Lecture No.1

Greenhouse is the most practical method of achieving the objectives of protected agriculture, where the natural environment is modified by using sound engineering principles to achieve optimum plant growth and yields.

Green House:

A greenhouse is a framed or an inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions of at least partially controlled environment and which is large enough to permit persons to work within it to carry out cultural operations.

The growing of off - season cucumbers under transparent stone for Emperor Tiberius in the 1st century, is the earliest reported protected agriculture. The technology was rarely employed during the next 1500 years. In the 16th century, glass lanterns, bell jars and hot beds covered with glass were used to protect horticultural crops against cold. In the 17th century, low portable wooden frames covered with an oiled translucent paper were used to warm the plant environment.

In Japan, primitive methods using oil -paper and straw mats to protect crops from the severe natural environment were used as long ago the early 1960s. Greenhouses in France and England during the same century were heated by manure and covered with glass panes. The first greenhouse in the 1700s used glass on one side only as a sloping roof. Later in the century, glass was used on both sides. Glasshouses were used for fruit crops such as melons, grapes, peaches and strawberries, and rarely for vegetable production.

Protected agriculture was fully established with the introduction of polyethylene after the World war II. The first use of polyethylene as a greenhouse cover was in 1948, when professor Emery Myers Emmert, at the University of Kentucky, used the less expensive material in place of more expensive glass.

The total area of glasshouses in the world (1987) was estimated to be 30,000 ha and most of these were found in North- Western Europe. In contrast to glasshouses, more than half of the world area of plastic green houses is in Asia, in which China has the largest area. According to 1999 estimates, an area of 6, 82,050 ha were under plastic greenhouses (Table 1.1). In most of the countries, green houses are made of plastic and glass; the majority is plastic.

Glasshouses and rigid plastic houses are longer-life structures, and therefore are most located in cold regions where these structures can be used throughout the year. In Japan, year-round use of greenhouses is becoming predominant, but in moderate and warm climate regions, they are still provisional and are only used in winter.

In India, the cultivation in the plastic greenhouses is of recent origin. As per 1994-95 estimates, approximately 100 ha of India are under greenhouse cultivation.

Since 1960, the greenhouse has evolved into more than a plant protector. It is now better understood as a system of controlled environment agriculture (CEA), with precise control of air and root temperature, water, humidity, plant nutrition, carbon dioxide and light. The greenhouses of today can be considered as plant or vegetable factories. Almost every aspect of the production system is automated, with the artificial environment and growing system under nearly total computer control.

Greenhouse Effect

In general, the percentage of carbon dioxide in the atmosphere is 0.035% (345 ppm). But, due to the emission of pollutants and exhaust gases into the atmosphere, the percentage of carbon dioxide increases which forms a blanket in the outer atmosphere. This causes the entrapping of the reflected solar radiation from the earth surface. Due to this, the atmospheric temperature increases, causing global warming, melting of ice caps and rise in the ocean levels which result in the submergence of coastal lines. This phenomenon of increase in the ambient temperature, due to the formation of the blanket of carbon dioxide is known as **greenhouse effect**.

The greenhouse covering material acts in a similar way, as it is transparent to shorter wave radiation and opaque to long wave radiation.

During the daytime, the shorter wave radiation enters into the greenhouse and gets reflected from the ground surface. This reflected radiation becomes long wave radiation and is entrapped inside the greenhouse by the covering material. This causes the increase in the greenhouse temperature. It is desirable effect from point of view of crop growth in the cold regions.

Advantages of Greenhouses

The following are the different advantages of using the green house for growing crops under controlled environment:

1. Throughout the year four to five crops can be grown in a green house due to availability of required plant environmental conditions.
2. The productivity of the crop is increased considerably.
3. Superior quality produce can be obtained as they are grown under suitably controlled environment.
4. Gadgets for efficient use of various inputs like water, fertilizers, seeds and plant protection chemicals can be well maintained in a green house.
5. Effective control of pests and diseases is possible as the growing area is enclosed.

6. Percentage of germination of seeds is high in greenhouses.
7. The acclimatization of plantlets of tissue culture technique can be carried out in a green house.
8. Agricultural and horticultural crop production schedules can be planned to take advantage of the market needs.
9. Different types of growing medium like peat mass, vermiculate, rice hulls and compost that are used in intensive agriculture can be effectively utilized in the greenhouse.
10. Export quality produce of international standards can be produced in a green house.
11. When the crops are not grown, drying and related operations of the harvested produce can be taken up utilizing the entrapped heat.
12. Greenhouses are suitable for automation of irrigation, application of other inputs and environmental controls by using computers and artificial intelligence techniques.
13. Self-employment for educated youth

CHAPTER 13: WINNOWING – MANUAL AND POWER OPERATED WINNOWERS, CARE AND MAINTENANCE

Wind winnowing is an agricultural method developed by ancient cultures for separating grain from chaff. It is also used to remove weevils or other pests from stored grain. Threshing, the separation of grain or seeds from the husks and straw, is the step in the chaff-removal process that comes before winnowing. "Winnowing the chaff" is a common expression. In its simplest form it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery. Techniques included using a winnowing fan (a shaped basket shaken to raise the chaff) or using a tool (a winnowing fork or shovel) on a pile of harvested grain

Winnowing, the process of separating quality grains from chaff, is a crucial process in the cultivation of paddy. The traditional way of winnowing is making the dried grains fall from a height using shovels and a sieve. The quality grains which are heavy fall vertically while the weightless chaff and straw get blown away by the wind. Thus, winnowing is effective only when there is a wind. Farmers often have to wait for hours for the wind to blow before they could start the process of winnowing.

Grain winnower

This machine winnows the paddy already threshed by a paddy thresher or other means. It has a feeding hopper at the top to receive the threshed paddy with other impurities. It discharges the threshed paddy over a scalper and removes bigger size impurities. A blower provided at bottom sends a stream of air against the grain falling through the scalper, which separates the straw, chaff and other impurities. The dust, chaff and straw are collected separately and cleaned paddy is taken out through another outlet near the bottom of the unit. The capacity of unit is 625 kg/h and the unit is operated by one hp motor.

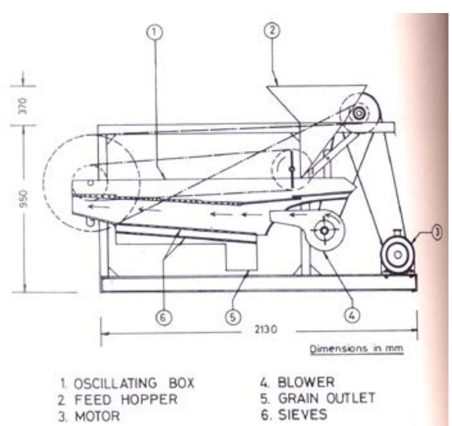


FIG. GRAIN WINNOWER

Paddy winnower

The machine winnows paddy already threshed by the paddy thresher or by other means. It has a feed hopper at the top to receive the threshed paddy, chaff and straw bit. A blower provided at the bottom sends a stream of air which separates straw, chaff and other impurities. The dust, chaff and straw come out through an opening and cleaned paddy is taken out through another spout. The unit is continuous type and operated by one hp electric motor.

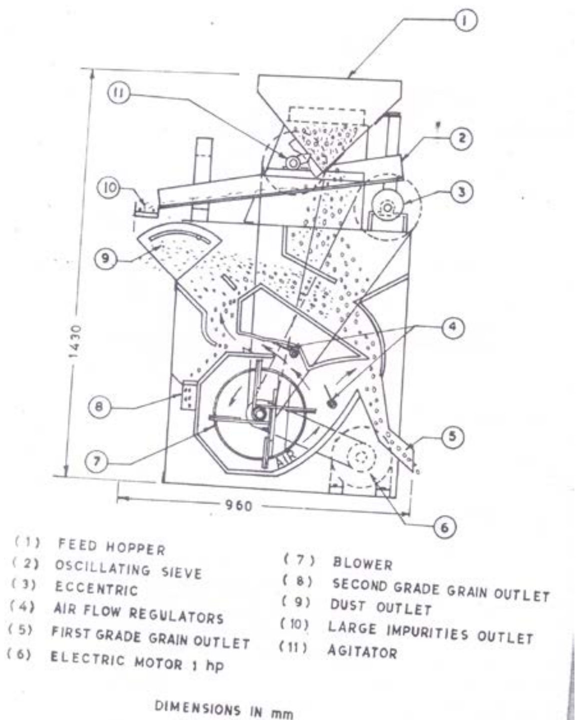
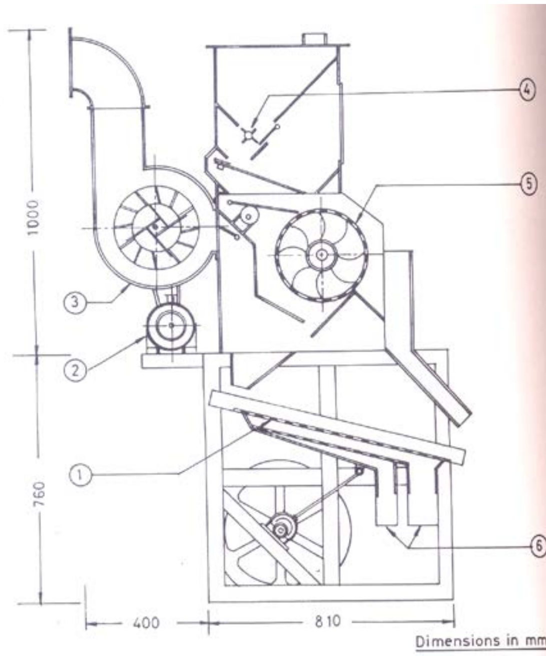


FIG 1-5: PADDY WINNOWER

Paddy precleaner

Paddy precleaner is used to remove appendages, glumes and foreign matter. The pre-cleaner is provided with an aspirator, a rotating scalping sieve and horizontal reciprocating grading sieve. By suitably changing the sieve, it can also be utilized for other seeds. By using the pre-cleaner, the efficiency of cleaner cum grader is improved. It also removes both smaller and larger size impurities and the dust from the grain. The capacity of the unit is 150 kg/h and it is operated one hp electric motor. The efficiency of the unit is 91%.



1. SIEVE
2. MOTOR
3. BLOWER
4. FEED ROLLER
5. ROTARY SIEVE
6. GRAIN OUTLETS

FIG. PADDY PRE-CLEANER

Lecture No.3

Plant response to greenhouse environments - light, temperature, relative humidity, ventilation and carbon dioxide and environmental requirement of agriculture and horticulture crops inside green houses.

The productivity of a crop is influenced not only by its heredity but also by the microclimate around it. The components of crop microclimate are light, temperature, air compositions and the nature of the root medium. In open fields, only manipulation of nature of the root medium by tillage, irrigation and fertilizer application is possible. The closed boundaries in greenhouse permit control of any one or more of the components of the micro climate.

3.1 Light

The visible light of the solar radiation is a source of energy for plants. Light energy, carbon dioxide (Co_2) and water all enter in to the process of photosynthesis through which carbohydrates are formed. The production of carbohydrates from carbon dioxide and water in the presence of chlorophyll, using light energy is responsible for plant growth and reproduction. The rate of photosynthesis is governed by available fertilizer elements, water, carbon dioxide, light and temperature.

The photosynthesis reaction can be represented as follows

$$Co_2 + \text{water} + \text{light energy} \xrightarrow[\text{Plant nutrients}]{\text{Chlorophyll}} \text{carbohydrates} + \text{oxygen}$$

Considerable energy is required to reduce the carbon that is combined with oxygen in CO_2 gas to the state in which it exists in the carbohydrate. The light energy thus utilized is trapped in the carbohydrate. If the light intensity is diminished, photosynthesis slows down and hence the growth. If higher than optimal light intensities are provided, growth again slows down because of the injury to the chloroplasts.

The light intensity is measured by the international unit known as Lux. It is direct illumination on the surrounding surface that is one meter from a uniform point source of 1 international candle. Green house crops are subjected to light intensities varying from 129.6klux on clear summer days to 3.2 Klux on cloudy winter days. For most crops, neither condition is ideal. Many crops become light saturated, in other words, photosynthesis does not increase at light intensities higher than 32.2klux. Rose and carnation plants will grow well under summer light intensities. In general, for most other crops foliage is deeper green if the greenhouse is shaded to the extent of about 40% from mid spring (May) to mid fall (August and September). Thus, it is apparent that light intensity requirements of photosynthesis are vary considerably from crop to crop.

Light is classified according to its wave length in nanometers (nm). Not all light useful in photosynthesis process. UV light is available in the shorter wavelength range, i.e less than 400nm. Large of quantities of it is harmful to the plants. Glass screens are opaque to the most UV light and light below the range of 325nm. Visible and white light has wavelength of 400 to 700nm.Far red light (700 to 750nm) affects plants, besides causing photosynthesis. Infrared rays of longer wavelengths are not involved in the plant process. It is primarily, the visible spectrum of light that is used in photosynthesis. In the blue and red bands, the photosynthesis activity is higher, when the blue light (shorter wavelength) alone is supplied to plants, the growth is retarded, and the plant becomes hard and dark in colour. When the plants are grown under red light (longer wavelength), growth is soft and internodes are long, resulting in tall plants. Visible light of all wavelengths is readily utilized in photosynthesis.

3.2 Temperature

Temperature is a measure of level of the heat present. All crops have temperature range in which they can grow well. Below this range, the plant life process stop due to ice formation within the tissue and cells are possibly punctured by ice crystals. At the upper extreme, enzymes become inactive, and again process essential for life cease. Enzymes are biological reaction catalyst and are heat sensitive. All biochemical reactions in the plant are controlled by the enzymes. The rate of reactions controlled by the enzyme often double or triple for each rise of temperature by 10^0C, until optimum temperature is reached. Further, increase in temperature begins to suppress the reaction and finally stop it.

As a general rule, green house crops are grown at a day temperature, which are 3 to 6^0C higher than the night temperature on cloudy days and 8^0C higher on clear days. The night temperature of green house crops is generally in the range of 7 to 21^0C. Primula, mathiola incana and calceolaria grow best at 7^0C, carnation and cineraria at 10^0C, rose at 16^0C, chrysanthemum and poinsettia at 17 to 18^0C and African violet at 21 to 22^0C.

3.3 Relative humidity

As the green house is a closed space, the relative humidity of the green house air will be more when compared to the ambient air, due to the moisture added by the evapo-transpiration process. Some of this moisture is taken away by the air leaving from the green house due to ventilation. Sensible heat inputs also lower the relative humidity of the air to some extent. In order to maintain the desirable relative humidity levels in the green houses, processes like humidification or dehumidification are carried out. For most crops, the acceptable range of relative humidity is between 50 to 80%. However for plant propagation work, relative humidity up to 90% may be desirable.

In summer, due to sensible heat addition in the daytime, and in winters for increasing the night time temperatures of the green house air, more sensible heat is added causing a reduction in the relative humidity of the air. For this purpose, evaporative cooling pads and fogging system of humidification are employed. When the relative humidity is on the higher side, ventilators, chemical dehumidifiers and cooling coils are used for de- humidification.

3.4 Ventilation

A green house is ventilated for either reducing the temperature of the green house air or for replenishing carbon dioxide supply or for moderating the relative humidity of the air. Air temperatures above 35^0C are generally not suited for the crops in green house. It is quite possible to bring the green house air temperature below this upper limit during spring and autumn seasons simply by providing adequate ventilation to the green house. The ventilation in a green house can either be natural or forced. In case of small green houses (less than 6m wide) natural ventilation can be quite effective during spring and autumn seasons. However, fan ventilation is essential to have precise control over the air temperature, humidity and carbon dioxide levels.

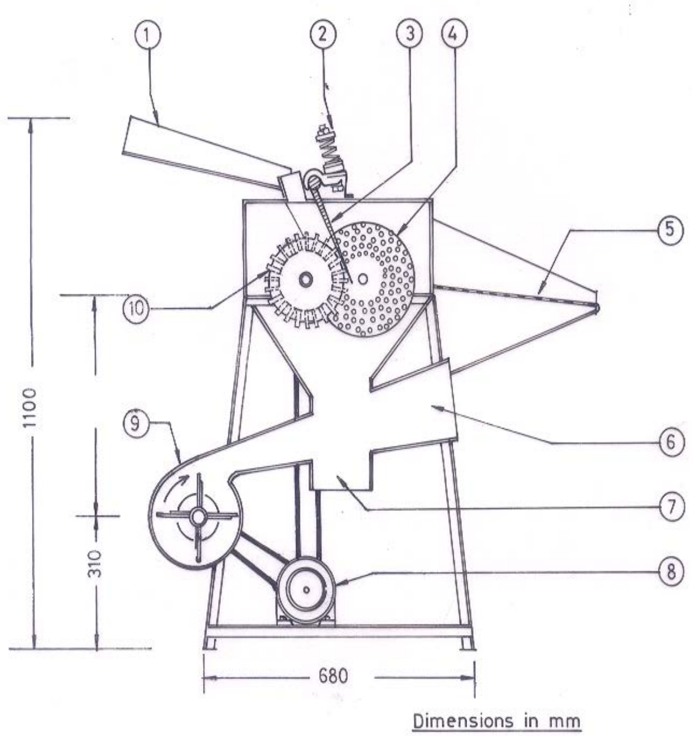
3.5 Carbon dioxide

Carbon is an essential plant nutrient and is present in the plant in greater quantity than any other nutrient. About 40% of the dry matter of the plant is composed of carbon. Under normal conditions, carbon dioxide (CO_2) exits as a gas in the atmosphere slightly above 0.03% or 345ppm. During the day, when photosynthesis occurs under natural light, the plants in a green house draw down the level of Co_2 to below 200ppm. Under these circumstances, infiltration or ventilation increases **carbon dioxide levels,** when the outside air is brought in, to maintain the ambient levels of CO_2. If the level of CO_2 is less than ambient levels, CO_2 may retard the plant growth. In cold climates, maintaining ambient levels of CO_2 by providing ventilation may be un-economical, due to the necessity of heating the incoming air in order to maintain proper growing temperatures. In such regions, enrichment of the green house with CO2 is followed. The exact CO_2 level needed for a given crop will vary, since it must be correlated with other variables in greenhouse production such as light, temperature, nutrient levels, cultivar and degree of maturity. Most crops will respond favorably to Co_2 at 1000 to 1200 ppm.

CHAPTER 15: SHELLER – MAIZE AND CASTOR SHELLER

Maize sheller

The maize sheller consists of a bevel gear fixed adjacent to the shelling disc, which pulls the cob inside, while a spring loaded tongue which is provided above the bevel gear holds the cob tight against the shelling disc,. Shelling is accomplished with beating and shearing action of the cast iron projections present in the rotating shelling disc. The shelled kernels with dust are passed through an air stream produced by a blower which separates the kernels. The cleaned kernels are collected at the bottom. The capacity of the unit is 500 kg of cob/h and it is operated by an one hp electric motor.

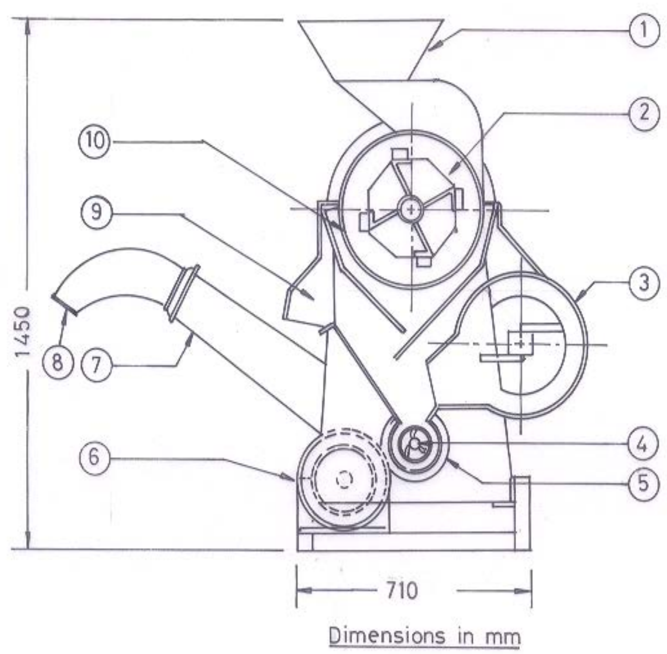


1. FEED TRAY
2. COMPRESSION SPRING
3. HOLDING TONG
4. THRESHING DISC
5. SIEVE
6. HUSK OUTLET
7. GRAINS OUTLET
8. MOTOR
9. BLOWER
10. BEVEL

FIG. MAIZE SHELLER

Husker sheller for maize

The machine consists of a hopper, rotor, sieve, blower, auger and an elevator. The removal of sheath and shelling of cob take place in the rotor sieve assembly. The shelled kernels are carried by the auger to one end and then elevated to the desired level for direct collection in bags. The capacity of the unit is 100 quintals per day. It is operated by 7.5 hp electric motor.



1. FEED HOPPER
2. ROTOR
3. BLOWER
4. AUGER
5. AUGER CASING
6. MOTOR
7. GRAIN ELEVATOR
8. MAIZE OUTLET
9. HUSK AND DUST OUTLET
10. CONCAVE SIEVE

FIG. HUSKER SHELLER FOR MAIZE

Castor sheller cum winnower

The machine consists of a teakwood cylinder and concave, a feed hopper, blower, sieve assembly and 2 hp electric motor. Unthreshed pods are retained on the top of sieve and come out from chute at the end of the sieve. Partially and completely shelled one pass through the top sieve. The middle sieve retains the partially shelled pods and allows the shelled beans to pass through. The partially shelled pods come out from chute at the end of middle sieve. The lighter hulls are blown out by the blast of air form the blower. The shelled bean comes out form the chute at the middle of the bottom perforated sheet. The perforations allow sand particles; weed seed etc., to be sieved out of the threshed castor bean. Capacity of the unit is 250 kg/h.

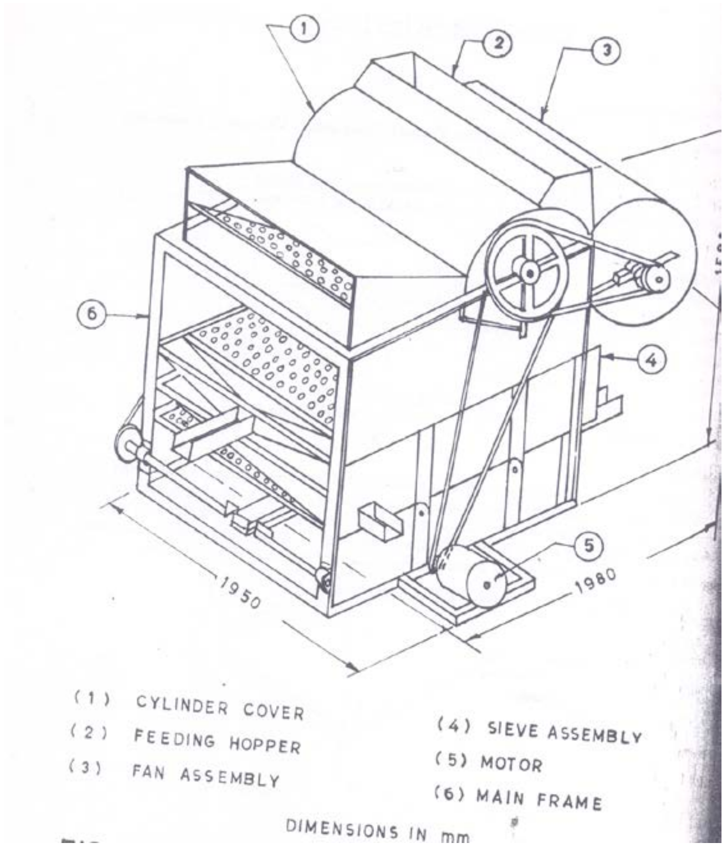


Fig. Castor Sheller cum winnower

Castor Sheller

The sheller consists of a wooden ribbed cylinder of 320 mm length and 380 mm diameter, concave, cylinder cover, feeding chute discharge cute, drive mechanism and crank. The clearance between the concave and cylinder adjustable depending on the size of bean. Shelling drum is operated by crank through a gear unit which shells the castor pods. Manual clearing is done. The unit is operated by two labours. Capacity of the unit is one quintal per day.

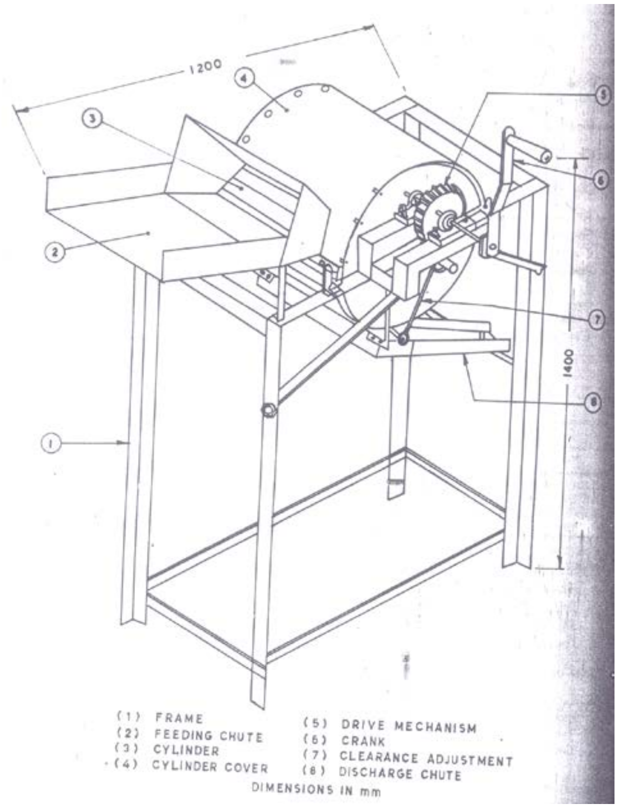


Fig. Castor Sheller

Lecture No.5

Planning of green house facility - site selection and orientation, structural design and covering materials.

A greenhouse, is basically the purpose of providing and maintaining a growing environment that will result in optimum production at maximum yield. The agriculture in the controlled environment is possible in all the regions irrespective of climate and weather.

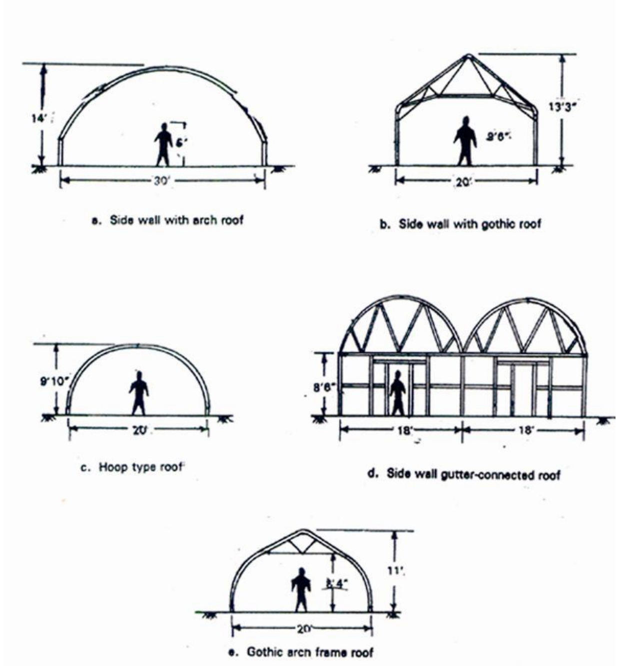
It is an enclosing structure for growing plants, greenhouse must admit the visible light portion of solar radiation for the plant photosynthesis and, there fore, must be transparent. At the same time, to protect the plants, a greenhouse must be ventilated or cooled during the day because of the heat load from the radiation. The structure must also be heated or insulated during cold nights. A greenhouse acts as a barrier between the plant production areas and the external or the general environment.

5.1 Site selection and orientation

A greenhouse is designed to withstand local wind, snow and crop loads for a specific cropping activity. In this way, the structure becomes location and crop specific. The building site should be as level as possible to reduce the cost of grading, and the site should be well aerated and should receive good solar radiation. Provision of a drainage system is always possible. It is also advisable to select a site with a natural windbreak. In regions where snow is expected, trees should be 30.5 m away in order to keep drifts back from the greenhouses. To prevent shadows on the crop, trees located on the east, south, or west sides should be at a distance of 2.5 times their height.

5.2 Structural design

The most important function of the greenhouse structure and its covering is the protection of the crop against hostile weather conditions (low and high temperatures, snow, hail, rain and wind), diseases and pests. It is important to develop greenhouses with a maximum intensity of natural light inside. The structural parts that can cast shadows in the greenhouse should be minimized.



The different structural designs of greenhouse based on the types of frames are available. A straight side wall and an arched roof is possibly the most common shape for a greenhouse, but the gable roof is also widely used. Both structures can be free standing or gutter connected with the arch roof greenhouse. The arch roof and hoop style greenhouses are most often constructed of galvanized iron pipe. If tall growing crops are to be grown in a greenhouse or when benches are used, it is best to use a straight side wall structure rather than a hoop style house, this ensures the best operational use of the greenhouse. A hoop type greenhouse is suitable for low growing crops, such as lettuce, or for nursery stock which are housed throughout the winter in greenhouses located in extremely cold regions. A gothic arch frame structure can be designed to provide adequate side wall height without loss of strength to the structure (Fig.10).

Loads in designing the greenhouse structures include the weight of the structure itself and, if supported by the structure, loads of the equipment for the heating and ventilation and water lines. Greenhouse structures should be designed to resist a 130 km/h wind velocity. The actual load depends on wind angle, greenhouse shape and size, and the presence or absence of openings and wind breaks.

The ultimate design of a greenhouse depends on the following aspects:

(i) The overall structural design and the properties of the individual structural components.

(ii) The specific mechanical and physical properties which determine the structural behaviour of the covering materials.

(iii) The specific sensitivity of the crop to light and temperature to be grown in the greenhouse.

(iv) The specific requirements relevant to the physical properties of the covering material.

(v) The agronomic requirements of the crop.

5.3 Covering materials

The following factors are to be considered while selecting the greenhouse covering material i.e., light, transmission, weight, resistant to impact, and durability to outdoor weathering and thermal stability over wide range of temperatures. Before selecting the covering material, two important points should be taken into consideration: the purpose for which greenhouse facility is intended and service life of material. In temperate regions where high temperatures are required, the covering material with high light transmission and far IR absorption must be selected. Also the loss of heat by conduction should be minimum.

Covering material	**Life span**
1. Glass and acrylic sheet	20 years
2. Polycarbonate and fiberglass-reinforced polyester sheet	5-12 years
3. Polyethylene	2-6 months
4. Polyethylene stabilized for UV rays	2-3 years

The ideal greenhouse selective covering material should have the following properties:

(i) It should transmit the visible light portion of the solar radiation which is utilized by plants for photosynthesis.

(ii) It should absorb the small amount of UV in the radiation and convert a portion of it to fluoresce into visible light, useful for plants.

(iii) It should reflect or absorb IR radiation which are not useful to plants and which causes greenhouse interiors to overheat.

(iv) Should be of minimum cost.

(v) Should have usable life of 10 to 20 years.

Lecture No.6

Materials for construction of green houses - wood, galvanized iron, glass, polyethylene film, poly vinyl chloride film, Tefzel T^2 film, fiberglass reinforced plastic rigid panel and acrylic and polycarbonate rigid panel.

The following materials commonly used to build frames for greenhouse are (i) Wood, (ii) Bamboo, (iii) Steel, (iv) Galvanized iron pipe, (v) Aluminum and (vi) Reinforced concrete (RCC). The selection of above materials was based on their Specific physical properties, requirements of design strength, life expectancy and cost of construction materials.

6.1 Wood

Wood and bamboo are generally used for low cost polyhouses. In low cost polyhouses, the wood is used for making frames consisting of side posts and columns, over which the polythene sheet is fixed. The commonly used woods are pine and casuarina, which are strong and less expensive. In pipe-framed polyhouses, wooden battens can be used as end frames for fixing the covering material. In tropical areas, bamboo is often used to form the gable roof of a greenhouse structure. Wood must be painted with white colour paint to improve light conditions within the greenhouse. Care should be taken to select a paint that will prevent the growth of mold. Wood must be treated for protection against decay. Chromated copper arsenate and ammonical copper arsenate are water based preservatives that are applied to the wood that may come into contact with the soil. Red wood or cypress (natural decay resistance woods) can be used in desert or tropical regions, but they are expensive.

6.2 Galvanised iron (GI), aluminum, steel and reinforced cement concrete

GI pipes, tubular steel and angle iron are generally used for side posts, columns and purlins in greenhouse structure, as wood is becoming scarce and more expensive. In galvanising operation, the surface of iron or steel is coated with a thin layer of zinc to protect it against corrosion. The commonly followed processes to protect against corrosion are:

(i) Hot dip galvanising (hot process) process: The cleaned member is dipped in molten zinc, which produces a skin of zinc alloy to the steel.

(ii) Electro-galvanising (cold process) process: The cleaned member is zinc plated similar to other forms of electro-plating

The galvanising process makes the iron rust proof, to eliminate the problem of rusting of structural members. Aluminum and hot dipped GI are comparatively maintenance free. In tropical areas, double dipping of steel is required, as single dip galvanising process does not give a complete cover of even thickness to the steel. Aluminum and steel must be protected by painting with bitumen tar**,** to protect these materials from corrosion, while these materials contact with the ground. Now-a-days, the greenhouse construction is of metal type, which is more permanent. RCC is generally limited to foundations and low walls. In permanent bigger greenhouses, floors and benches for growing the crops are made of concrete.

6.3 Glass

Glass has been traditional glazing material all over the world. Widely used glass for greenhouse are: (i) Single drawn or float glass and (ii) Hammered and tempered glass. Single drawn or float glass has the uniform thickness of 3 to 4 mm. Hammered and tempered glass has a thickness of 4 mm. Single drawn glass is made in the traditional way by simply pulling the molten glass either by hand or by mechanical equipment. Float glass is made in modern way by allowing the molten glass to float on the molten tin. Coating with metal oxide with a low emissivity is used for saving of energy with adequate light transmittance. Hammered glass is a cast glass with one face (exterior) smooth and the other one (interior) rough. It is designed to enhance light diffusion. This glass is not transparent, but translucent. Tempered glass is the glass, which is quickly cooled after manufacture, adopting a procedure similar to that used for steel. This kind of processing gives higher impact resistance to the glass, which is generally caused by hail. Glass used as a covering material of greenhouses, is expected to be subjected to rather severe wind loading, snow and hail loading conditions. The strength mainly depends on the length/width ratio of the panel and on the thickness of the panel, but the most widely used thickness is 4 mm.

6.4 Polyethylene film

Polyethylene is principally used today for two reasons- (i) Plastic film greenhouses with permanent metal frames cost less than glass greenhouses and (ii) Plastic film greenhouses are popular because the cost of heating them is approximately 40% lower compared to single-layer glass or fiberglass-reinforced plastic greenhouses. The disadvantages are **:** **t**hese covering materials are short lived compared to glass and plastic panels. UV light from the sun causes the plastic to darken, thereby lowering transmission of light, also making it brittle, which leads to its breakage due to wind. A thermal screen is installed inside a glass greenhouse that will lower the heat requirement to approximately that of a double-layer plastic film greenhouse, but this increases the cost of the glass greenhouse. Polyethylene film was developed in the late 1930s in England and spread around the middle of this century. Commonly used plastic for greenhouse coverings are thermoplastics. Basic characteristics of thermoplastics are: (i) thermoplastics consists of long chain molecules, soften with heating and harden with cooling and this process is reversible and (ii) thermoplastics constitute a group of material that are attractive to the designer for two main reasons: (a) Thermoplastics have the following specific physical properties- stiffness, robustness and resilience to resist loads and deformations imposed during normal use and (b) It can readily be processed using efficient mass production techniques, result in low labour charge.

The main reason to use polyethylene year round for greenhouse covering is due to presence of UV-inhibitor in it. Otherwise it lasts for only one heating season. UV-inhibited plastic cover may last for a period of 4 to 5 years. UV-grade polyethylene is available in widths up to 15.2 m in flat sheets and up to 7.6 m in tubes. Standard lengths include 30.5, 33.5, 45.7, 61 and 67 m. Some companies provide custom lengths upto a max. of 91.5 m. Condensation on ploythene film is a big problem. Condensation causes disease development, development of water logged condition and oxygen deficient inside the greenhouse. Condensation reduces light intensity within the greenhouse. To avoid this problem, anti-fog surfactant, which discourages condensation, is built into the film or panel. Warm objects, such as plants, the greenhouse frame and soil radiate IR energy to colder bodies at night, which result in loss of heat in greenhouse. Since polyethylene is a poor barrier to radiant heat, it is formulated with IR-blocking chemicals into it during manufacture, will stop about half of the radiant heat loss. On cold and clear nights, as much as 25% of the total heat loss of a greenhouse can be prevented in this way and on cloudy nights only 15% is prevented. UV-stabilised polyethylene, on an average, transmits about 87% of photosynthetically active radiation (PAR) into the greenhouse. IR absorbing polyethylene, reduces radiant heat loss, transmits about 82% of photosynthetically active radiation (PAR) into the greenhouse. The amount of light passing through two layers of a greenhouse covering is approximately the square of the decimal fraction of the amount passing through one layer. Eg. When 87% passes through one layer of UV-inhibited polyethylene, only 76% (0.87 x 0.87) passes through two layers**.** Similarlly, when 82% passes through one layer of IR-absorbing polyethylene, only 67% (0.82 x 0.82) passes through two layers.

6.5 Polyvinyl chloride film (PVC films)

PVC films are UV light resistant vinyl films of 0.2 to 0.3 mm and are guaranteed for 4 to 5 years respectively. The cost of 0.3 mm vinyl film is three times that of 0.15 mm polyethylene. Vinyl film is produced in rolls upto 1.27 m wide. Vinyl films tend to hold a static electrical charge, which attracts and holds dust. This in turn reduces light transmittance unless the dust is washed off. Vinyl films are seldom used in the United States. In Japan, 95% of greenhouses are covered with plastic film, out of which 90% are covered with vinyl film.

6.6 Tefzel T^2 film

The most recent addition of greenhouse film plastic covering is Tefzel T^2 film (ethylene tetrafluoroethylene). Earlier, this film was used as covering on solar collectors. Anticipated life expectancy is 20 years. The light transmission is 95% and is greater than that of any other greenhouse covering material. A double layer has a light transmission of 90% (0.95 x 0.95). Tefzel T^2 film is more transparent to IR radiation than other film plastics. Hence, less heat is trapped inside the greenhouse during hot weather. As a result, less cooling energy is required. Disadvantage is that, the film is available only in 1.27 m wide rolls. This requires clamping rails on the greenhouse for every 1.2 m. If reasonable width strips become available, the price is not a problem, because a double layer covering will still cost less than a polycarbonate panel covering with its aluminum extrusions, and will last longer, and will have much higher light intensity inside the greenhouse.

6.7 Polyvinyl chloride rigid-panel

Initially, PVC rigid panels showed much promise as an inexpensive covering material (almost 40% of cost of long lasting fiberglass reinforced plastics), has the life of 5 years. After commercial application, these panels indicated that the life expectancy was much shorter, less than 2 years. This is undesirable factor, because the cost of PVC panels was 4 to 5 times that of polyethylene film and they required much more time to install. Now-a-days, PVC rigid panels are not in use.

6.8 Fiberglass-reinforced plastic (FRP) rigid panel

FRP was more popular as a greenhouse covering material in the recent past. Advantage of FRP is that it is more resistant to breakage by factors, such as hail or vandals. Sunlight passing through FRP is scattered by the fibers in the panels, as a result the light intensity is rather uniform throughout the greenhouse in comparison with a glass covering. Disadvantages with these are the panels subjected to etching and pitting by dust abrasion and chemical pollution. Based on the grade, the usable life period of FRP panel varies. Some grades give 5 to 10 years, while better grades can last up to 20 years. FRP panels are flexible enough to conform to the shape of quonset greenhouses, which make FRP a very versatile covering material. FRP can be applied to the inexpensive frames of plastic film greenhouses or to the more elaborate frames of glass type greenhouses. The price of FRP greenhouse lies between that of a plastic film greenhouse and that of a glass greenhouse. But the cost is compensated by the elimination of the need for replacement of film plastic in every year or alternate years. Corrugated panels were used because of their greater strength. Flat panels are used occasionally for the end and side walls, where the load is not great. It is available in 1.3 m width, length up to 7.3 m and in a variety of colours. The total quantity of light transmitted through clear FRP is approximately equivalent to that transmitted through glass, but diminishes in relation its colour. For greenhouse crops in general, only clear FRP permits a satisfactory level of light transmission (88 to 90%). Coloured FRP has found a limited use in greenhouses intended for growing houseplants that require low light intensity and in display greenhouses for holding plants during the sales period. FRP has advantage over glass is that, it cools easily. FRP greenhouses require fewer structural members since sash bars are not needed.

6.9 Acrylic and polycarbonate rigid-panel

These panels have been available for about 15 years for greenhouse use. The panels have been used for glazing the side and end walls of plastic film greenhouses and retrofitting old glass greenhouse. Acrylic panels are highly inflammable, where as polycarbonate panels are non-flammable. Acrylic panels are popular due to their higher light transmission and longer life. Acrylic panels are available in thickness of 16 and 18 mm, and have 83% of PAR light transmission. Acrylic panels cannot be bent, but the thinner panels can be bent to fit curved-proof greenhouses. These panels are also available with a coating to prevent condensation drip. Polycarbonate panels are preferred for commercial greenhouses due to lower price, flame resistance and greater resistance to hail damage. Polycarbonate panels are available in thickness of 4,6, 8, 10 and 16 mm. These panels are also available with a coating to prevent condensation drip and also with an acrylic coating for extra protection from UV light.

CHAPTER 18: FRUITS AND VEGETABLES CLEANING – MACHINERY FOR CLEANING FRUITS AND VEGETABLES, CARE AND MAINTENANCE

Impurities in Freshly Harvested Fruits

- Field Soil
- Dust and surface microorganism
- Fungicide / insecticide etc
- Sap
- Black spots

Fruit and Vegetable Cleaning Machine

Specifications

Capacity	: 20 kg/batch
Power requirement	: 1 person
RPM	: 20 – 30 rpm
Fruit and vegetable	: Most fruits & vegetable inclusive mango & tomato

Foreign matter removal :

Field Soil, Dust and surface microorganism, Fungicide / insecticide, Sap, Black spots etc

Multifunctional cleaning machine

The machine is a multifunctional fruit and vegetable cleaning equipment with bubbles, spraying and brush available in cleaning with features such as highly cleanness, energy-saving, water-saving, stable and reliable. This equipment is suitable for cleaning fruits and vegetables. It is easy to operate, convenient in maintenance and wiring.

Fruit cleaning machine

The equipment is suitable for cleaning of ball-shape or oval-shape fruits and vegetables. The fruits and vegetables rotate continuously in all directions randomly. Brushing and spraying is in effect at a same time, with features such as high cleanness. The machine is easy to operate, convenient in maintenance and wiring.

Brush Type Vegetable & Fruit Cleaning Machine

Production capacity

Apple 30T/h

Watermelon 10T/h

Carrot 8T/h

Orange 35T/h

The fruit and vegetable raw materials are making irregular rotation under the effect of rotary brush roller to carry out spraying and brushing simultaneously. The brush is made of high temperature resistant nylon wire through two kinds of technologies such as hair planting and stainless steel winding.

a) Brush fruit cleaning machine for apple and fruits

b) Brush clearing machine for watermelon

c) Brush cleaning machine for carrot vegetable

d) Brush cleaning machine for citrus fruit

Surf Type Fruit Cleaning Machine

The equipment is mainly composed of water cabinet, material turning device, fan and lifter etc. It is widely used for soft washing of fruit and vegetable raw materials. The lifter can be made of complete stainless steel and engineering plastic. It can be additionally provided with spray cleaning device.

Roller with Brush Cleaning Machine

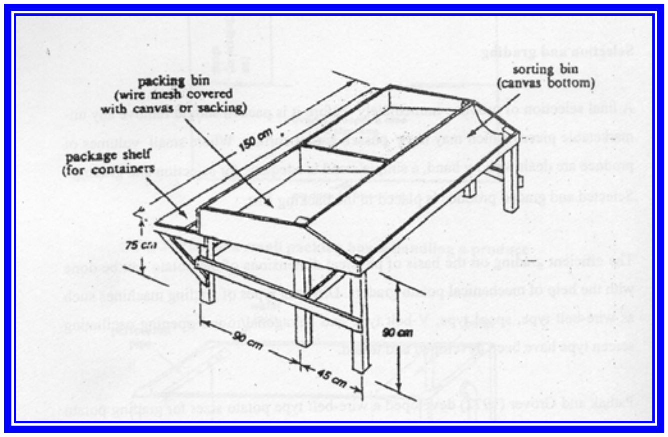
The fruit washing equipment consists of a roller with brush washing (cleaning) machine for washing fruits and vegetables. Roller with brush washing machine is made up of stainless steel tube and brush. The brush is made of polyethylene, and will make revolution as the movement of stainless steel chain. Fruits are driven to circumvolve and washed by brush. At the same time, the bad or rejected fruits are picked up by manual and then sent away by scrap conveying device.

Rolling Drum Brush Washing Machine

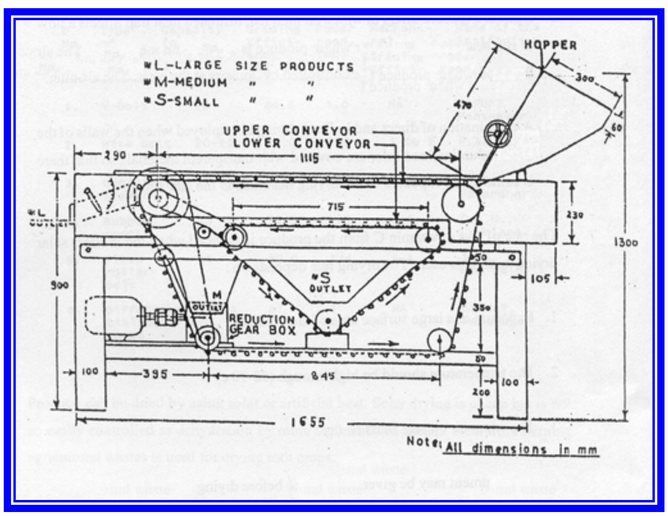
The fruit washing equipment consists of a rolling drum brush washing (cleaning) machine for washing root vegetables. Rolling drum brush washing machine is made up of electric motor, water pump, roller drum, supporter, riding wheel, brush, water spraying tubes, feeding funnel, cover board, water box, transmission shaft, supporter for motor, electric control switches, and other parts.

Roller drum is driven to rotate by chain wheel of electric motor through stainless steel chain. When materials enter into the rotating roller drum, they are washed by spraying water and brush. There are two water boxes in our rolling drum brush washing machine. One is used to hold fresh water, and the other with filtering net in it is to recycle water.

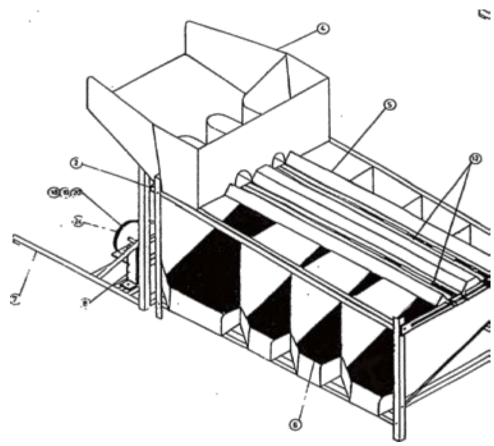
CHAPTER 19: GRADING – METHODS OF GRADING, EQUIPMENTS FOR GRADING OF FRUITS AND VEGETABLES, CARE AND MAINTENANCE



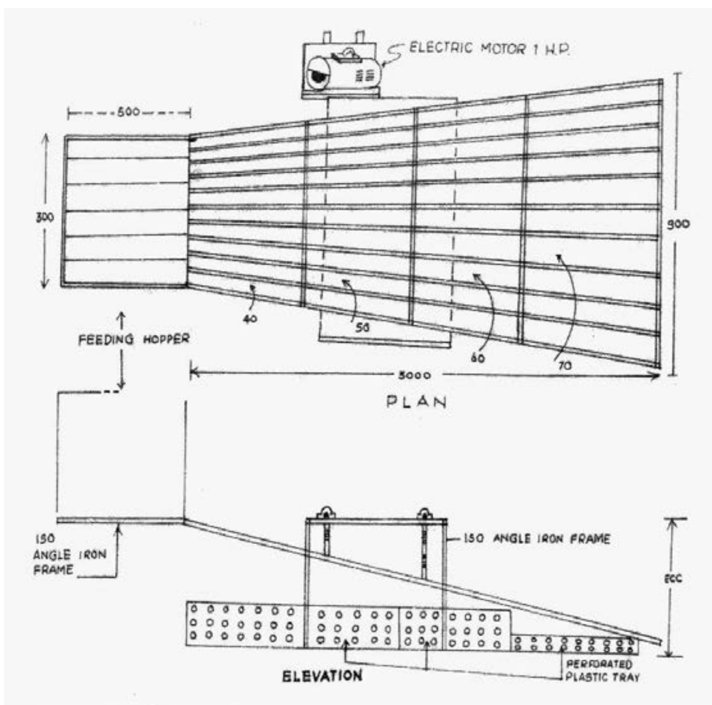
Sorting Bench



IARI Fruit and Vegetable Grader

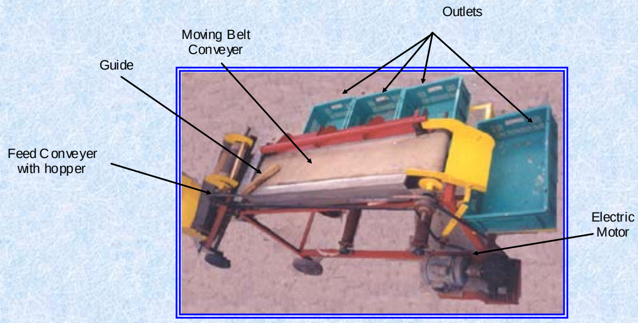


Divergent roller type fruit sorting machine for lemon and sapota, MPKV, Rahuri



Divergent rails/slit size mango grader.CISH, Lucknow

Fruit and Vegetable Grader for Tomato & Mango



Capacity	**= 500 Kg/h**
Power requirement	**= ½ HP electric motor**
Efficiency	**= 85 – 90%**

Plate 3.5 Orange grading (weight basis) machine in operation

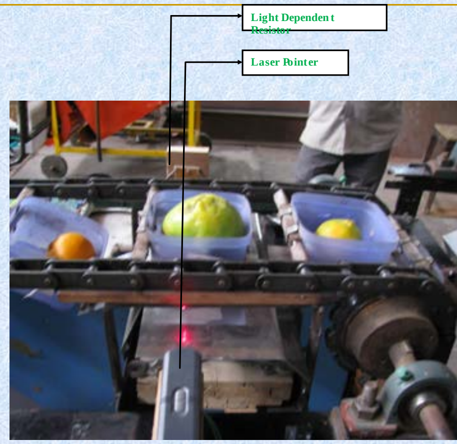


Plate 3.4 Electronic laser sensing assembly of orange grading machine

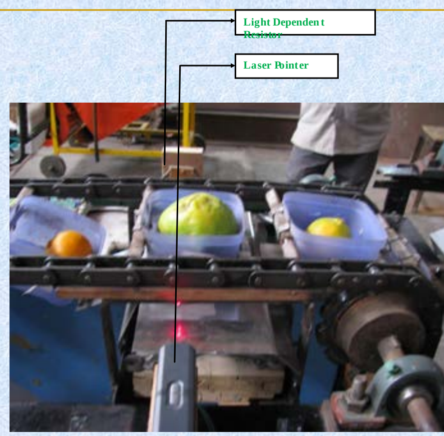
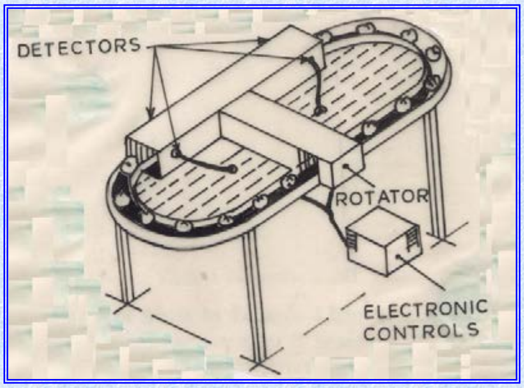


Plate 3.4 Electronic laser sensing assembly of orange grading machine

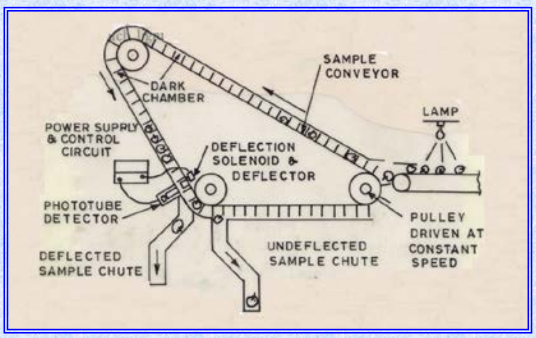
Optical Grader for Apples

(Colour Grading)



Optical Grader for Fruits

(Delayed Light Emission)



Mango grader

Potato grader

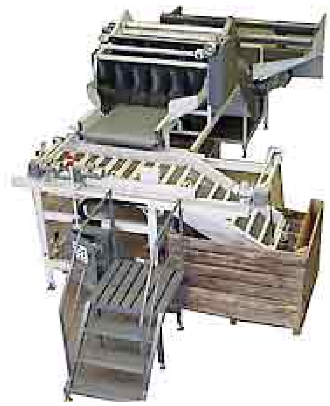
Features

- Capacities range from 5 tonne/hr to 30 tonne/hr
- Washing
- Dry brushing lines
- Sizing
- Bagging lines

Onion grader

Features

- Capacities range from 8 tonne/hr to 30 tonne/hr
- Bulk receival
- Top and tailing
- Sizing
- Bagging lines



Sweet Potato Sorter

Electronic sizer for sweet potato

Grader for sweet potato

Belt grader

- Used to separate round from other shaped seeds/parts or weeds in flower, herb, tree, cactus and vegetable seeds.
- For vegetable seeds separation of triangular or sharp shaped seed from round spinach seed

Indented cylinder grader

- Used for. separating plant parts and weeds in carrot, onion and lettuce, but also for flower seeds like marigold and impatiens.
- Used for calibrating the seeds based on their length to obtain more uniformity to produce seed pellets

CHAPTER 20: SIZE REDUCTION – EQUIPMENT FOR SIZE REDUCTION, CARE AND MAINTENANCE

Unit operation in which the average size of solid pieces of food is reduced by the application of

- grinding
- compression
- impact forces

Related terms

- **Homogenization or Emulsification**
  - Reduction in size of globules of immiscible liquids
- **Atomization**
  - Size reduction of liquids by droplets
- **Extrusion, Agglomeration or Forming**
  - Size enlargement

Benefits in food processing

- ✓ Increase in the surface area to volume ratio of the food
- ✓ Increases the rate of drying, heating or cooling
- ✓ improves the efficiency and rate of extraction of liquid components
- ✓ Eg. Fruit juice, cooking oil extraction
- ✓ When combined with screening, a predetermined range of particle sizes is produced which is important for the correct functional or processing properties of some products
- ✓ Eg. Icing sugar, spices, corn starch
- ✓ A similar range of particle sizes allows more complete mixing of ingredients
- ✓ Eg. Dried soup and cake mixes

Methods

- ❖ Chopping, cutting, slicing and dicing
- ❖ Large to medium (Cheese and sliced fruit for canning)
- ❖ Medium to small (Diced carrot)
- ❖ Small to granular (minced meat, flaked fish or nuts and shredded vegetables)
- ❖ Milling to powders or pastes
- ❖ Grated products
- ❖ Emulsification and homogenization

Theory

Three types of forces

- Compression
- Impact
- Shearing or Attrition forces

Stress is applied to a food; the resulting internal strains are first absorbed to cause deformation of the tissues. Amount of energy needed to fracture a food is determined by its hardness and tendency to crack – in turn depends on the structure of the food. Fewer the lines of weakness in a food, the higher are the energy input needed to cause fracturing. Harder foods absorb more energy and require a greater energy input to create fractures. Extent of size reduction, the energy expanded and the amount of heat generated in the food depend on both the size of the forces that are applied and the time that food is subjected to the forces. Compression forces are used to fracture friable or crystalline foods. Combined impact and shearing forces are necessary for fibrous foods. Shearing forces are used for fine grinding of softer foods.

Factors influencing the energy input

- **Moisture content**
  - Wheat is conditioned to optimum moisture content
  - Maize is thoroughly soaked and wet milled for complete disintegration
- **Heat sensitivity of the food**
  - Determines the permissible temperature rise and the necessity to cool the mill
  - Liquid N_2 or solid CO_2 are mixed with foods before milling to cool the product and to retain volatiles
- Quantum of the forces that are applied
- Time that food is subjected to the forces

Equations for energy requirement determination

Kicks law

- Energy required to reduce the size of particles is directly proportional to the ratio of the initial size of a typical dimension to the final size of that dimension

$E = K_k \ln (D_f/D_p)$

E – Energy required per mass of feed

K_k – Kick's constant

D_f – Average initial size of feed

D_p – Average size of product

D_f / D_p – Size reduction ratio

- Coarse grinding has RRs below 8:1
- Fine grinding can exceed 100:1
- Grinding of coarse particles in which the increase in surface area per unit mass is relatively small, Kick's Law is a reasonable approximation
- Rittinger's law
  - States that the energy required for size reduction is proportional to the change in surface area of the pieces of food

- $E = K_R \left(\frac{1}{D_p} - \frac{1}{D_f} \right)$
- K_R – Rittinger's constant
- For the size reduction of fine powders, in which large areas of new surface are being created, Rittinger's Law fits the experimental data better.

Bond's law

- The work required to form particles of size Dp from very large feed is proportional to the square root of the surface to volume ratio of the product
- $P/f = 0.3162\, wi \left(\frac{1}{\sqrt{Dp}} - \frac{1}{\sqrt{Df}} \right)$

P – Power in kW

f – feed rate, t/hr

Dp – 80% of the product passes through mesh of dia Dp, mm

Df – 80% of feed passes through mesh of dia, Df, mm

Wi – Work index

Gross energy requirement in kilowatt-hour per tonne of feed needed to reduce a very large feed to such a size that 80% of the product passes through a 100 micro meter screen

- An ideal size reduction equipment should fulfill the following conditions
  - Large capacity
  - Should yield a pre desired sized product or range of size
  - Small power input requirement per unit of product handled
  - Easy & trouble free operation
- Amount of power required to create smaller particles
- Desired uniformity of size

- Work required to strain the material is temporarily stored in the form of mechanical energy of stress.
- When external force exceeds the amount of stored mechanical energy, the material is disturbed beyond its strength and finally broken in to fragments – results in creation of new surface
- Solids have a certain amount of surface energy, thus for creation of new surface, work is required and supplied by the release of stress energy when material breaks.
- Stress energy excess of the new surface energy create is converted into heat energy.

Grinding

- Classified in to two
- Plain grinding
  - Milled to a free flowing meal consisting of sufficiently uniform particle size
- Selective grinding
  - Grinding operation is carried out in various stages depending upon the differences in structural and mechanical properties of components of grain

Degree of grinding

- Ratio of the overall surface area of the ground product to the overall surface area of the feed

Dg = Sp/Sf

Dg – degree of grinding

Sp – Overall surface area of product

Sf – Overall surface area of feed

Milling efficiency

- Product of coefficient of hulling (E hulling)and coefficient of wholeness of kernel (E wk)
- Coefficient of hulling
  - Percentage of the hulled grains obtained from the total amount of grain input
- Coefficient of Wholeness of kernel
  - Ratio of the amount of kernel, crushed grains and mealy waste obtained by any milling system

Size reduction machinery

- Crushers
- Grinders
- Fine grinders
- Cutting machines

Crushers

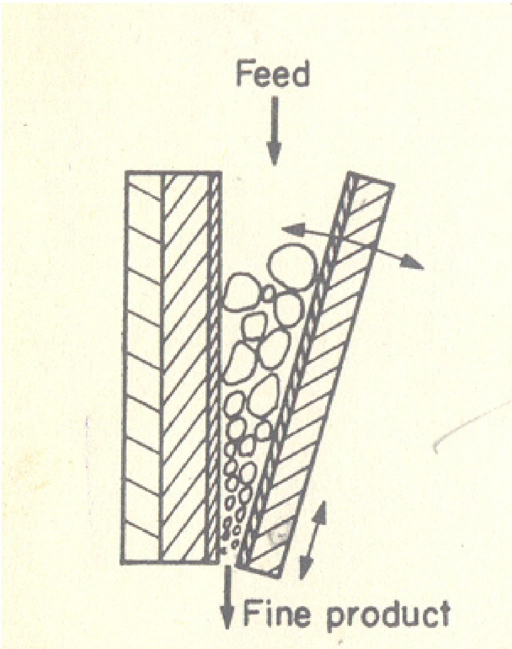
- Squeeze or press the material until it breaks
- Mostly used to break large pieces of solid materials into small lumps
- Use of crushers in agricultural operations is limited

Types

  - Jaw crushers
  - Gyratory crushers

Jaw crusher

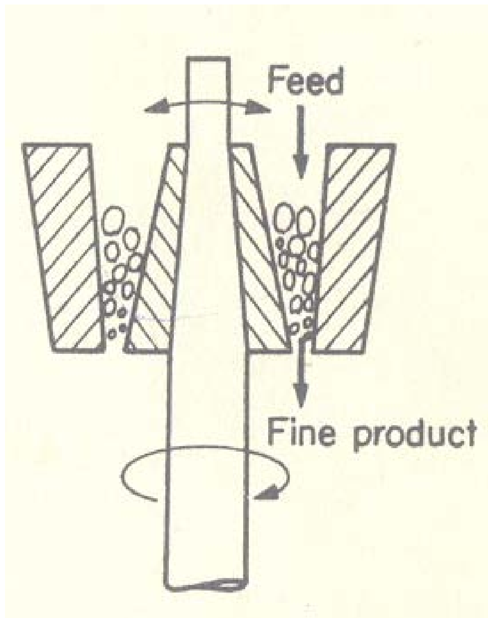
- Feed is admitted between two jaws, which are open at the top like V
- One of the jaws is fixed and vertical, while the other is the swinging jaw
- This jaw reciprocates in a horizontal plane and makes the angle of 20-30° with the fixed jaw
- Movable jaw is operated by an eccentric unit so as to impart great compressive force
- Solids which has to be broken is caught between the two jaws
- Large lumps of solid materials are caught between the upper parts of the jaws
- Subsequently broken and dropped into the narrower space below
- Broken pieces are further reduced next time when jaws come closer.
- No. of strokes given to the movable jaw ranges between 250 to 400 times per minute



Gyratory crusher

- Jaws between which the solid materials fed are circular
- Material is being crushed at all times at some point

- Solids are caught between V shaped space between the head and casing
- Material is repeatedly broken in sufficiently small pieces to pass out from the bottom.
- Speed of crushing ranges between 125 to 425 gyrations per minute
- Discharge from the gyratory crusher is continuous
- Less maintenance is required as compared to jaw crusher
- Power requirement is low



Crushing rolls

- Mainly used for extraction of juice from sugarcane
- Two types
  - Smooth roll crusher
  - Serrated or toothed roll crusher

Smooth roll crusher

- Two heavy smooth faced roll rotating towards each other at same speed on parallel horizontal axes
- Size of the material caught by the rolls depends upon the coefficient of friction between the material and the roll surface
- $D_p = 0.04R + g$

D_p – maximum size of particle

R – roll radius

g – half of the width of gap between the rolls

- Used to make grits or meal from food grains

- One of the rolls should be spring loaded to avoid any damage to roll surface
- Extensively used for making food grains flakes

Serrated or toothed roll crusher

- Rolls are serrated as per need
- Much more versatile than smooth roll crusher
- Best example – Break and reduction rolls of wheat milling
- Disintegrators are toothed roll crushers in which the corrugated rolls are rotating at different speeds
- Size reduction is by compression, impact and shear and not by compression alone, as in the case of smooth roll crushers
- Can accommodate larger particles than smooth roll crushers

Crushing efficiency

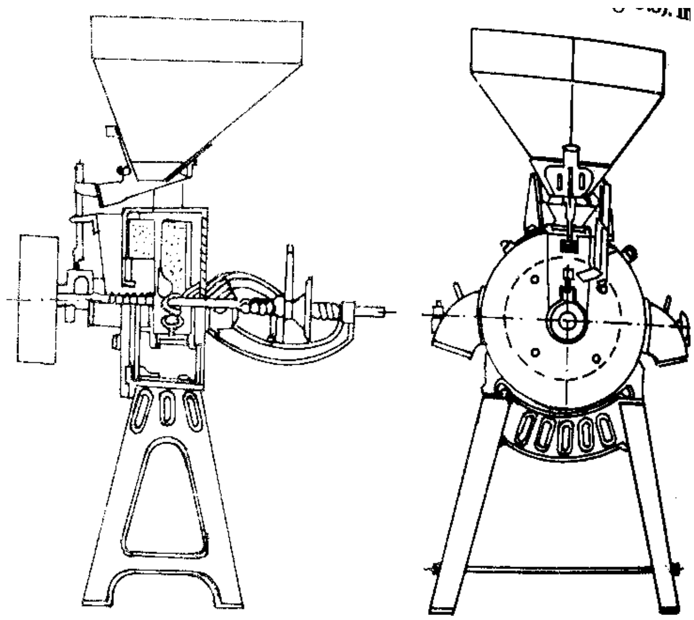
- Ratio of the surface energy created by crushing to the energy absorbed by the solid

Grinders

- Used to mill the grains into powder
- Types
  - Attrition mill
  - Hammer mill
  - Impactors
  - Rolling compression mill

Attrition mill

- Also known as burr mill
- Grains are rubbed between the grooved flat faces of rotating circular disks
- Axis of the roughened disks may be horizontal or vertical
- One plate is stationary and fixed with the body of the mill while the other one is rotating disk
- Material is fed between the plates and is reduced by crushing and shear
- Mills with different patterns of grooves, corrugations on the plates perform a variety of operations
- Overfeeding
  - lowers grinders performance
  - Increases heat generation during milling
- Disks are 20-137 cm in dia and operated at 350 to 700 rpm



- Used for making whole grain and dehusked grain flour
- Use in spice grinding is limited
- Double runner disks type attrition mills are also available
- Used for grinding of soft materials
- Both disks are driven at high speed in opposite direction
- Operated between 1200 to 7000 rpm
- Capacity is large

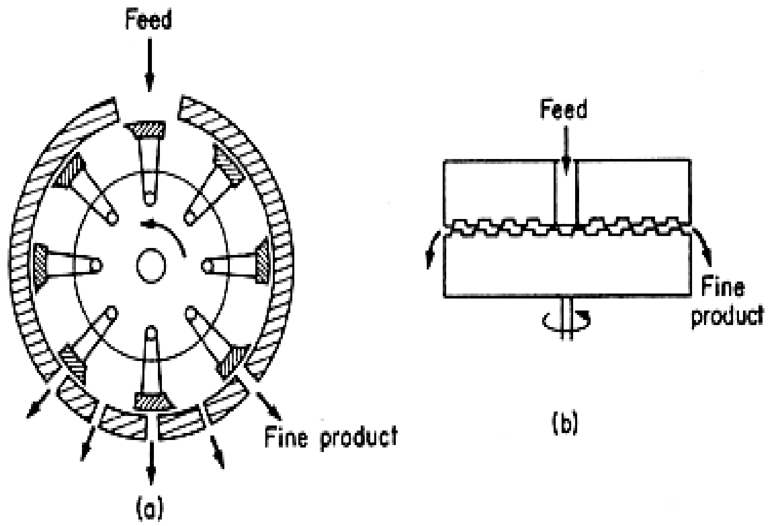
Salient features

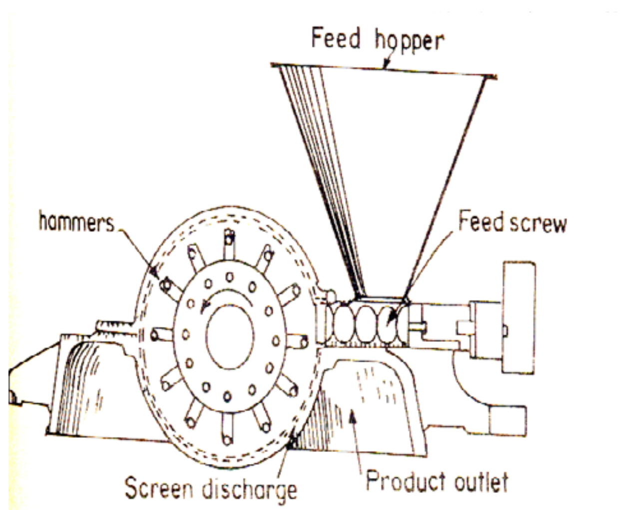
- Fineness of grinding is controlled by the type of plates and the gap between them
- Spacing between the plates is adjustable
- Arrangement is spring loaded
  - to avoid damage to plates in case of overloading
  - to overcome the damage to plates by foreign material coming along with the feed
- Lower initial cost
- Lower power requirements

Hammer mill

- Used for various types of size grinding jobs
- Size reduction takes place by impact force
- Consists of high speed rotor rotating inside a cylindrical casing
- Shaft is usually kept horizontal

- Materials are fed into the mill from the top of the casing and is broken by the rotating hammers and fall out through a screen at the bottom
- Feed is broken by the fixed or swinging hammers, pinned to a rotor
- Hammers are rotated between 1550 to 4000 rpm, strike and grind the material until it becomes small enough to pass through the bottom screen





- Fineness of grinding is controlled by the screen size
- There is less chances of damage of hammer in swinging hammer mill
- Can grind tough fibrous solids, steel chips, food grains, hard rock etc.
- Assumed to reduce size by impact of hammers

Salient features

- Simplicity and versatility in design
- Less chances of damage due to foreign objects
- High power requirement
- Capacity and power requirement depend on the nature of feed to be ground
- Used for poultry feed grinding, spices grinding
- Suitable for grinding of wet sorghum and millets
- Also used for potato, tapioca, banana flour making

Ball mill

- ❖ Cylindrical or conical shell slowly rotating about a horizontal axis.
- Half of its volume is filled with solid grinding balls
- Shell is made of steel lined with high carbon steel plate, porcelain or silica rock.
- Size reduction is achieved by impact of the balls when they drop from near the top of the shell
- Energy consumed in lifting the balls is utilized for grinding job
- When the ball mill is rotated , the balls are carried by the mill wall nearly to the top
- Balls are released by the gravitational pull and drop to the bottom and picked up again
- Centrifugal force keeps the ball in contact with the mill wall.
- Due to centrifugal force, if the speed of rotation of mill is faster, the balls are carried to more distance.
- Centrifuging: In case of too high speed, balls stick to mill wall and are not released

Critical speed: Rotational speed at which centrifuging occurs

- At this speed, no impact occurs hence little or no grinding results
- Operating speed must be kept less than the critical speed
- Speed at which the outermost ball released from the mill wall depends on the interaction of gravitational and centrifugal forces
- Critical speed can be determined by
- $n_c = 1/2\pi \sqrt{g/R-r}$

nc = critical speed, revolution/sec

g= acceleration due to gravity, 9.8 m/s2

R- radius of the mill, m

r = radius of the ball, m

Roller mills

- Roller mills are similar to roller crushers
- They have smooth or finely fluted rolls, and rotate at differential speeds.
- They are used very widely to grind flour.
- Because of their simple geometry, the maximum size of the particle that can pass between the rolls can be regulated.
- If the friction coefficient between the rolls and the feed material is known, the largest particle that will be nipped between the rolls can be calculated, knowing the geometry of the particles.

CHAPTER 21: EVAPORATION – PRINCIPLES, TYPES OF EVAPORATORS

Evaporation is an operation used to remove a liquid from a solution, suspension, or emulsion by boiling off some of the liquid. It is thus a thermal separation, or thermal concentration, process. We define the evaporation process as one that starts with a liquid product and ends up with a more concentrated, but still liquid and still pumpable concentrate as the main product from the process. There are actually a few instances where the evaporated, volatile component is the main product, but we will not discuss that here.

In most cases it is essential that the product be subject to minimal thermal degradation during the evaporation process, requiring that temperature and time exposure must be minimized. This and other requirements brought on by the physical characteristics of the processed product have resulted in the development of a large range of different evaporator types. Additional demands for energy efficiency and minimized environmental impact have driven development toward very innovative plant configurations and equipment design.

In the field of thermal separation / concentration technology, evaporation plants are widely used for concentration of liquids in the form of solutions, suspensions, and emulsions. The major requirement in the field of evaporation technology is to maintain the quality of the liquid during evaporation and to avoid damage to the product. This may require the liquid to be exposed to the lowest possible boiling temperature for the shortest period of time. This and numerous other requirements and limitations have resulted in a wide variation of designs available today. In almost all evaporators the heating medium is steam, which heats a product on the other side of a heat transfer surface. The following list contains the descriptions of the most common types of evaporators.

1. Falling Film Evaporators
2. Rising Film Evaporators
3. Forced Circulation Evaporators
4. Plate Evaporators
5. Thermal and Mechanical Vapor Recompression (TVR & MVR)

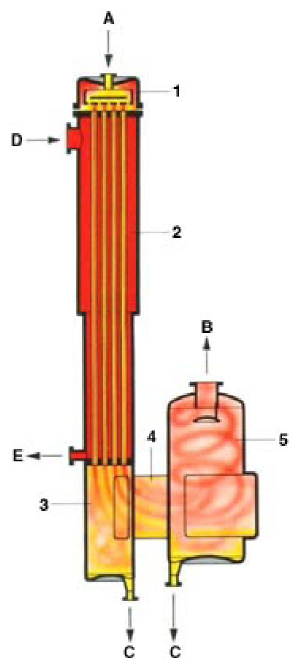
Typical evaporator applications:

- Product concentration
- Dryer feed pre-concentration
- Volume reduction
- Water / solvent recovery
- Crystallization

Falling Film Evaporators

In falling film evaporators, liquid and vapors flow downwards in parallel flow. The liquid to be concentrated is preheated to boiling temperature. An even thin film enters the heating tubes via a distribution device in the head of the evaporator, flows downward at boiling temperature, and is partially evaporated. This gravity-induced downward movement is increasingly augmented by the co-current vapor flow.

Falling film evaporators can be operated with very low temperature differences between the heating media and the boiling liquid, and they also have very short product contact times, typically just a few seconds per pass. These characteristics make the falling film evaporator particularly suitable for heat-sensitive products, and it is today the most frequently used type of evaporator.



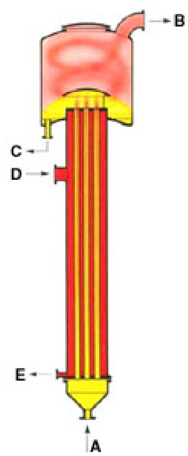
A: Product	1: Head
B: Vapor	2: Calandria
C: Concentrate	3: Calandria, Lower part
D: Heating Steam	4: Mixing Channel
E: Condensate	5: Vapor Separator

Fig. 1. Falling Film Evaporator

However, falling film evaporators must be designed very carefully for each operating condition; sufficient wetting of the heating surface by liquid is extremely important for trouble-free operation of the plant. If the heating surfaces are not wetted sufficiently, dry patches and incrustations will occur; at worst, the heating tubes will be completely clogged. In critical cases extending or dividing the evaporator effects, keeping the advantages of single pass operation, can increase the wetting rate. The proper design of the liquid distribution system is critical to achieve full and even product wetting of the tubes. Because of the low liquid holding volume in this type of unit, the falling film evaporator can be started up quickly and changed to cleaning mode or another product easily. Falling film evaporators are highly responsive to alterations of parameters such as energy supply; vacuum, feed rate, concentrations, etc. When equipped with a well-designed automatic control system they can produce a very consistent concentrated product. The fact that falling film evaporators can be operated with small temperature differences makes it possible to use them in multiple effect configurations or with mechanical vapor compression systems in modern plants with very low energy consumption.

Rising Film Evaporators

These operate on a "thermo-siphon" principle. Feed enters the bottom of the heating tubes and as it heats, steam begins to form. The ascending force of this steam produced during the boiling causes liquid and vapors to flow upwards in parallel flow. At the same time the production of vapor increases and the product is pressed as a thin film on the walls of the tubes, and the liquid rises upwards.



A: Product

B: Vapor

C: Concentrate

D: Heating Steam

E: Condensate

Fig.2. Rising Film Evaporator

This co-current upward movement has the beneficial effect of creating a high degree of turbulence in the liquid. This is advantageous during evaporation of highly viscous products and products that have a tendency to foul the heating surfaces. Usually there must be a rather high temperature difference between the heating and boiling sides of this type of evaporator. Otherwise the energy of the vapor flow is not sufficient to convey the liquid and to produce the rising film. The length of the boiling tubes will typically not exceed 23 ft. This type of evaporator is often used with product recirculation, where some of the formed concentrate is reintroduced back to the feed inlet in order to produce sufficient liquid loading inside the boiling tubes.

Forced Circulation Evaporator

Forced circulation evaporators are used if boiling of the product on the heating surfaces is to be avoided due to the fouling characteristics of the product, or to avoid crystallization. The flow velocity in the tubes must be high, and high-capacity pumps are required. The circulating liquid is heated when it flows through the heat exchanger and then partially evaporated when the pressure is reduced in the separator, cooling the liquid to the boiling temperature corresponding to this pressure.

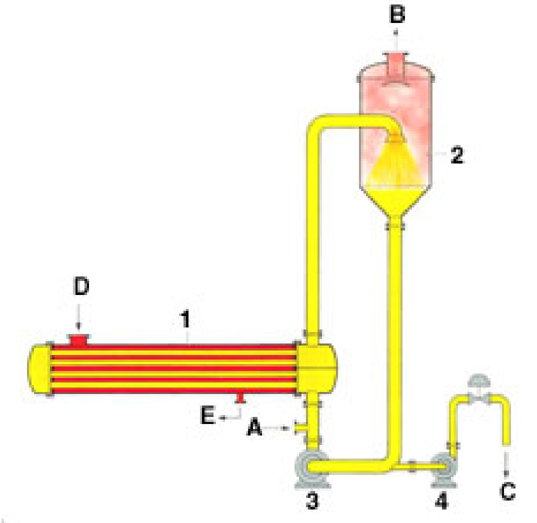


Fig. 3. Forced Circulation Evaporator

A: Product
B: Vapor
C: Concentrate
D: Heating System
E: Condensate

1: Calandria
2: Separator (Flash Cooler)
3: Circulation Pump
4: Concentrate Pump

The liquid is typically heated only a few degrees for each pass through the heat exchanger, which means the recirculation flow rate has to be high. This type of evaporator is also used in crystallizing applications because no evaporation, and therefore no concentration increase, takes place on the heat transfer surface. Evaporation occurs as the liquid is flash evaporated in the separator/flash vessel. In crystallizer applications this is then where the crystals form, and special separator designs are used to separate crystals from the recirculated crystal slurry. The heat exchanger (in evaporator parlance sometimes called the "calandria") can be arranged either horizontally or vertically depending on the specific requirements in each case.

Methods of Operation of Evaporators

1. **Single-effect evaporators**

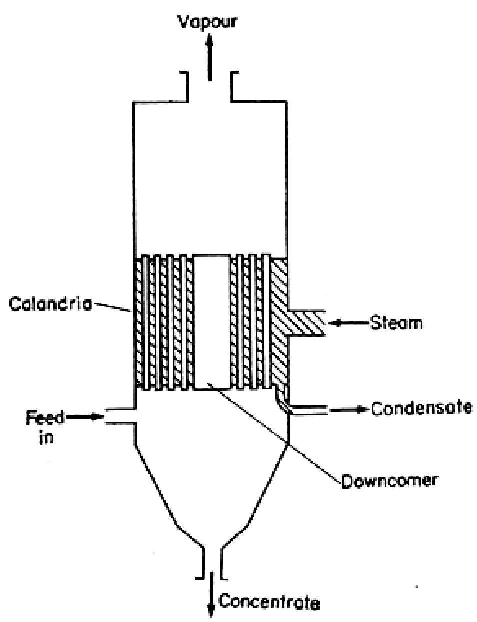
A simplified diagram of a single-stage or single-effect evaporator is given in Fig.1. The feed enters at T_F K and saturated steam at T_s enters the heat-exchange section. Condensed steam leaves as condensate or drips. Since the solution in the evaporator is assumed to be completely mixed, the concentrated product and the solution in the evaporator have the same composition and temperature T_t, which is the boiling point of the solution. The temperature of the vapor is also T_t, since it is in equilibrium with the boiling solution. The pressure is P_1, which is the vapor pressure of the solution at T_t.

If the solution to be evaporated is assumed to be dilute and like water, then 1 kg of steam condensing will evaporate approximately 1 kg of vapor. This will hold if the feed entering has a temperature T_F near the boiling point.

The concept of an overall heat-transfer coefficient is used in the calculation of the rate of heat transfer in an evaporator. The general equation can be written

$$q = UA\Delta T = UA(T_s - T_1) \quad (1)$$

where q is the rate of heat transfer in W, U is the overall heat-transfer coefficient in W/m^2. K, A is the heat-transfer area in m^2, T_sk is the temperature of the condensing steam in K, and T_l is the boiling point of the liquid in K.



Single-effect evaporators are often used when the required capacity of operation is relatively small and/or the cost of steam is relatively cheap compared to the evaporator cost. However, for large-capacity operation, using more than one effect will markedly reduce steam costs.

2. Forward-feed multiple-effect evaporators

A single-effect evaporator as shown in Fig.1 is wasteful of energy since the latent heat of the vapor leaving is not used but is discarded. However, much of this latent heat can be recovered and reused by employing multiple-effect evaporators. A simplified diagram of a forward-feed triple-effect evaporation system is shown in Fig.2. If the feed to the first effect is near the boiling point at the pressure in the first effect 1 kg of steam will evaporate almost 1 kg of water. The first effect operates at a high-enough temperature so that the evaporated water serves as the heating medium to the second effect. Here, again, almost another kg of water is evaporated, which can be used as the heating medium to the third effect. As a very rough approximation, almost 3 kg of water will be evaporated for 1 kg of steam for a three-effect evaporator. Hence, the steam economy, which is kg vapor evaporated/kg steam used, is increased. This also approximately holds for a number of effects over three. However, this increased steam economy of a multiple-effect evaporator is gained at the expense of the original first cost of these evaporators.

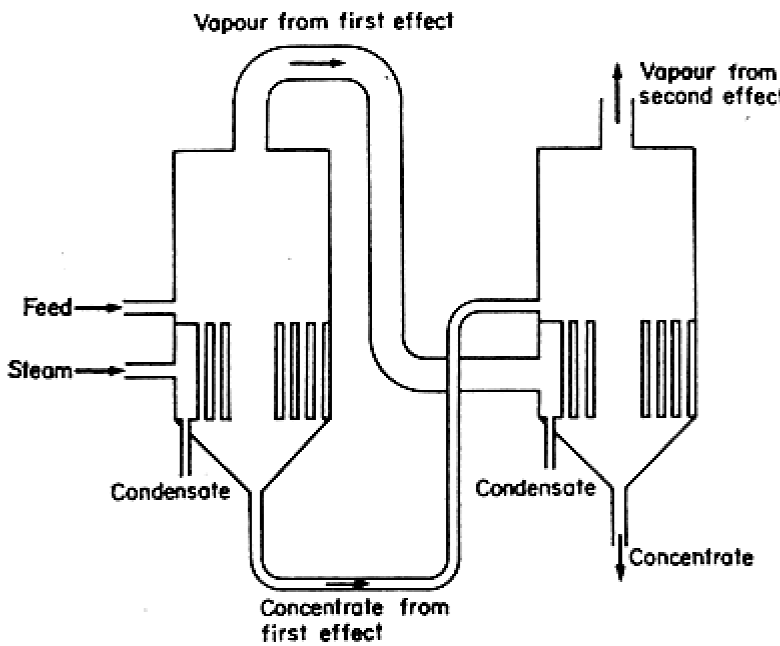


Fig 2. Double effect evaporator – forward feed

In forward-feed operation as shown in Fig.2, the fresh feed is added to the first effect and flows to the next in the same direction as the vapor flow. This method of operation is used when the feed is hot or when the final concentrated product might be damaged at high temperatures. The boiling temperatures decrease from effect to effect. This means that if the first effect is at P_1= 1 atm abs pressure, the last effect will be under vacuum at a pressure P_3.

3. Backward-feed multiple-effect evaporators

In the backward-feed operation shown in Fig.3 for a triple-effect evaporator, the fresh feed enters the last and coldest effect and continues on until the concentrated product leaves the first effect. This method of reverse feed is advantageous when the fresh feed is cold, since a smaller amount of liquid must be heated to the higher temperatures in the second and first effects. However, liquid pumps are used in each effect, since the flow is from low to high pressure. This method is also used when the concentrated product is highly viscous. The high temperatures in the early effects reduce the viscosity and give reasonable heat-transfer coefficients.

4. Parallel-feed multiple-effect evaporators

Parallel feed in multiple-effect evaporators involves the adding of fresh feed and the withdrawal of concentrated product from each effect. The vapor from each effect is still used to heat the next effect. This method of operation is mainly used when the feed is almost saturated and solid crystals are the product, as in the evaporation of brine to make salt.

Chapter 22: FOOD STANDARDS AND REGULATIONS

U.S. FOOD SAFETY SYSTEM

The Food and Drug Administration (FDA) is charged with protecting consumers against food that is impure, unsafe, produced under unsanitary conditions, or fraudulently labeled. Through its Center for Food Safety and Applied Nutrition (CFSAN) and the Office of Regulatory Affairs (ORA), the FDA regulates both domestic and imported foods, except meat and poultry and processed eggs and has primary responsibility for enforcing food safety laws including food import and export regulations. (FDA. 2001) Some of the activities of the FDA with particular impact on imported produce include

- Inspecting food production establishments and food warehouses and collecting and analyzing samples for physical, chemical, and microbial contamination.
- Establishing good agricultural practices and good manufacturing practices and other production standards, such as plant sanitation, packaging requirements, and Hazard Analysis and Critical Control Point programs.
- Sampling and inspection of imported foods.
- Working with foreign governments (and with FDA counterparts in these countries, if they exist) to ensure safety of imported foods.
- Taking appropriate enforcement actions.
- Educating industry and consumers on safe food handling practices.

The Centers for Disease Control and Prevention (CDC) work closely with state and local public health epidemiologists and laboratories to identify illnesses and clusters of illnesses that may be food borne. CDC surveys and studies various environmental and chronic health problems and administers national programs for prevention and control of vector-borne diseases (diseases transmitted by a host organism) and other preventable conditions.(CDC. 1999)

The U.S. Department of Agriculture (USDA) has several agencies that may play a role in assuring food safety by establishing the safety of imported fruits and vegetables.

- The Agricultural Marketing Service (AMS) carries out a wide range of programs aimed at facilitating the marketing of agricultural products, assuring consumers a quality food supply, and ensuring fair trading practices. Certain agricultural commodities (including fresh tomatoes, avocados, mangoes, limes, oranges, grapefruit, green peppers, Irish potatoes, cucumbers, eggplants, dry onions, walnuts and filberts, processed dates, prunes, raisins, and olives in tins) must meet United States import requirements relating to grade, size, quality, and maturity. These commodities are inspected and the AMS must issue an inspection certificate to indicate import compliance.

- The Foreign Agricultural Service (FAS) has primary responsibility for the USDA's overseas programs, including market development, international trade agreements and negotiations, and the collection of statistics and market information.
- The Food Safety and Inspection Service (FSIS) regulates meat, poultry and egg products and maintains a comprehensive system of import inspection and controls.
- The Economic Research Service (ERS) provides estimates of costs of food borne disease and conducts benefit/cost analyses of alternative regulatory options.
- USDA’s Animal and Plant Health Inspection Service (APHIS) inspects imported agricultural products for disease and pests which might infect plants and animals. Through monitoring activities at airport terminals, seaports, and border stations, it guards U.S. borders against the entry of foreign agricultural pests and diseases.

U.S. Environmental Protection Agency (EPA) includes regulating pesticides and assuring that drinking water meets standards for health. Through the Office of Pesticide Programs (OPP), EPA determines the safety of new pesticide products, sets tolerance levels for pesticide residues in foods.

INTERNATIONAL FOOD LAWS AND REGULATIONS

Sanitary (human and animal health) and phytosanitary (plant health) standards are necessary to ensure that food is safe for consumers, to prevent the spread of pests and diseases among animals and plants and to ensure fair practices in trade. In recent years, world food trade has been profoundly altered by the adoption of agreements that provide a more precise framework for trade, and define the rights and the obligations of all partners. These agreements served to strengthen the status of institutions like the Codex Alimentarius Commission and the International Plant Protection Convention since these were used as a basis for harmonization.

THE URUGUAY ROUND AGREEMENTS

The Uruguay Round of Multilateral Trade Negotiations, which concluded in 1994, established the World Trade Organization (WTO) to replace the General Agreement on Tariffs and Trade (GATT). The Uruguay Round negotiations were the first to deal with the liberalization of trade in agricultural products, an area excluded from previous rounds of negotiations. They also included negotiations on reducing non-tariff barriers to international trade in agricultural products and concluded with two binding agreements: the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical

Barriers to Trade (TBT Agreement). The Agreement on the Application of Sanitary and Phytosanitary Measures confirms the right of WTO member countries to apply measures necessary to protect the life and health of humans, animals and plants (FAO, 2000).

The Agreement on Technical Barriers to Trade was established with the objective of preventing the use of national or regional technical requirements, or standards in general, as unjustified barriers to trade (FAO, 2000). The agreement covers standards relating to all types of products including industrial and agricultural products. Not covered are food standards related to sanitary and phyto sanitary measures. It includes numerous measures designed to protect consumers against deception and economic fraud. Examples of food standards covered by the TBT Agreement are those related to quality and labeling. The TBT Agreement basically provides that all technical standards and regulations must have a legitimate purpose and that the impact or cost of implementing a standard must be proportional to the purpose of the standard. It also says that if there are two or more ways of achieving the same objective, the least trade-restrictive alternative should be followed. The agreement also places emphasis on international standards and WTO members are obliged to use international standards or parts of them except where the international standard would be ineffective or inappropriate in the national situation. The TBT Agreement does not include a program for harmonizing national standards.

CODEX ALIMENTARIUS

The adoption of the SPS and TBT Agreements resulted in new emphasis and importance being placed on the work of Codex in establishing international food quality and safety standards.

Codex Alimentarius

The purpose of Codex is

- to guide and promote the elaboration of definitions and requirements for foods and assist in their harmonization
- to facilitate world trade
- to promote consumer protection

The name Codex Alimentarius is taken from Latin and translates literally as “food code” or “food law”. The Codex Alimentarius is a series of food standards, codes and other regulations adopted by the Codex Alimentarius Commission (CAC) that countries can use as models in their domestic food legislation and regulations, and which can be applied to international trade. Codex provides the assurance that any foods produced according to its codes of hygienic practices and complying with its standards are safe and nutritious and offer adequate health protection. The CAC was created in 1962 by two United Nations organizations, the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Its main purpose is to promote consumer protection and to facilitate world trade in foods through the development of food standards, codes of practice and other guidelines (FAO/WHO, 1999). Since its inception, the CAC has been responsible for implementing the Joint FAO/WHO Food Standards Program (FAO, 2000).

The CAC is an intergovernmental body with a current membership of 165 Member governments. Membership is open to all Member Nations and Associate Members of FAO and WHO. In addition, observers from international scientific, food industry, food trade and consumer associations may attend sessions of the Commission and of its subsidiary bodies. While observer organizations can fully participate in the proceedings of the meeting, by statute, only Member governments can participate in any decision process. To facilitate international trade, it has been necessary for efforts to be made to harmonize food standards. Those involved in harmonization efforts recognized that countries have the right to adopt standards they feel are appropriate to protect human, animal and plant health and the environment. They also have the right to take the steps necessary to assure these standards are met. However, preventing these standards from becoming barriers to trade is important to promote trade between countries (FAO, 1998).

The Codex Alimentarius is a series of food standards, codes and other regulations adopted by the Codex Alimentarius Commission (CAC) that countries can use as models in their domestic food legislation and regulations, and which can be applied to international trade. Codex provides the assurance that any foods produced according to its codes of hygienic practices and complying with its standards are safe and nutritious and offer adequate health protection.The Codex Committee on Food Hygiene is currently developing a code of hygienic practice for fresh fruits and vegetables entitled *“Draft Code of Hygienic Practice for Fresh Fruits and Vegetables”.* This draft code addresses GAPs and GMPs that will help control microbial, chemical, and physical hazards associated with all stages of the production of fresh fruits and vegetables from primary production to packaging. To facilitate international trade, harmonization of food standards is necessary to prevent these standards from becoming barriers to trade between countries.

INDIAN STANDARDS

There are a number of food laws being implemented by various Ministries/Departments. These are primarily meant for two purposes namely (1) Regulation of Specifications of food and (2) Regulation of Hygienic condition of Processing/Manufacturing. Some of these food laws are mandatory and some are voluntary. The details of various food laws in operation in India are as under:-

A. Food Laws

The main Acts/Regulations/Control orders to regulate trade

- Prevention of Food Adulteration Act 1954
- Plant Quarantine (Regulation of Import into India) Order, 2003
- Meat Food Product Order 1973
- Milk And Milk Product Order 1992
- Bureau Of Indian Standards Act, 1986
- Standards On Weight And Measurement Act, 1976
- Livestock Importation Act, 1898
- AGMARK Act ,1937
- The Infant Milk Substitutes, Feeding Bottles and Infant Foods Act ,1992
- Export (Quality Control and Inspection) Act, 1963
- Essential commodities Act,1955
- Indian Explosives Act,1884
- Energy Conservation Act, 2001

1. Prevention of Food Adulteration Act (Ministry of Health)

The Act lays down specifications for various food products and is mandatory. The Ministry of Health in 1995 had constituted a Task Force. This Task Force recommended that there should be emphasis on good manufacturing practices instead of detection of adulteration and prosecution. It also expresses concern about lack of laboratory equipments and quantified persons. In addition it also suggested that the name of PFA Act be changed to Food Safety Act.

2. Agriculture Produce (Grading & Marking) Act (Ministry of Rural development)

This Act is commonly known as AGMARK and is voluntary. The Act lays down the specifications for various agricultural commodities including some processed foods.

3. Laws being operated by Bureau of Indian Standards (BIS)

BIS is the largest body for formulating standards for various food items. These standards are also voluntary.

4. Essential Commodities Act

A number of quality control orders have been issued under Essential Commodities Act such as FPO, MMPO, Meat Product Order and Vegetable Oils Control Order. These orders are mandatory and primarily meant for regulating the hygienic conditions. They need to be clubbed under one order which may called Food Products Order.

B. Harmonization of Food Laws

The review of multiple laws is necessary to have a uniform and logical approach for regulating the quality of food. The following action is being taken by various Ministries:-

1. The Ministry of Civil Supplies & Consumer Affairs has brought out a paper for consideration of Committee of Secretaries (COS). The paper recommends that BIS should formulate standards for all food items in the country. This will be a major step towards harmonization of food laws and is still under consideration of COS for finalization.
2. The Task Force had advocated promotion of food safety and quality. The Task Force has further made following suggestions
   - Food Regulation Authority (FRA) be set up to formulate and update food standards for domestic and export market.
   - FRA should replace the PFA to conform to international standards. The Task Force has given ten specific recommendations such as provision of storage, simplification of sampling procedure, simplification of procedure for nominee, time limit for prosecution, standard methods of analysis to be prescribed, penalty should graded according to the gravity of offences and provision of adequate/infrastructure and laboratories.
   - Harmonization of Indian standard with quality norms of Codex and WTO.
   - The Central Committee of food Standard (CCFS) should be replaced by FRA Governing Body for expeditious decisions.

THE FOOD SAFETY AND STANDARDS BILL, 2005

A Bill to consolidate the laws relating to food and to establish the Food Safety and Standards Authority of India for laying down science based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import, to ensure availability of safe and wholesome food for human consumption and for matters connected therewith or incidental thereto. The Central Government shall, by notification, establish a body to be known as the Food Safety and Standards Authority of India to exercise the powers conferred on, and to perform the functions assigned to, it under this Act. The Food Authority shall consist of a Chairperson and the following twenty-two members out of which one third shall be women, namely

1. Seven Members, not below the rank of a Joint Secretary to the Government of India, to be appointed by the Central Government, to respectively represent the Ministries or Departments of the Central Government dealing with
   (i) Agriculture
   (ii) Commerce
   (iii) Consumer Affairs

(iv) Food Processing

(v) Health

(vi) Legislative Affairs

(vii) Small Scale Industries who shall be Members ex officio

2. Two representatives from food industry of which one shall be from small scale industries;
3. Two representatives from consumer organizations
4. Three eminent food technologists or scientists
5. Five members to be appointed by rotation every three years, on each in seriatim from the Zones as specified in the First Schedule to represent the States and the Union territories.
6. Two persons to represent farmers' organization.
7. One person to represent retailers' organizations.

REFERENCES

CDC. 1999. PulseNet. The National Molecular Subtyping Network in Place to Combat Foodborne Illness. Press Release. Updated 2/18/99. Available via the Internet at http://www.cdc.gov/ncidod/dbmd/pulsenet/pulsenet.htm

FAO. 1998. Food Quality and Safety Systems. A Training Manual on Food Hygiene and the Hazard Analysis and Critical Control Point (HACCP) System. Food Quality and Standards Service, Food and Nutrition Division,Food and Agriculture Organization of the United Nations.

FAO. 2000. Manual on Multilateral Trade Negotiations on Agriculture: A Resource Manual. SPS and TBT Agreements. FAO, Rome. 2000.

FAO/WHO. 1999. Understanding the Codex Alimentarius. Available via the Internet at http://www.fao.org/docrep/w9114e/w9114e00.htm

FDA. 1999. Import Program System Information. Food and Drug Administration,Office of Regulatory Affairs. Available via the Internet at http://www.fda.gov/ora/import/ora_import_system.htm

FDA. 2001. Requirements of Laws and Regulations Enforced by the U.S. Food and Drug Administration. Available via the Internet at http://www.fda.gov/opacom/morechoices/smallbusiness/blubook.htm#baseinfo.

FRUIT PRODUCTS ORDER (FPO) REGULATIONS IN FOOD SAFETY

INTRODCUTION

The Food Safety and Standards Act, 2006

"An Act to consolidate the laws relating to food and to establish the food Safety and Standards Authority of India for laying down science based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import, to ensure availability of safe and wholesome food for human consumption and for matters connected therewith or incidental thereto."

The following laws were consolidated:

1. The Prevention of Food Adulteration Act, 1954 (37 of 1954)
2. The Fruit Products Order, 1955
3. The Meat products Order, 1973
4. The Vegetable Oil Products (Control) Order, 1947
5. The Edible Oils Packaging (Regulation) order, 1998
6. The Solvent Extracted Oil, De oiled Meal, and Edible Flour (Control) Order, 1967
7. The Milk and Milk Products Order, 1992
8. Any other order issued under the Essential Commodities Act, 1955 (10 of 1955) relating to food

"Food Safety" means assurance that food is acceptable for human consumption according to its intended use.

"Food Safety Management System" means the adoption of Good Manufacturing Practices, Good Hygienic Practices, Hazard Analysis and Critical Control Point and such other practices as may be specified by regulation, for the food business"

THE FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA

As per the Gazette notification of India under S.O.2127 dated 28.08.2008, the activities of FPO have been transferred to the Food Safety and Standards Authority of India from 01.12.2008 onwards.

Duties and Functions of Food Authority

1. To regulate and monitor the manufacture, processing, distribution, sale and import of food so as to ensure safe and whole some food
2. To specify the standards and guidelines in relation to articles of food and specifying an appropriate system for enforcing various standards notified under this Act
3. Accreditation of certification bodies in certification of food safety management system for food businesses
4. Enforcement of quality control in relation to any article of food imported into India
5. To provide scientific advice and technical support to the Central Government and the State Governments in matters of framing the policy and rules in areas which have a direct or indirect bearing on food safety and nutrition.

ABSTRACTS OF FRUIT PRODUCTS ORDER, 1955.

CLAUSE 4(1): No person shall carry on the business of manufacture of Fruit & Vegetable Products except and in accordance with the terms of an effective licence granted to him under this order.

CLAUSE 5(2): The following fee being appropriate fees shall be payable for one term or part thereof to be paid ONLY WHEN INSTRUCTED BY THIS OFFICE.

Categories	**Minimum manufacturing area, m^2**	**Raw materials stores, m^2**	**Finished goods area, m^2**	**Total area, m^2**	**Minimum height, feet**	**Licence fee, Rs.**
HOME SCALE B: Annual Production of fruit products Except Canned vegetables Not exceeding 10 M.T.	25	10	15	50	10	100
COTTAGE SCALE: Annual Production of fruit products Exceeding 10 MT & upto 50 MT	60	20	40	120	10	250
SMALL SCALE-A: Installed Capacity of not exceeding 1 MT per day or Annual production ranging over 50 MT and upto 100 MT	100	40	60	200	14	400
SMALL SCALE-B: Installed Capacity upto 2 MT per day	150	50	100	300	14	600

And total annual production of more than 100 MT & Upto 250 MT						
LARGE SCALE: Installed Capacity of more than 2MT fruit Products per day or total Annual production of 250 MT And above	300	100	200	600	14	1500

NOTE:

1. Area occupied by Machinery shall not be more than 50% of manufacturing area.
2. WATER: Every licensee shall arrange for atleast l Kilo litre per day of potable water and its availability. Water shall be adequately increased as per production. Free flowing pipe water supply shall be made available to the processing hall.
3. The workers engaged in Fruit & Vegetable processing shall be got medically examined for their fitness to ensure that they are not suffering from any contagious diseases.
4. For Large/Small Scale B category units, a qualified CHEMIST shall be appointed as QUALITY CONTROL INCHARGE.
5. All the workers engaged in the production of Fruit & Vegetable products shall be provided with clean APRONS AND HEADWEARS.

FRUIT PRODUCTS ORDER (FPO) 1955

- Constituted under Section3 of Essential Commodities Act
- Aims at regulating Sanitary & Hygienic conditions in the manufacture of Fruit Products.
- Mandatory for all Manufacturers of Fruit and Vegetable Products to obtain a licence under FPO.
- Implemented by the Food Safety and Standards Authority of India through Directorate of Fruit & Veg. Processing at its Regional Offices.

Products covered under FPO 1955

- All types of Processed Fruit and Vegetable products (eg:- Pickles,Jams,juices etc..)
- Sweetened aerated water
- Non- Fruit Vinegar & Non- Fruit Syrup.

Important Clauses under FPO-1955

- Clause-4:- No person shall carry on the business of a manufacturer except under and in accordance with the items of an effective licence granted to him under this order in Form-B.
- Clause-5:- Every application for grant of licence under Cl.4 shall be made in duplicates to the licensing officer in Form-A and shall be accompanied by a fee of such amount as is appropriate to the each of the clause of licence.
- Clause-7:-Every manufacturer shall manufacture fruit products in conformity with the sanitary requirements and the appropriate standard of quality and composition specified.
- Clause-9:- Every Manufacturer shall submit by the 31st of January of every year to the licensing officer a return in duplicate in Form-C in respect of each class of Fruit products manufactured, sold and exported by him during the previous term.
- Clause-12:- every manufacturer to whom any directions or order is issued in pursuance of any provision of this order shall be bound to comply with such directions or order any failure shall be deemed to be a contravention of the provisions of this order.

Documents to be submitted for grant of FPO license

1) Application in Form A (Copy enclosed)
2) Plan of the factory showing the dimensions in metres /sq.metres duly ear-marking the area for Processing, raw-materials store & finished goods Store.
3) List of Machinery and Equipments showing the Capacity, Horse-power Used, Number and Source of supply of each Machine.
4) Proof of possession of factory premises – Rental/Lease Agreement and Property Tax receipt indicating Name of Owner & address of unit .
5) N.O.C. from the Local Government Authority.
6) Water Analysis Report –Chemical & Bacteriological, from Public Health Laboratory /GOVT. APPROVED LABORATORY and the report should indicate that the water has been drawn from the factory premises either by The representative of the laboratory or by the Public Health Authority. Under remarks column, it shall clearly indicate that the water is fit for drinking purpose /Potable.

CLAUSE 7

Every manufacturer shall manufacture fruit products in conformity with the sanitary requirements and appropriate standards of quality and composition specified in the Second Schedule of this Order.

THE SECOND SCHEDULE (see Clause 7)

PART 1 (A): SANITARY REQUIREMENTS OF A FACTORY OF FRUIT PRODUCTS

1. The premises shall be adequately lighted, ventilated & cleaned by white washing/ colour washing or oil painting.
2. Windows and doors shall be fly proofed, doors fitted with automatic closing springs. Roof shall be permanent. Floor cemented.
3. The equipment and the factory shall not be used for manufacture of repugnant products like fish, meat, eggs etc., However, permission may be granted a special case if arrangements are made for disinfection of premises after changing from meat products to fruit products (One month idle gap will be required for change over).
4. The premises shall be located in a sanitary place with open surroundings, preferably in industrial area/estates. The premises shall not be used as or communicated directly with Residence.
5. Adequate arrangements for cleaning equipments, machinery, Containers, tables and raw materials shall be provided.
6. Copper, brass or iron equipments, containers or vessels are not permitted , in the preparation, packing or storage of fruit Products.
7. The water used shall be potable and shall be got examined Chemically and bacteriologically by a Public Health Laboratory (if no municipal water is available at the premises). The water sample should be drawn for such examination by the Public Health Authority of the area where the premises is located or should be drawn in the presence of the above authority. Free flowing tap water of 1 kilo litre per day shall be made available.
8. Adequate drainage system and provisions for disposal of refuse shall be made.
9. Sufficient number of laterine & urinals shall be provided for workers.
10. Wherever cooking is done on open fire, proper outlets for the smoke/steam etc., like chimney, exhaust fan etc., shall be provided.
11. The workers engaged in the factory shall be healthy and shall be medically examined, inoculated and vaccinated, whenever required.
12. The workers shall be provided with aprons, head-wears, gloves etc., and shall be personally neat and tidy.

Grant-in-aid: For setting up or up gradation of food processing units, Ministry of Food Processing Industries is giving grants. More details can be obtained from the Ministry's web site – www/mofpi.nic.in

Office Details:

The enforcement of FPO 1955, is being carried out from four regional offices located at

1. New Delhi
2. Mumbai
3. Kolkatta
4. Chennai
5. Guwahatti

The jurisdiction of our office covers Southern States of India *i.e.* Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Pondicherry and Lakshadweep.

Southern Regional Office is located at

Office of the Deputy Director(F&VP)
Food Safety And Standards Authority Of India,
C-1-D, Rajaji Bhawan, Besant Nagar,
Chennai-600 090
Tel:- 044-24912421, Fax:- 044-24463569

Address of the Food Safety and Standards Authority of India

Food Safety and Standards Authority of India
Ministry of Health and Family Welfare, Government of India,
FDA Bhawan,Kotla Road, New Delhi-110002
Website: www.fssai.gov.in; Tel: 011-23220992