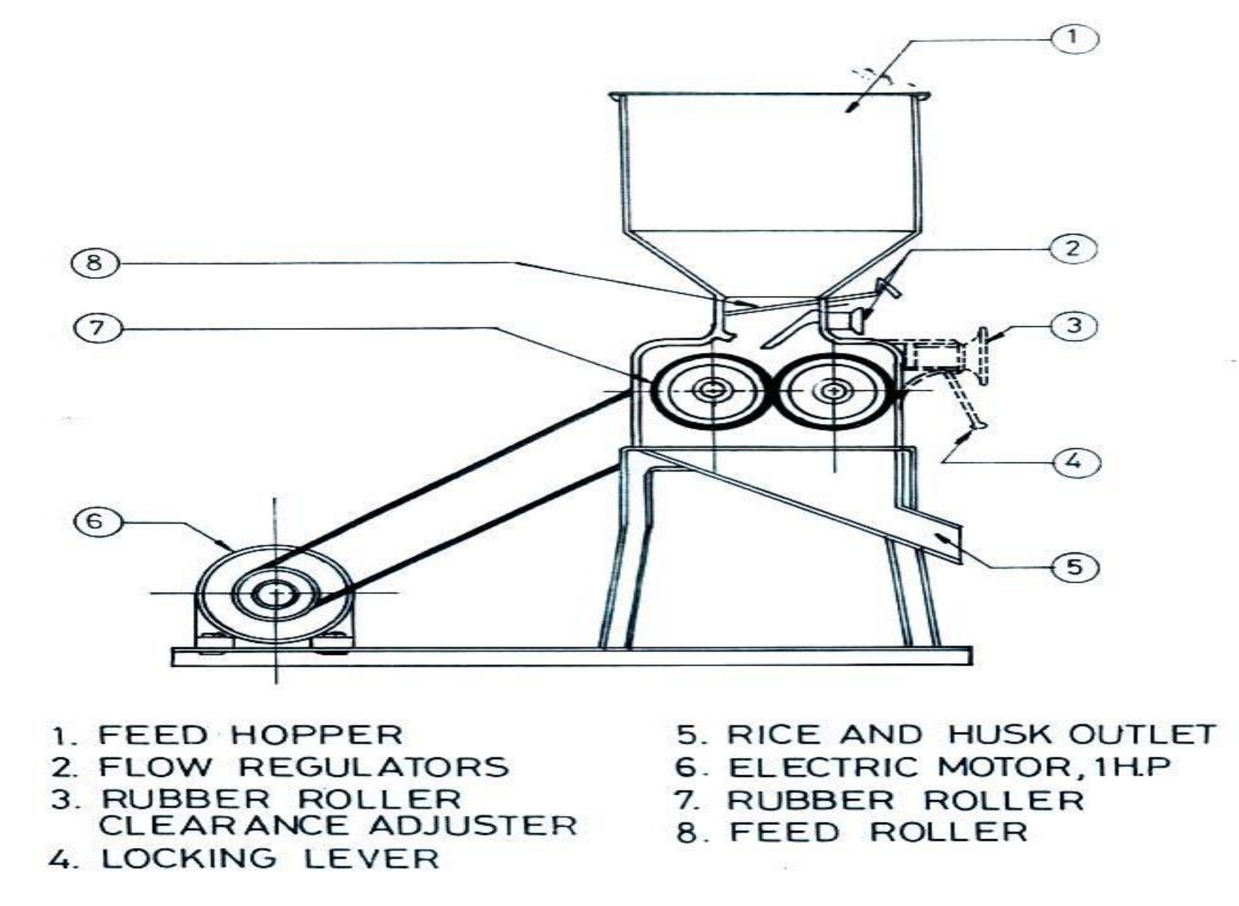
Weight of shelled paddy ($e$) = g

Weight of brokens ($f$) = g

Weight of husk ($g$) = g

ii Percentage of brokens ($C$) , % $= \dfrac{f}{c-(g+d)} \times 100$

**Fraction of Broken Rice (D) = C/100**




Percentage of brown rice coming out ($E$) from dehusker (%) = $\left(1-\dfrac{g+d}{c}\right)\times 100$

iii. Shelling efficiency (%) ($F$) $= \dfrac{E}{B}(1-D^2)\times 100$

iv. Total rice yield ($G$) $= \dfrac{e}{c}\times W_f$ kg

v. Head rice recovery (%) ($H$) $= \dfrac{e-f}{c}\times 100$

**RESULTS**

| | | |
|---|---|---|
| 1. Capacity of rubber roll sheller | = | kg/h |
| 2. Shelling efficiency | = | % |
| 3. Total rice yield | = | kg |
| 4. Head rice recovery | = | % |
| 5. Percentage of broken | = | % |

# Ex.No:10 Determining the Oil Content of Oil Seeds

**AIM**

To determine the oil content of sesame oil sample

**MATERIALS AND APPARATUS REQUIRED**

Grounded oil seed sample, thimble, petroleum ether, Soxhlet apparatus, Hot air oven and weighing balance

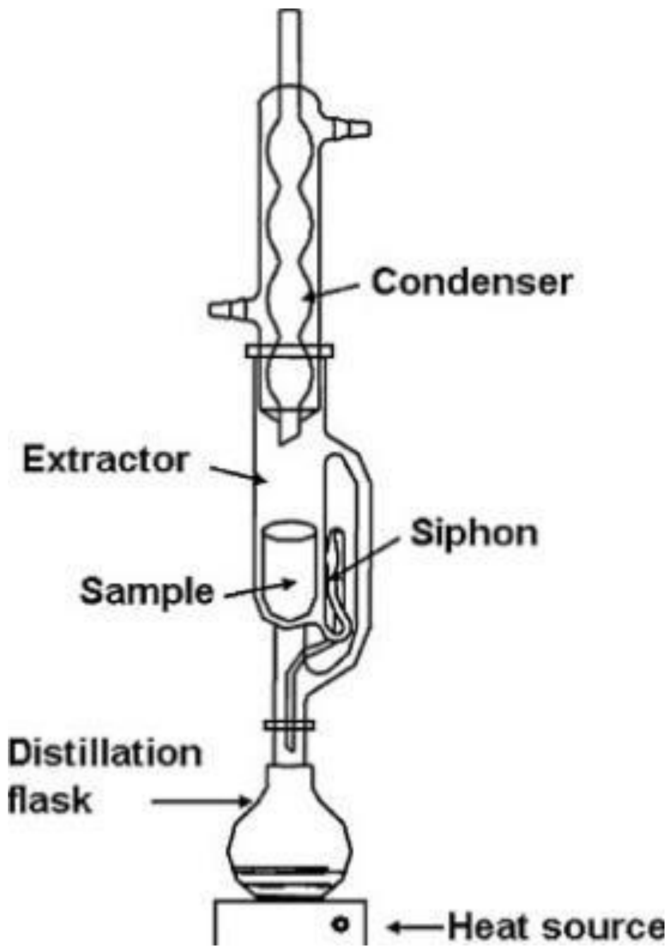
**PRINCIPLE**

This process involves extraction of oil from the test portion in the soxhlet apparatus with solvents like hexane or petroleum ether. Which is then made free of solvent and the extract obtained is then weighed.

**PROCEDURE**

Turn on the Soxhlet apparatus and start to heat up the unit. Open the cold water tap for the reflux condensers. Weigh the sample into the thimbles. Put a cotton plug on the top of the sample and place the thimbles into thimble support attached to the holder. Insert the thimbles into the Extraction Unit. Weigh the extraction cups (with boiling chips). Insert the extraction cups, each with 50 ml of extraction solvent, into the Extraction Unit (use the cup holder).

Extract the sample for 3 hours. Collect the distillate after extraction. Dry the distillate in an oven with adjusted temperature between 103 and 105 ºC for 20 minutes. Cool the extraction cups in a desiccator (20 minutes) and weigh them.




**Soxhlet Apparatus**

## OBSERVATIONS AND CALCULATION

Weight of the sample (W) =

Weight of distillation flask (W1) =

Weight of distillation flask with dried extract (W2) =

Oil Content % = {(W2 – W1) X 100/W} =

## RESULT

The oil content of the given sesame oil seed sample =