UNIT 2 CLEANING AND GRADING

Structure

2.0 OBJECTIVES

After reading this unit you should be able to:

- understand principles of cleaning and grading
- know factors affecting cleaning and grading operation
- learn principles of separation and grading
- understand screening and its principles
- learn about efficiency of cleaners and graders
- learn about pneumatic and spiral separators
- know about cyclone separators

2.1 INTRODUCTION

Cleaning and grading are the first and most important post harvest operations undertaken to remove foreign and undesirable materials from the threshed crops and grains and also to separate the grains into various fractions. Cleaning in agricultural processing generally means the removal of foreign and undesirable matters from the desired grains/products. This may be accomplished by washing, screening, hand picking etc. Grading refers to the classification of cleaned products into various quality fractions depending upon the various commercial values and other usage. Sorting refers to the separation of cleaned product into various quality fractions that may be defined on the basis of size, shape, density, texture and colour. Scalping refers to the removal of few large particles in an initial process. This unit covers the principles of cleaning and grading of crops, its mechanism and machines used for the operation.

2.2 CLEANING OPERATION FOR GRAIN, NUTS AND SEEDS

The grain stock consists of grains of the main crop, other plants and admixture of various contaminants of mineral and organic origin. The main crop may include grains, which are wholesome or damaged (mechanically or biologically) or shriveled and underdeveloped. During cleaning other materials are removed from the grain stock while in grading the cleaned grains are sorted into seed material, food stock, forage and industrial grains. Each of these groups is governed by special quality specifications. In most cases cleaning and grading is done simultaneously. The choice of equipment for mechanical cleaning and grading is governed by the physical and mechanical properties of the grain material. The comparative commercial value of agricultural products is dependent on their grade factors. These grade factors further depend upon: Physical characteristics like size, shape, moisture content, colour etc., Chemical characteristics like odour, free fatty acid content and biological factors like insect damage and germination in case of seeds.

2.3 FACTORS CONTROLLING THE CLEANING OPERATION-SIZE, SHAPE, SPECIFIC GRAVITY AND SURFACE CHARACTERISTICS

The differences between crop material and the contaminants in physico-mechanical properties are used to clean and grade grains. These properties include;

1. Grains size (length, width, thickness)
2. Mass of grain (bulk density, difference in weight)
3. Nature and properties of surface
4. Shape
5. Aerodynamic properties
6. Surface texture
7. Colour
8. Electromagnetic properties
9. Affinity for liquid Seed Conductivity

Grain size: The size of grains can be determined by direct measure using special scales or a caliper. Grain length, width and thickness are noted for grains to obtain an average representing the lot. Important deviations exist among varieties.

Shape: It defines the form of an object. Based on longitudinal and cross sections of the grains, its shape is compared with standard shapes. The grains may be round, oblate, oblong, conic, ovate, obviate, elliptical, truncate, unequal, ribbed, regular or irregular shaped.

Equivalent diameter and sphericity: Equivalent diameter is the geometric mean of three dimensions *viz*; length, width and thickness. Sphericity is defined as the ratio of surface area having same volume as that of grain to the surface area of the grain.

Thousand-grain weight: The weight of thousand grains (as-is basis) is defined as the weight of 1000 grains including their water content at the time of determination. It is determined using the method described by BIS as IS: 4333

(part IV)-1968. This characteristic is thus influenced by water-content variations. In certain cases, it is referred to as the "thousand dry-grain weight" when grains are supposedly dried out. This must be mentioned with the numerical results obtained.

Hectoliter weight: The natural hectoliter mass of grains is defined as the apparent volumetric mass of grains as they fill a container of known volume including the natural inter-granular space. This characteristic is measured in a fast and easy way, conventional but normalized. The result is expressed in kilograms per hectoliter.

Angle of repose: It is considered an important property in design of grain bins, silos and other storage structures. When the grain is allowed to flow freely from a point into a pile, the angle, which the side of the pile makes with horizontal plane, is called angle of repose.

Dielectric properties: Dielectric properties of grains vary widely and are dependent upon many factors relating to quality. Electrical properties of agricultural material depend heavily on their moisture content and the nature of water held. Chemically bound water exerts less influence on the dielectric properties than the free water in which polar molecules can orient freely with an applied electric field. Both dielectric constant and dielectric loss factor increase with moisture content of a product and decrease with frequency. There may be linear relationship between dielectric properties of particulate materials and their densities, especially, bulk density but not particle density.

Separation of grain mix according to the particle size is the most widely used method for cleaning and grading. The size of a grain is specified by its length, width and thickness, where the largest dimension is the length, the intermediate dimension the width and the smallest dimension the thickness. The variational series or the variational curve constituted from large-scale measurement data for the grain under consideration serves as the variability index of one or the other dimension over the entire population.

The absolute mass of the grains is characterized by the mass of 1000 grains reduced to that of dry product. The density of a grain is given by

$$P = m/V$$

Where m is the mass of grain and V is its volume.

Cleaning and grading according to the grain density is widely used in pneumatic grading boards. The grain stock is delivered to an inclined sieving board, which executes a reciprocating motion. Air is blown from below the board. Heavy grains gravitate downward while lighter ones raise to the surface.

Among the aerodynamic properties the most important is its critical velocity at which the grains are held in suspension in a flowing medium. It is also known as terminal velocity of the grain. If a thin layer of grain mass and contaminants with different terminal velocities are subjected to an air stream of a given velocity, those particles with a smaller terminal velocity would be blown farther away.

Differences in the friction coefficient of grains over a surface are used to separate grain mixes on belt and canvas cleaners. The angle of inclination of the canvas

cleaner and grader is selected so that coarse grains, which have a large friction angle, slide downward.

Differences in electric conductivity, dielectric permeability, polarizability and the ability to be electrically charged and discharged may serve as the basis for using electrical methods of separating grain mixtures.

Differences in colour of grains are also used for separating the grain mixtures. The mud balls, foreign matters and immature or diseased grains have different colour than mature grains. Based on sensing the grain colour, the grains can be separated.

2.4 SELECTION OF MACHINES

It is very difficult to clearly differentiate among the processes of cleaning, grading and separation because all of these are carried out simultaneously with the common procedures. The operation of cleaning, grading and separation of the products are performed by exploiting the difference in engineering properties of the materials. The appropriate machine is selected based on the fact that differences in the identified properties of grain and admixture is more as well as based on the end use of the product. These products may be used either for food or seed purposes. Various types of cleaning, grading and separation equipment have been designed and developed on the basis of properties of product to be handled. These machines separate the impurities of specific types as described below.

1. **Screen cleaner cum grader:** It performs the separation according to the size alone. The mixture of grain and foreign matter is dropped on a screening surface, which is vibrated either manually or mechanically. A single screen can make separation into two fractions. The screening unit may be composed of two or more screens as per the cleaning requirement.
2. **Air-screen cleaner cum grader:** The screens used in combination with air blast performs better cleaning and separation operation for most of the grains. The air screen cleaner cum grader uses three cleaning systems; blowing or aspiration, scalping screens and grading lower screens. The air screen cleaner cum grader can be classified into two distinct types: (i) Vibratory screen in which screens are tightened together and suspended by hangers in such a manner that these have horizontal oscillating motion and slightly vertical motion. These two motions in combination move the grain down the screen and at the same time toss the grain sufficiently above the screen to stir the grain. (ii) Rotary screen, which consists of circular decks. It rotates in circular motion in a horizontal plane. These have either single or double drum(s).
3. **Cellular surface separator**: The criteria for mechanical separation of grains on cellular surfaces is length of the grain corresponding to which cell size, its diameter is selected. The working component of this grader is honeycombed surface while its working element is cell. The cells trap the grain mass delivered to a moving cellular surface and grains of different lengths are trapped in different ways. Small, short grains, which can be completely enclosed in the cells, are more likely to be trapped than longer ones, which may not fit in them.
4. **Spiral Separator:** It separates the grains as per their roundness. The round material of mixture while flowing through a screw conveyor pick up speed as they roll down the inclined surface until centrifugal force becomes sufficient enough to throw them in the outer helix.
5. **Specific gravity separator:** It makes separation according to difference in density or specific gravity of the materials. It works on two principles, (i) the

characteristics of the grains to flow down over inclined surface, (ii) the floatation of the particle due to upward movement of air. During downward movement on a perforated deck, lighter materials are lifted to the top of stratified mass whereas the air does not lift the heavier particle. The stratified mass moves along the direction of conveyance due to oscillating motion of the deck.

6. **Destoner:** It is a form of specific gravity separator. It separates the grain mass into two fractions as per the difference in specific gravity. It consists of a perforated deck. The air coming through the deck from bottom stratifies the materials while the reciprocating action of the deck separates the heavy material from lighter particles. The heavier material moves upward while the lighter material flows downward. This machine is only used when stones and heavy impurities are present in the grain.
7. **Inclined draper:** The separation by inclined belt draper takes place due to difference in shape and surface texture of the material. This technique is used only when all other methods of separation fail.
8. **Velvet roll separator:** It is also called roll mill. It separates grains on the basis of differences in shape and surface texture. It is a finishing machine and should be used only after cleaning and separation of grain from chaff and trash. It is effective in separating grain with a rough seed coat or sharp angles from smooth surface grain.
9. **Pneumatic separator:** It is based on the differences in aerodynamic properties of the various constituents of the mixture. The aerodynamic properties of a particle depend upon its shape, size, density, surface and orientation with respect to air current.
10. **Separation based on fluidization technique:** The fluidized bed cleaner/ separator makes the classification of the seed due to difference in density and size. It is suitable for cleaning lighter seeds like cabbage, radish, lettuce, carrot, onion etc. Airflow rate plays important role during separation of the grain.
11. **Magnetic separator:** It performs separation based on surface texture and stickiness properties of the grain. Since the grains do not contain any free iron, therefore, are not attracted to magnet. A selective pretreatment of mixing finely ground iron powder to feed mass given to the grain causes iron powder adheres to rough, cracked, broken and sticky seed coats. On application of magnetic field the material having iron powder is separated.
12. **Colour Separator:** It is specifically used for grains of high commercial value. It separates the grains due to difference in colour or brightness. Seeds differ in colour because of varietal differences and also due to immaturity or disease. The mud balls and discoloured or defective seeds can be removed with the help of electronic separator.

While selecting a machine following points should be considered.

1. The machine should ensure a reduction in labour expended on unit production.
2. Differences in the physical and mechanical properties of the seeds. Machines based on only those properties should be selected where difference in property is more in grain and foreign matter.
3. Depending upon the end use of the grain like for seed purpose, commercial use, food use, feed use etc.
4. For high value crops, specific machines of low capacity may be selected whereas for low value grains higher capacity machine can be used.

5. Plant capacity and plant size.
6. Type of foreign matter present in the mixture.

2.5 AERODYNAMICS OF SMALL PARTICLES, METHODS OF SEPARATION- COLOUR, SPECIFIC GRAVITY, WEIGHT, SCREENING, TYPE OF SCREENS (REVOLVING, ROTARY, VIBRATORY, HORIZONTAL AND PERFORATED ETC.), EFFECTIVENESS OF SCREENS

Aerodynamic properties: The aerodynamic properties of grain include critical/ terminal velocity, drag coefficient and sailing velocity. Grain separation by an air stream is based on the differences among these properties.

Terminal velocity: The terminal velocity of a particle may be defined as equal to the air velocity at which a particle remains in suspended state in a vertical pipe. In this condition, after attaining the terminal velocity, if the density of the particle is greater than the density of the fluid, the particle will move downward. If the density of the particle is lesser than the density of the fluid, the particle will rise upward. Terminal velocity of a particle can be calculated using following equation,

$$V_t^2 = \frac{2mg(\rho_p - \rho_f)}{(\rho_p \rho_f A_p C)}$$

Where

V_t	terminal velocity, m/s
C	overall drag coefficient
g	acceleration due to gravity, m/s^2
m	mass of particle, kg
ρ_p	density of particle, kg/m^3
ρ_f	density of fluid, kg/m^3
A_p	projected area of the particle in perpendicular direction of motion, m^2

The drag coefficient of the material and its resistance to air flow depends upon

1. Bed thickness of the material
2. Type, shape and size of grain
3. Air velocity
4. Orientation and packing of the material

Colour Separation: Colour is one of the finest indices of the quality of agricultural produce, Unlike other sorting methods, the production process of grain separation by colour requires the material to be delivered to the monitoring device as a successive chain of grains one following the other at some specific speed so that the transducer can signal the actuating mechanism and the latter releases the grain from the flow. Colour sorting mainly uses the difference between the reflective properties of grains over some specific portion of spectrum where these differences are great.

In colour sorter, the material to be sorted is delivered in such a way that seeds move in single file. These seeds are thrown in to a lighted optical chamber which houses two photo elements, a standard calibrating screen and an electrode needle.

Particles, which are either lighter or darker than the colour of the screen, induce a signal in the photo element. After its amplification the signal in the amplifier switches on the high voltage circuit resulting in a corona discharge between needle electrode and the corona electrode. The instant at which photo element discriminates a particle by colour and its charging practically coincide. The charged particles deflect from the natural trajectory to fall and separation takes place. In some machines air stream is used to deflect the particles.

Specific gravity separation: The specific gravity separator makes the separation according to the difference in specific gravity of the material. The machine consists of a triangular shape perforated deck. The deck is properly baffled underneath to ensure uniform distribution of the air over it. The pressure or terminal velocity of the air rising through the deck is controllable very closely within a wide range. The mixture of grain is fed into the feed box. The air is blown up through the porous deck surface and bed of the grain by a fan at such a rate that the material is practically lifted from contact with deck surface. The lightest materials are lifted to the top of the stratified mass. The air does not lift the heavier particles. The stratified mass moves along the direction of conveyance due to oscillating motion of the deck and is discharged at the right edge of deck.

Screening: Screening is a method of separating grain/ seed into two or more fractions according to size alone. For cleaning and separation of seeds, the most widely used device is screen. When solid particles are dropped over a screen, the particles smaller than the size of screen openings pass through it, whereas larger particles are retained over the screen or sieve. A single screen can thus make separation into two fractions. When the feed is passed through a set of different sizes of sieves, it is separated into different fractions according to the size of openings of sieves. Screens along with an air blast (air screen) can satisfactorily clean and sort most of the granular materials. The screens are generally suspended by hangers, and when this unit is oscillated by an eccentric unit they have a horizontal oscillating motion and at the same time a smaller vertical motion. These two motions cause grains to travel downward to the screen and at the same time the grains are thoroughly stirred during the passage.

Types of screens: In most screens the grain/ seed drops through the screen opening by gravity. Coarse grains drop quickly and easily through large opening in a stationary surface. With finer particles, the screening surface must be agitated in some way. The common ways are, (1) revolving a cylindrical screen about a horizontal axis *and* (2) shaking, gyrating or vibrating the flat screens.

Grizzly: The grizzly *is* a simple device consisting of a grid made up of metal bars, usually built on a slope, across which the material is passed. The path of material flow is parallel to the length of bars. The bars are usually so shaped that the top is wider than the bottom. The grizzly is often constructed in the form of a short endless belt so that the oversize is dumped over the end while the sized material passes through. In this case bar length is transverse to the path of materials. The grizzly is used for coarsest and rough separations.

Revolving screen/cylinder sorter: Trammel or revolving screen is a cylinder that rotates about its longitudinal axis. The wall of the cylinder is made of perforated steel plate or sometime the cloth wire on a frame, through which the material falls as the screen rotates. The axis of cylinder is inclined along with the feed end to the discharge end. Sizing is achieved by having smallest opening screen at the feed

end with progressively larger opening screens towards the discharge end. This type of sorter is simple and compact with no vibration problem. But the capacity of cylinder sorter is lesser than vibrating screen of same size. Although it is an accurate sizer, it does not perform well with friable material or in cases where particle degradation is undesirable because tumbling produces some autogeneous grinding. The speed of rotation of the trammel is to be kept within the limit at which the material is carried from bottom to a distance equal to the radius of cylinder before it starts tumbling. The inclination of cylinder sorter for dry granular materials is kept up to 125 *mm/m*. The capacity, bed depth and efficiency of these screens can be changed by changing the speed of operation and the inclination of cylinder. Effective screening area not the total surface area of cylinder is calculated by multiplying the length of cylinder by 1/3 of the diameter.

Shaking screen: Like the vibrating screen, shaker is a rectangular surface over which raptorial moves down on an inclined plane. Motion of the screen is back and forth in a straight line. Although in some cases vibration is also given to the screen. Unlike the vibrating screen, the shaker does not tumble or turn material enroute except that some shaking screens have a step-off between surfaces having different size openings, so that there may be two or three tumbles over the full length of the screen. The shaker is widely used as combined screen and conveyor for many types of bulk material.

Rotary screen: Rotary and gyratory screens are either circular or rectangular decked. Their motion is almost circular and affects sifting action. These are capable of accurate a complete separation of very fine sizes but their capacity is limited. These screens are further classified into two categories.

1. **Gyratory screens:** This is generally a single decked machine. It has horizontal plane motion, which is circular at feed end and reciprocating at the discharge end the drive mechanism is at the feed end and is either a V-belt or direct coupling.

   The shaft that imparts motion to the screen is a counter balanced eccentric. The shaft moves about a vertical axis. At the discharge end most rotary screens have linkage to the base frame, usually a self-aligning bearing. Gyratory screens open with screening surface nearly horizontal.

2. **Circular screens:** These are also rotary screens but their motion in horizontal plane is circular over the entire surface. Similar to the gyratory screens, the screening surface of circular screens is also little bit tilted for allowing the material to move over them.

Vibratory screen: an eccentric unit agitates the vibratory screens. When materials to be separated are put on a vibratory screen, because of its vibration, materials are also agitated and separated during their transit over the screen. The eccentricity is usually of two types, (1) a shaft to which off center weights are attached, and (2) a shaft that itself is eccentric or off centered. In the later case the eccentricity is balanced by a flywheel for providing uniform vibration. Most vibrating screens are inclined downward from the feed end. Vibration is provided to the screen assembly only, and the body and other surrounding structure are isolated from vibration. Generally, up to three decks are used in vibrating screens. The capacity of vibrating screen is higher than any other similar sized screen and is very popular for cleaning and grading of granular agricultural products.

Horizontal screen: Horizontal screens are special case of vibrating screen. These

are designed for operation with low headroom. These operate absolutely flat without the aid of gravity. All sorting, stratification and material transportation take place on the strength of a sharp forward thrust, which imparts motion to particles with a missile. like trajectory, while the return stroke pulls the deck out from underneath the bed. Effectiveness of these screens is higher because material is kept on the screen for a longer period in comparison to inclined screens.

Screen openings: Screens are generally constructed by perforated sheet metal or woven wire mesh. The openings in perforated metal sheets may be round, oblong or triangular. The openings in wire mesh are square or rectangular. The size and shape and their combination of the screens available in market are identified by some trade numbers.

Perforated metal screens

i) **Round openings:** The round openings in a perforated sheet metal screen are measured by the diameter *(mm* or in.) of the openings. For example, screen has round perforation of 1 in. in diameter or 2 *mm.*

ii) **Oblong openings:** The oblong or slotted openings in a perforated sheet metal screen are designated by two dimensions, the width and length of the opening While mentioning oblong openings the dimension of width is listed first then the length as 1.8 x 20 *mm.* Generally, the direction of the oblong opening is kept in the direction of the grain flow over the screen.

iii) **Triangular openings:** There are two different systems used to measure triangular perforations. The most commonly used system is to mention the length of earl side of the triangle in *mm,* it means, 9 *mm* triangle has 3 equal sides each 9 mm long.

The second system is to mention openings according to the diameter in *mm* that can be inscribed inside the triangle. This system is identified by the letter *V as 9V, 10V* etc.

Wire mesh screens

i) **Square mesh:** The square openings in wire mesh are measured by the number of openings per inch in each direction. *A* 9 x 9 screen has 9 openings per inch.

ii) **Rectangular mesh:** the rectangular openings in wire mesh screens are measured in the same way as square wiremesh screen. A 3 x 6 rectangular wiremesh screen will have 3 openings per inch in one direction and 6 openings per inch in the other direction. The rectangles formed by the wiremesh are parallel to the direction of grain flow.

Effectiveness of screen: The screen effectiveness may be defined as the ability of a screen in closely separating the feed into overflow and underflow according to its size. If the screen functions properly, all material 'O' would be in the overflow, while all the material *'U'* would be in the underflow. The materials balance in a screening operation can be derived as follows:

If E = Effectiveness of screen
F = mass flow rate of feed, kg/hr
m_f = mass fraction of material in feed
m_o = mass fraction of material in overflow
m_u = mass fraction of material in underflow
O = feed in overflow
U = feed in underflow

Then

$$F = O + U$$
$$Fm_f = Om_o + Um_u$$

Therefore

$$O / F = (m_f - m_u) / (m_o - m_u)$$
$$U / F = (m_o - m_f) / (m_o - m_u)$$

A common measure of screen effectiveness is the ratio of actual amount of over size materials in the overflow to the amount of over size entering with the feed. Thus,

$$E_o = Om_o / Fm_f$$

and $E_u = U(1 - m_u) / F(1 - m_f)$

Over all effectiveness $E = E_o \times E_u$

Substituting the values we get

$$E = \frac{(m_f - m_u)(m_o - m_t) m_o (1 - m_u)}{(m_o - m_u)^2 (1 - m_t) m_f}$$

2.6 MANUAL AND MECHANICAL GRADING

Manual grading: Manual grading is usually based on size of the grain. Hand operated screen cleaner is generally made of mild steel. The separation takes place due to difference in size of grain and foreign matter. The cleaner is operated by hanging on an elevated point with the help of ropes. Grain is fed on the screening surface in batches. The screens can be changed as per grain is handled. The cleaner is swung to and fro till all the grain is screened. The cleaned grain is retained by the bottom sieve, which can be discharged. Impurities of larger size stubbles, chaff etc. are retained on top sieve. Down stream from the bottom sieve consists of dust, dirt, broken, and shriveled grain etc. this method used for grading small quantities of grain.

Mechanical grading: In mechanical grading all moving parts of the machine are operated by mechanical means. Grading machines can be designed based on different properties of grain. These machines are used for high capacity handling of grain.

2.7 EFFICIENCY OF CLEANERS AND GRADERS

The cleaning efficiency for an air screen grain cleaner as suggested by the Bureau of Indian Standards (BIS) is given below (IS 5817:1980)

$$\text{Cleaning Efficiency} = \frac{E(F - G)(E - F)(1 - G)}{F(E - G)^2 (1 - F)}$$

Where

E = fraction of clean seed at clean seed outlet
F = fraction of clean seed in feed
G = fraction of clean seed at foreign matter outlet

Efficiency of cleaner and grader depends upon two factors as given below

1. Material factors
2. Machine and operational factors.

1. **Material factors:** The various material factors that affect the efficiency of a cleaner cum grader are as given below
   a) Compaction or bed density
   b) Particle size, shape and other properties
   c) Distribution of various fraction sizes
   d) Stickiness and abrasiveness
2. **Machine and operational factors:** Capacity and efficiency in screening operation are closely related to each other. In cleaning operation, when the rated capacity is increased, its efficiency decreased. Some of the machine and operation factors that affect the efficiency of grader are as given below
   a) Feeding mechanism
   b) Size of screen surface
   c) Grain bed depth
   d) Shape of the opening
   e) Percentage open (perforated) area
   f) Aperture size
   g) Stroke length
   h) Angle of inclination
   i) Vibration amplitude and frequency
   j) Number of screens
   k) Rate of forward travel
   l) Air velocity
   m) Screen cleaning mechanism

2.8 PNEUMATIC SEPARATORS

Pneumatic systems may be part of grain cleaning machines or they may be independent units. They separate the fine impurities from the grains and grade them. The working components of pneumatic systems include the blowers, separating passages, settling chambers and dust separators.

Pneumatic systems are classified as (1) vertical or inclined, according, to the direction of flow, (2) induced, forced or combined induced and forced (balanced) flow according to the mode in which air enters the passage, (3) single or twin channel according to the number of separating passages, and (4) open or closed cycle systems according to the mode of circulation of the air stream.

In induced flow systems the pressure developed in the passages is below atmospheric while in forced flow systems this pressure is above atmospheric. In the combined induced-forced balanced flow system two blowers are used of which one forces the air in while the other inducts it. In open cycle system the air is blown out to the surroundings after the contaminants separated from the grains settle in the chamber, in the closed cycle system the same volume of the air is circulated through the machine. In the later case the dust loading of the surroundings greatly decreases.

2.9 SPIRAL SEPARATORS

The spiral separator separates the grain as per their roundness. The main component of the separator is a stationary, open screw conveyor standing on one end. The mixture is fed at the top of the unit. The round materials of the mixture pick up speed as they slide or roll down the inclined surface until their centrifugal force becomes sufficient enough to throw them in the outer helix, the non-round materials are caught in the inner helix and are discharged through a separate spout.

There is no moving part in the spiral separator. The rate of feeding is the only adjustable component. The feeding should be such that each grain rolls independently for effective separation. The main limitation of the spiral separator is lack of flexibility.

Separation of mustard, rapeseed, soybean, wild peas or other round seeds can be performed from wheat, flax, oats etc. by this device. It is less versatile as compared to other mechanical cleaners, but is simple, inexpensive and quite useful for seed cleaning purposes.

2.10 CYCLONE SEPARATORS

The cyclone separator is a device for collecting the end product in processing operations. It is most commonly used for collection of dust and wastes during processing of grains. It can also be used with air screen cleaners to collect light particles, which could be carried by air stream. The application of cyclone separator is also made to separate out air borne material from the discharge of pneumatic conveyor. In operation of the separator, the air and material both enter the cyclone tangentially at the top of the separator where pressure drop occurs and aid forms a vortex around the center of the chamber. The whirling air being lighter gets collected at the center and is delivered out through the top opening. The heavier materials slide down along the walls of the cyclone and are discharged at the bottom.

2.11 LET US SUM UP

Cleaning and grading are most important post harvest operations undertaken to remove foreign and undesirable materials from the threshed crops and grains. The differences between crop material and the contaminants in physico-mechanical properties are used to clean and grade grains. Number of machines has been developed based on these properties of grains to clean and grade them. Other properties like colour, magnetic properties and dielectric properties are also used to grade the grains of high commercial value. Screening is the most important operation and widely used method of cleaning and grading. Different types of screens of various types of opening are used in cleaning operation. Screening in combination with aerodynamic properties is widely used in most of air screen cleaner graders. Efficiency of these machines depends upon material and machine factors. Spiral and cyclone separators are two machines that do not require mechanical power to run.

2.12 KEY WORDS

Cleaning : Removal of foreign and undesirable matters from the desired grains/products.

Grading	:	Classification of cleaned products into various quality fractions depending upon the various commercial values and other usage.
Sorting	:	Separation of cleaned product into various quality fractions that may be defined on the basis of size, shape, density, texture and colour.
Scalping	:	Removal of few large particles in an initial process.
Screen cleaner/grader	:	It performs the separation according to the size alone.
Air-screen cleaner/grader	:	The screens used in combination with air blast.
Aerodynamic Properties	:	It includes critical velocity, drag coefficient and sailing velocity.
Terminal velocity	:	It is the velocity equal to the air velocity at which a particle remains in suspended state in a vertical pipe.
Screening	:	It is a method of separating grain/ seed into two or more fractions according to size alone.
Effectiveness of screen	:	Ability of a screen in closely separating the feed into overflow and underflow according to its size.

Check Your Progress

Note a) Use the spaces given below for your answers.
b) Check your answer with those given at the end of the unit.

1. Define cleaning, grading and scalping.

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2. Name factors controlling the cleaning and grading operation of grains.

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3. What is terminal velocity? How terminal velocity is correlated with drag coefficient?

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4. Differentiate perforated sheet and wire mesh screens.

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5. What is screen effectiveness?

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6. Name material factors that affect screening efficiency.

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7. Classify pneumatic cleaning system and define them.

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8. Name two machines that does not require moving parts and write their working principle.

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9. What is colour sorting and when it is used?

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10. Name working principles of following equipment

    Air screen cleaner: .....

    Gravity separator: .....

    Magnetic separator. .....

    Destoner: .....

2.13 SOME USEFUL REFERENCES

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2.14 ANSWERS TO CHECK YOUR PROGRESS

1. Your answer should include the definitions of terms.
2. Your answer should include physico-chemical, mechanical other properties of food.
3. Your answer should include definition of terminal velocity and equation for it.
4. Your answer should include usefulness, opening types and material type.
5. Your answer should include definition and formula to calculate it.
6. Your answer should include all factors that affect screening.
7. Your answer should include all four systems and definitions.
8. Your answer should include spiral and cyclone separator.
9. Your answer should include mechanism of colour sorting and products categories.
10. Name working principles of each machine.