ADITYA ENGINEERING COLLEGE (A)

UNIT – V
MILLING AND MATERIAL HANDLING

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Rice Milling

- **Paddy is the seed of certain variety of grass of Gramineae family.**
- **Botanical name of paddy is *Oryza sativa*.**
- **Nearly 1/2 to 2/3 of total world population has partially or totally adapted rice as their main food.**
- **It comprises of Palea and Lemma, two halves of the seed cover known as husk or hull and bottom portion known as empty glume which keeps palea and lemma in position.**
- **Rice kernel remains covered under the husk**

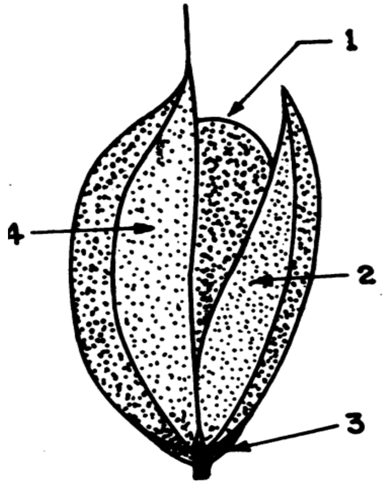
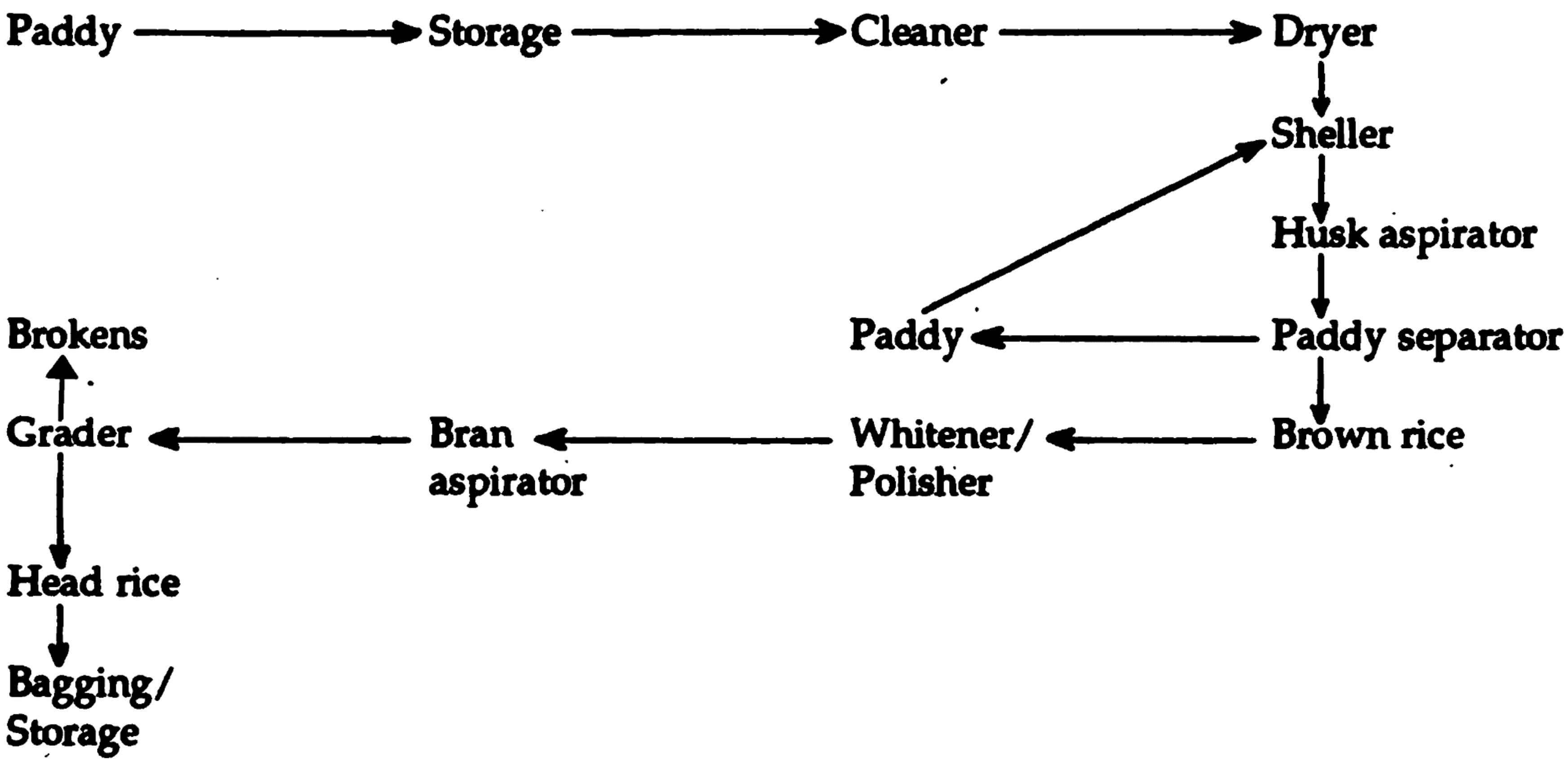


Fig. 5.20 : Paddy grain
1. rice kernel 2. palea
3. empty glume 4. lemma

The various unit operations and equipment used in a modern rice mill are:

1. **Cleaning/cleaner :** for removing foreign matter from paddy
2. **Shelling/rubber-roll sheller :** for separating husk from the paddy grain,
3. **Husk separation/husk aspirator :** for separation of husk from the product obtained from sheller.
4. **Paddy separation/paddy separator :** for separation of paddy from brown rice
5. **Bran removal/polisher/whitener :** removal of bran layers from brown rice
6. **Bran aspiration/bran aspirator :** removal of bran adhering to the rice kernel
7. **Grading/grader :** for separation of broken rice from head rice
8. **Handling equipment :** for conveying of paddy-rice to various processing units

Basic flow chart of rice processing in a modern mill



Parboiling

- It is a premilling (optional) treatment given to paddy prior to its milling to achieve maximum recovery of head rice and to minimise breakage.
- In this process, paddy is soaked and the wet paddy is heated and then dried.
- The paddy grain is mainly composed of polygonal starch granules.
- The voids or inter-granular spaces are filled with air and moisture.
- Due to these voids cracks develop and it cause **breakage during milling**.
- This breakage may be reduced by **gelatinising the starch**. During gelatinization process starch swells and fill the voids.

- During soaking of paddy **water penetrates into starch** granules and results in **swelling of grains**. In heating the energy **weakens the granule structure** and more surface becomes available for **water absorption** and results in irreversible granule swelling.
- This phenomenon is called **gelatinization of starch.** The temperature at which gelatinization takes place is known as the **gelatinization temperature** and it is specific for particular variety in the nearhood of **70°C**.

The main objectives of parboiling are:

(1) to increase the total and **head rice yield** of paddy

(2) to prevent the **loss of nutrients** during milling

(3) to salvage wet or damaged paddy and

(4) to mill the rice according to requirements of consumers

Parboiling of paddy is carried out in three steps,

1) Soaking, (2) Steaming, and (3) Drying

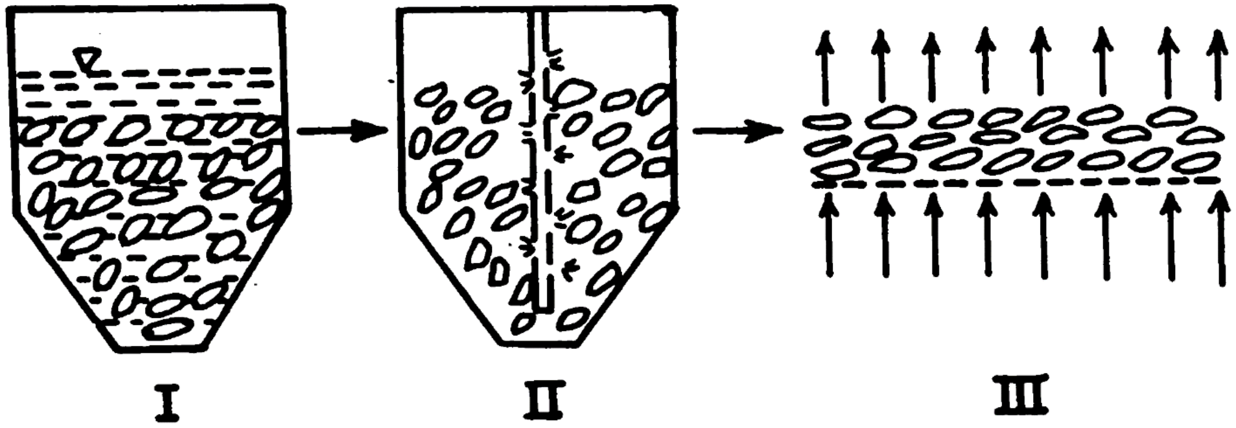


Fig. 5.21 : Various steps of parboiling of paddy
I. soaking II. steaming III. drying

Advantages of Parboiling

1. The **milling yield increases** and the quality is improved, as there are ***fewer*** **broken grains**.

2. The grain structure becomes compact and vitreous, even if some kernels were **entirely or partially chalky**.

3. The milled rice becomes **translucent and shining**.

4. The **shelf life of parboiled paddy** and milled parboiled *rice* is longer than in the raw state, as germination is no longer possible and the kernel becomes hard enough to resist the attack by insects and to adsorption of atmospheric moisture.

5. The grains remain firmer during cooking and less likely to **become sticky.**

6. A greater amount of water is absorbed during cooking causing the **rice to swell.**

Advantages of Parboiling

7.After cooking the rice absorbs less fat from added condiments, the rice keeps longer and does **not become rancid easily**.

8. Parboiled rice retains more **proteins, vitamins and minerals**.

9. Parboiled rice is **more digestible** and less solids are left behind in the cooking water.

10. **Shelling** of parboiled rice is easier.

11. Bran of parboiled rice has **more oil.**

Disadvantages of Parboiling

1. The heat treatment during parboiling destroys some **natural anti-oxidants**, hence rancidity developed in parboiled rice during storage is more than that in raw rice.

2. **Parboiled rice takes more time to cook** than raw rice and may have characteristic off-flavour which may not be liked by raw rice eaters.

3. Parboiling process needs **extra capital investment.**

4. Parboiling adds **to the cost of drying**.

5. As paddy is soaked for a longer time during parboiling, it may be attacked by spores which may cause health hazard.

6. **More power** is required for polishing of parboiled rice. The process becomes difficult and lowers the capacity of polisher.

- **Inspite of the above disadvantages 1 to 2 per cent extra rice is obtainable by parboiling than raw rice milling.**

Parboiling methods

The methods of parboiling may be classified as under:

A. Traditional methods :

(i) Single boiling

(ii) Double boiling

B. Modern methods :

(i) CFTRI method

(ii) Jadavpur university method

(iii) Pressure parboiling process

Traditional methods

- **In a single boiling method**, paddy is soaked in ordinary water for **24-72 hours** and them steamed.
- **In double boiling method**, **steam is first injected** into raw **paddy** in the steaming kettle before soaking, Hot paddy raises the temperature of soaking water to 45-50°C which helps to reduce the **soaking time to 24 hours**. Therefore soaked paddy is steamed.
- Sometimes, the soaking water is heated to about 50°C then the raw paddy is put into it and in this case first steaming is not required.

Modern method

I. CFTRI method

- In this process, parboiling tanks are filled with clean water and heated to a temperature of **about 85°C** by passing steam through the coils placed inside the tank.
- The resultant temperature of paddy-water mixture in the tank **stays around 70°C**. After soaking paddy for **3 to 3.5 hours**, the water is drained out.
- Soaked paddy is exposed to steam at a pressure of about **4 kg/cm^2** through the open steam coils.
- The parboiled paddy is taken out by opening the bottom door and dried either under **sun or by a mechanical dryer.**

2. Jadavpur University method

- Soaking of paddy is completed in high temperature water (60-70°C) within 1-3 hours, while the steaming time is limited to 3.5 minutes.
- After steaming and before drying the paddy is rapidly cooled.
- Drying takes place in a rotary steam jacketed high temperature air dryer.
- With the first, the soaking and steaming take place in the same tank, whereas in the second, these two operations are performed separately in a horizontal apparatus.

3. Pressure parboiling method

- ✓ This method of parboiling was developed at **Tiruvarur in Tamil Nadu**.
- ✓ The parboiling is achieved by penetration of moisture into the paddy in the form of water vapour under pressure.
- ✓ This results in gelatinization of starch of the kernel.
- ✓ The paddy is soaked for **40 minutes at 85-90°C**. Thereafter it is steamed under pressure for **18 minutes**.
- ✓ The water vapour which penetrates the kernel drives out entrapped air. It is reported that the whole process is completed **in 1 to 1.5 hours**.
- ✓ The rice obtained by this method has a pleasing and slightly **yellowish uniform colour.**

Effect of parboiling on milling

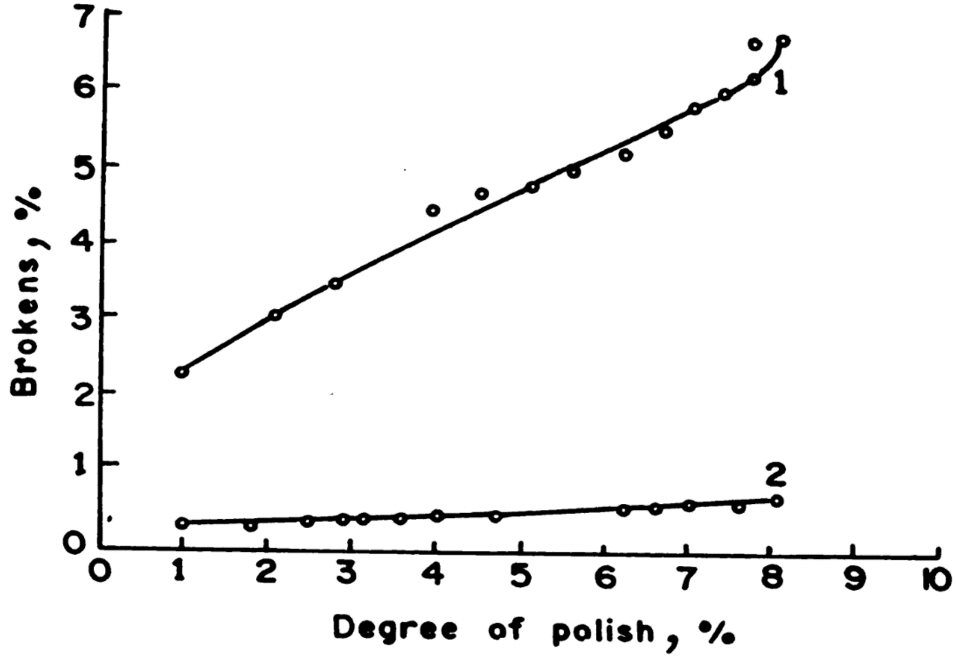


Fig. 5.22 : The broken percentage vs degree of polish
1. raw rice 2. parboiled rice

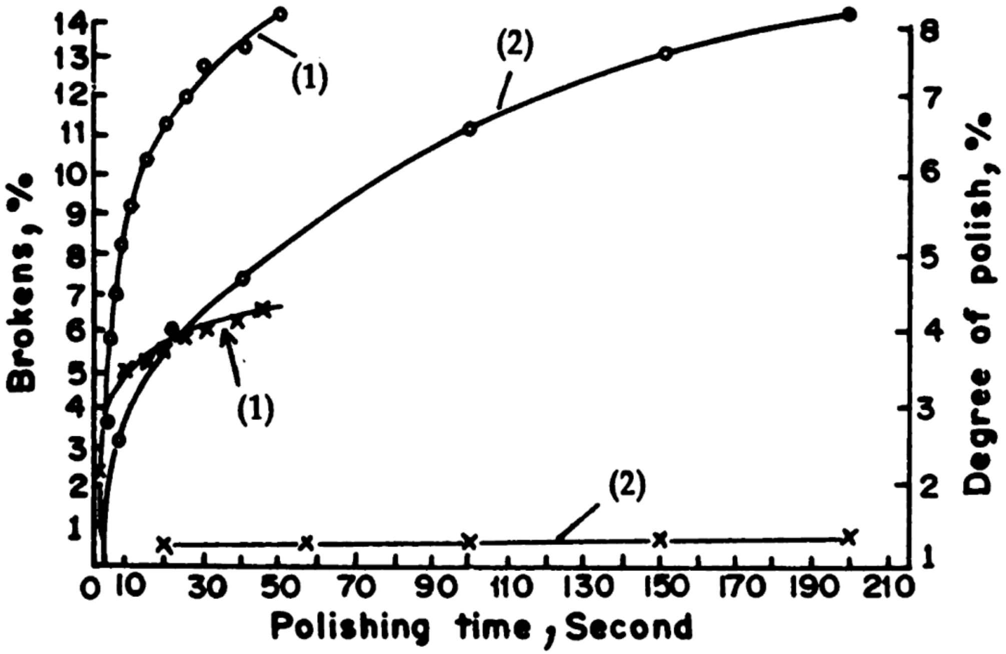


Fig. 5.23 : Effect of polishing time on degree of polish and brokens
– o – degree polish – x – x – broken
1. raw rice 2. parboiled rice

Effect of parboiling on nutritional qualities

Chemical composition of raw and parboiled rice bran

Chemical constituents, %	Raw rice bran	Parboiled rice bran
Moisture	9.8	9.1
Protein	14.2	18.5
Fat	16.6	19.8
Fibre	8.7	7.1
Ash	8.9	10.3

MILLING

Milling of paddy is the major operation in paddy processing. It removes husk and outer layer of bran so as to produce acceptable white rice with minimum breakage and impurities.

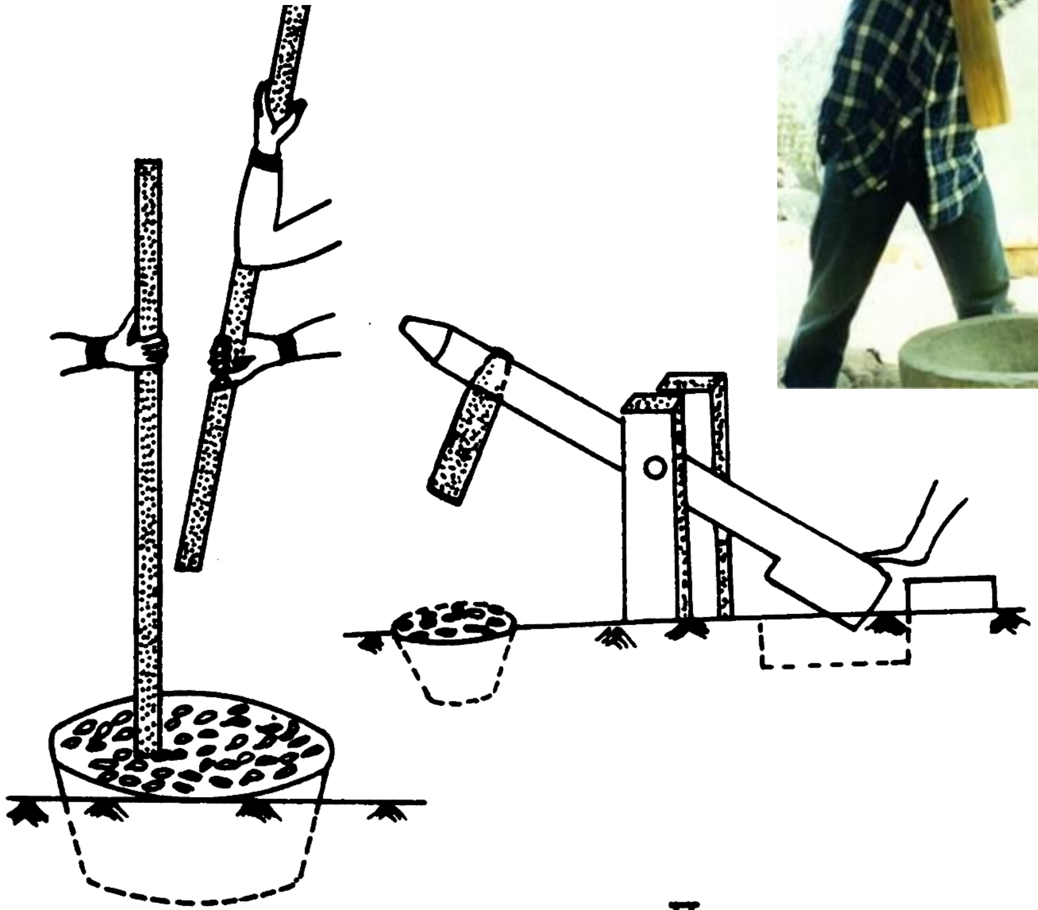
1. Head rice : It refers to the milled whole rice of 6/8 and more of actual kernel size.

2. *Broken rice :* Rice kernels which are lesser than 6/8 of the actual size are called broken rice. It is further divided into three categories, (1) big brokens, these include 4/8 to 6/8 of kernel portion, (2) small brokens, these include 1/8 to 4/8 parts of kernel and (3) points- lesser than 1 /8 part of rice grain.

3. ***Total rice :*** It includes both head and broken rice.

Milling Equipment

- In some rice growing areas rice milling is accomplished by primitive methods such as pounding the paddy in a wooden mortar and pestle followed by winnowing.
- It is estimated that in India 1/3 of the total paddy production is processed by hand pounders and foot pounders.
- Labor requirement is high and total rice recovery ranges between 60-65%.



I II

Fig. 5.24 : Hand and foot pounders for milling of rice
I. hand pounder II. foot pounder

Hulling: The purpose of hulling machine is to remove husk from paddy grain with minimum damage to the bran layer.

1) Huller:

- Most common machine used for paddy hulling in India is "Engleberg" huller.
- Working element is ribbed cast iron roller rotated at 600 to 900 rpm inside a concentric cylinder.
- Friction between the grains and steel parts of huller causes the husk and bran to be scrapped off.
- Capacity ranges from 250 to 750 kg/h.
- Average yield is 56% for raw rice and 62-64% for parboiled rice.
- It generates around 25 to 30% brokens.

Engleberg huller

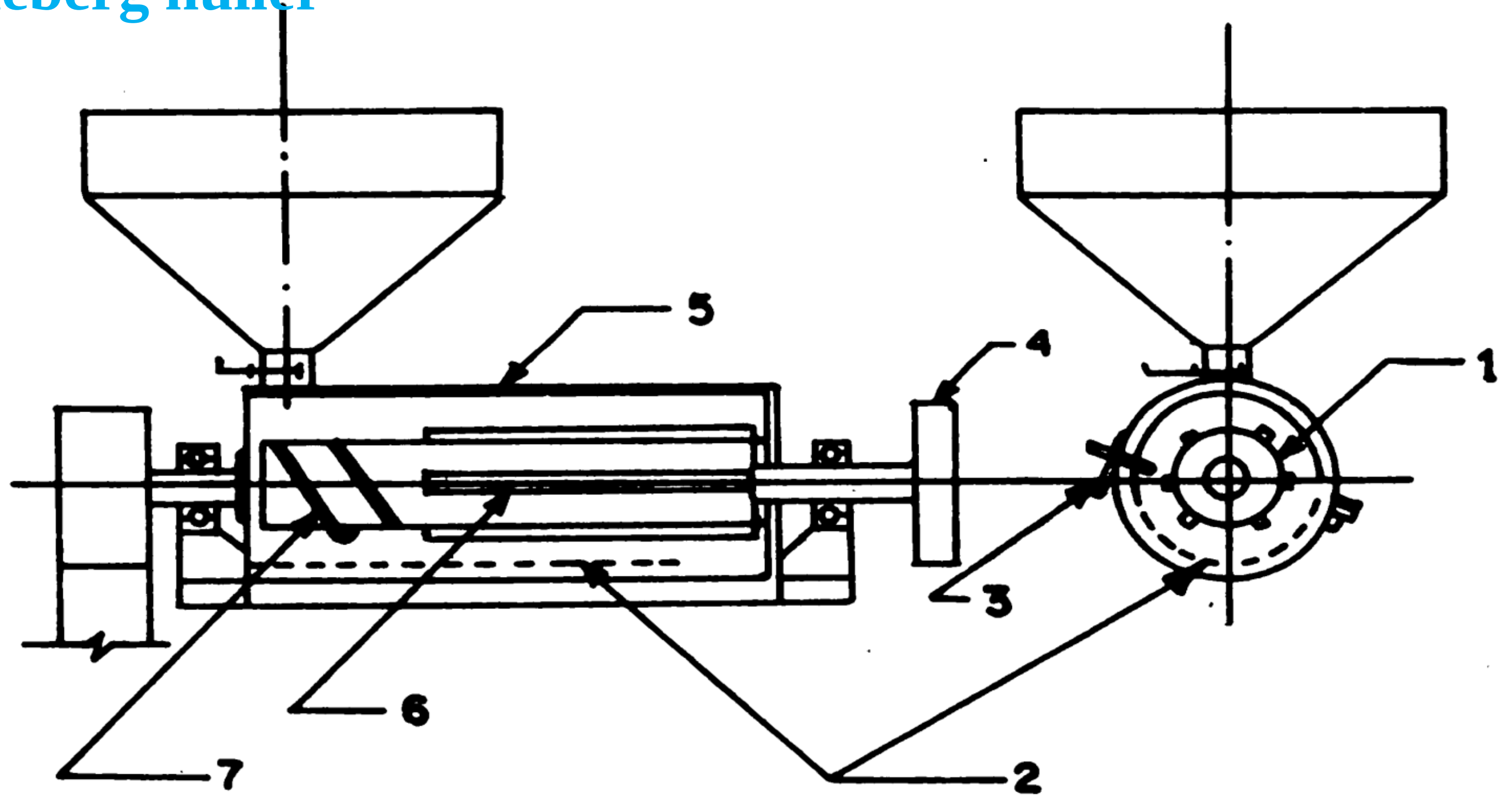


Fig. 5.25 : Engleberg huller
1. hulling roller 2. screen 3. knife 4. balancing pulley
5. casing 6. straight ribs 7. spiral ribs

Advantages:

1. The initial investment and operating cost are small
2. The huller can be manufactured locally and operated with unskilled labor
3. The huller can be utilized for whitening of parboiled rice as it produces uniformly whitened rice.

Disadvantages:

1. Both total and head yield are low (in comparison to other milling machines) as the degree of whitening cannot be adjusted to low level.
2. The huller bran, contaminated with large amount of husk, cannot be utilized for oil extraction and for feed purpose.

2) Under runner disc huller

- Consists of two horizontal cast iron disc partly covered with an abrasive layer preferably of emery.

- Top disc is fixed while bottom disc is rotated.

- By centrifugal force the paddy is forced between the disk and dehusking takes place due to friction and pressure.

Disc diameter, mm	Capacity, kg/h	Horsepower requirement
750	450-600	3.0
1000	700-1000	3.5
1250	1000-1400	4.0
1400	1600-2100	5.5

Under runner disc huller

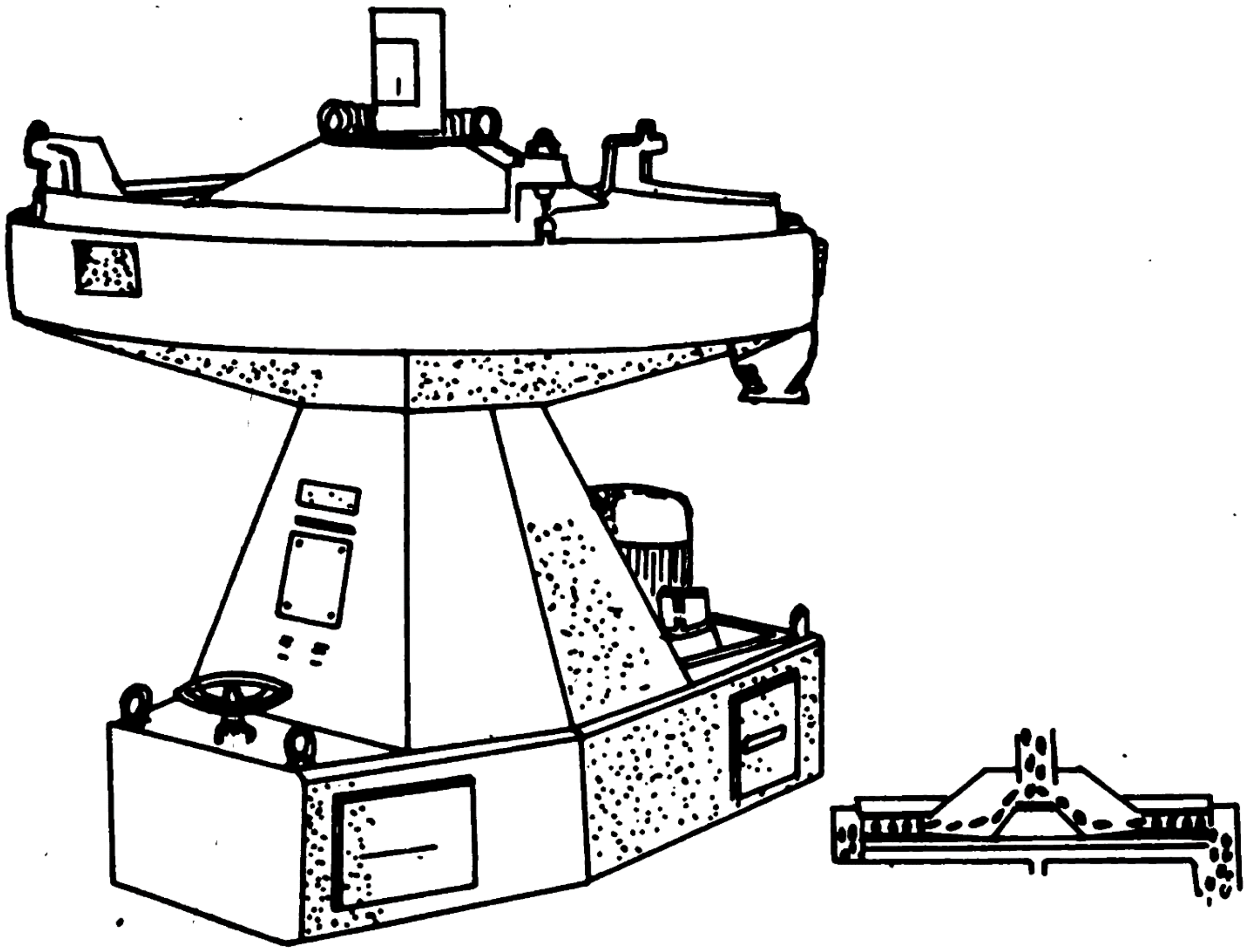


Fig. 5.26 : Under-runner disk huller

3) Centrifugal dehusker

- Centrifugal dehusker shells paddy due to impact.
- Paddy grains are subjected to a centrifugal force by means of a rotating impeller with a rotational speed ranging between 2500-3000 rpm.
- Initial cost and operational cost is low.
- Requires less power, 1 hp/500 kg paddy dehusking per hour

Centrifugal dehusker

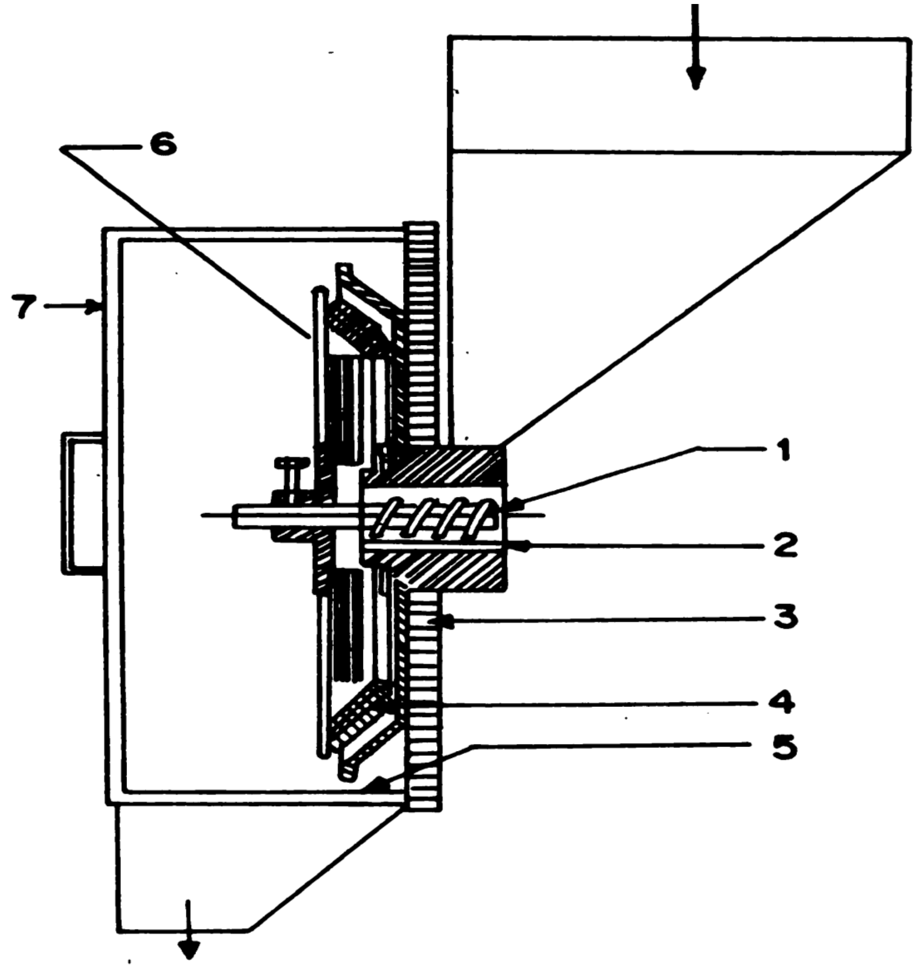


Fig. 5.27 : Centrifugal dehusker
1. feed screw 2. coller 3. crank gear 4. rubber ring
5. lining 6. impeller 7. lid

3) Rubber roll sheller

- Consists of two rubber rolls rotating in opposite direction at different speeds.
- One roll is fixed and the other is adjustable and it runs about 25% slower than the fixed one.
- Difference in surface speeds of the rolls develop a shearing force on grain surface.
- During shelling, the faster roll should have a peripheral surface speed of 10 to 13 m/s, while slower roll 8-10 m/s.

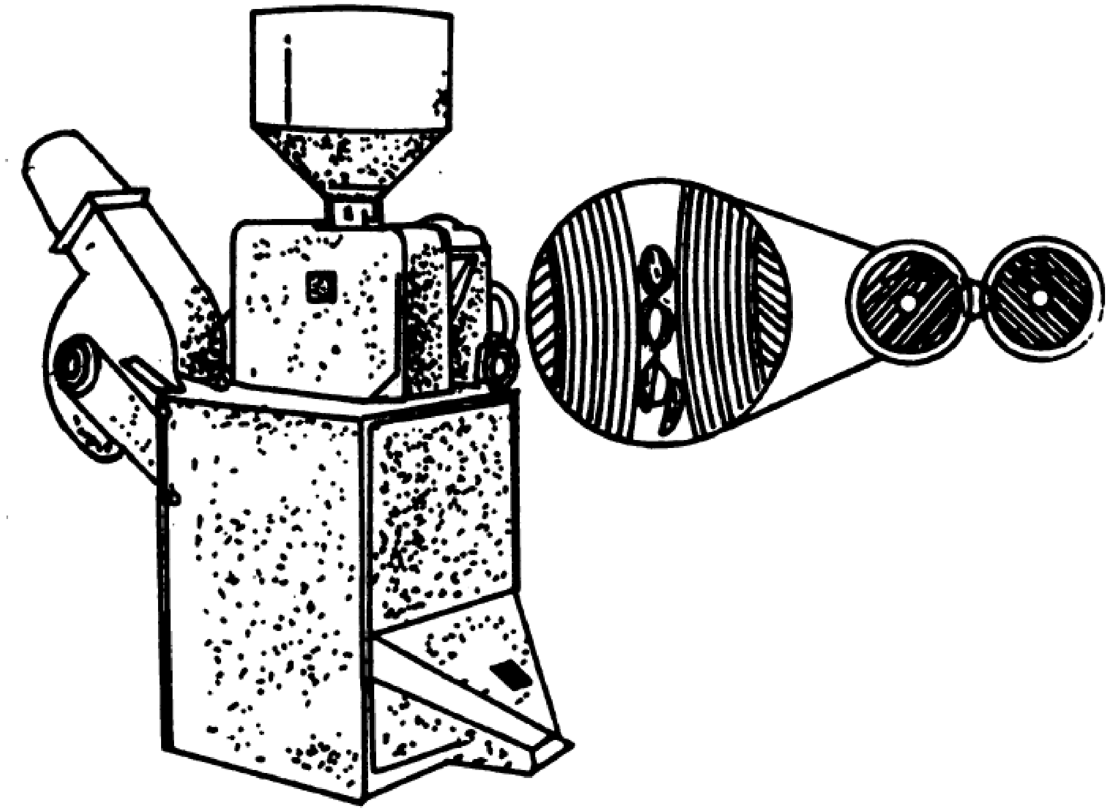


Fig. 5.28 : Rubber-roll sheller

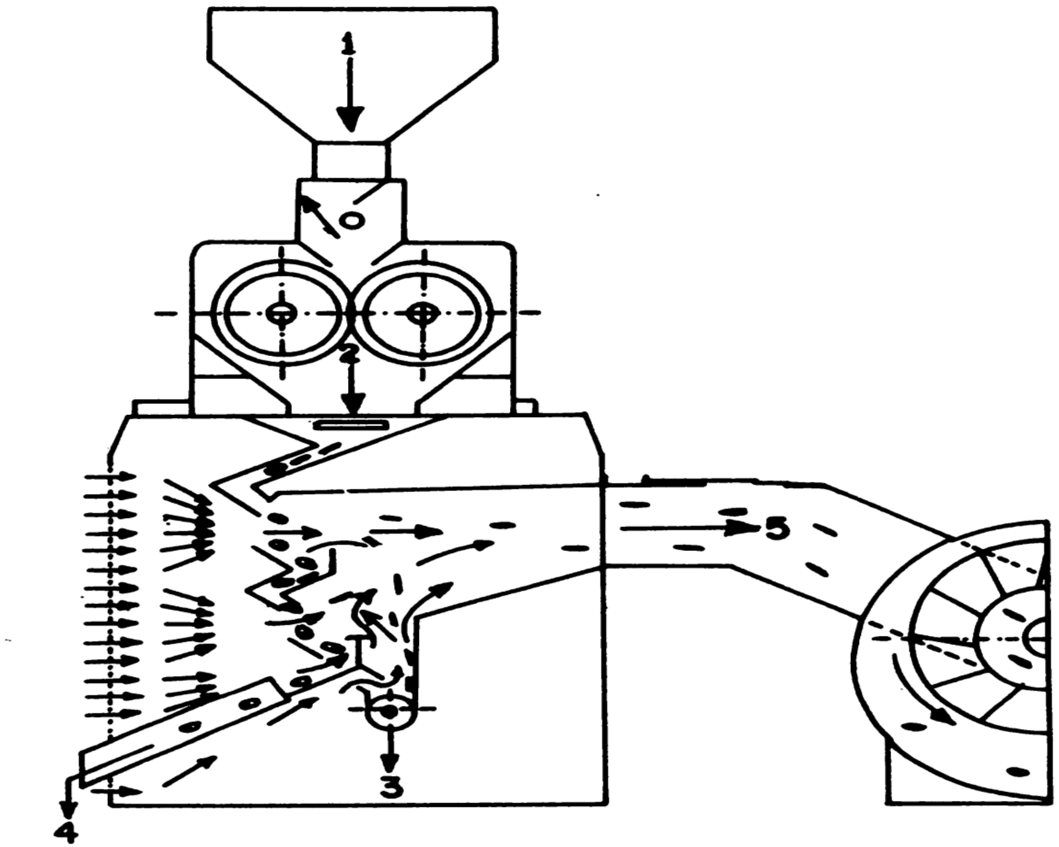


Fig. 5.30B : Rubber-roll sheller with husk separator
1. paddy 2. brown rice paddy-husk mixture
3. immature grains 4. brown rice, paddy 5. husk

The details of speeds of rubber rolls

Rubber-roll diameter, mm	Width of roll, mm	Faster roll, rpm	Slower roll, rpm
150	64	1320	900
220	76	1200	900
250	250	1000	740

The capacities and power requirements of various sizes of rubber-roll

Dimension of rubber-roll, mm			Capacity, t/hr		Horse power requirement, hp
Size	length	diameter	long-grain	short-grain	
4	100	220	0.9	1.25	2.5
6	150	220	1.2	1.90	4.0
10	254	254	2.2	3.80	6.0

Advantages:

1. Highest percentage of sound and whole husked rice is produced as the risk of breaking the kernel is small and the chance of forming scratches of the kernel is also nil.

2. The mixture of different sizes and varieties in husked rice.

3. Husking ratio can be increased to 0.9 without reduction in head yield.

4. It does not remove germ.

Disadvantages:

1. Operating costs are high due to wear of rubber rolls.

2. Storage life of rubber roll is limited as storage deteriorates its quality and in consequence shortens its working life.

3. If the paddy separator fails to separate paddy completely and the husked rice is returned to the husker along with paddy, the constituent of the rubber may impart color and odour to the rice.

4. It requires skilled labor too operative the machine efficiently.

5. Sometimes on account of uneven grain distribution and uneven thickness of rubber, the rolls surface wears out unevenly which adversely affects the efficiency and capacity. If the roll surfaces are corrected by turning, the life of the rubber rolls will be reduced considerably.

6. In general the husking capacity of the rubber rolls in tropical countries is low due to: (a) high temperature and humidity of the atmospheric air, (b) structure, and (c) larger surface area of the long grain husk in contact with the rubber rolls.

Husk separator

- This machine is required to blow away husk from the mixture of shelled rice, husk and unshelled paddy obtained from huller/sheller.
- Simple machine with a fan to distribute the product uniformly on an oscillating sieve with fine perforations.

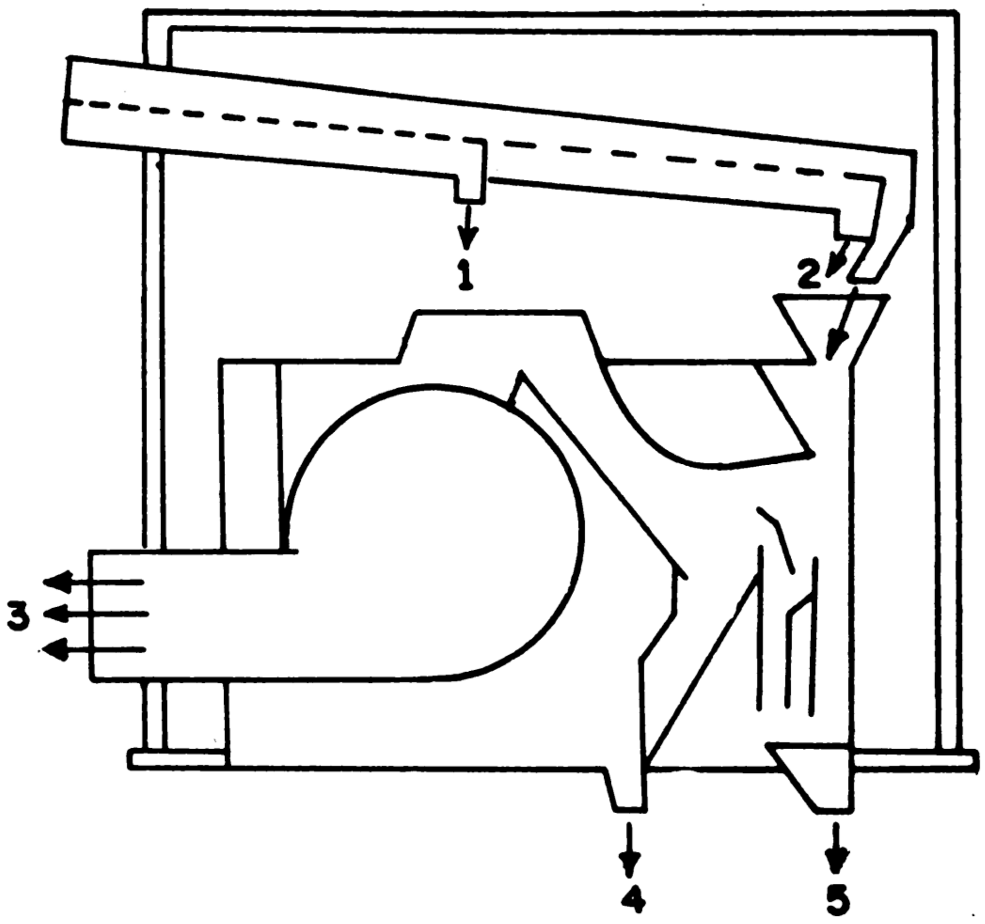


Fig. 5.30A : Husk separator with plansifter
1. bran and dust 2. brokens 3. husk 4. paddy 5. brown rice

Paddy separator

Paddy separation depends on following factors:

1. Uniformity of paddy
2. Variety of paddy
3. Condition of paddy
4. husking machine
5. Condition of husking machine
6. Operator skills

Compartment type paddy separator

- No.of decks varies from 1 to 4
- Capacity is 40 kg for long grain and 60 kg for short grain
- Zig-zag shape with impact angle of 30°
- Two types, fixed stroke and adjustable stroke
- Fixed stroke runs at 100/100 rpm with table inclination 3 to 4°
- For adjustable stroke,

long grain rice: 90-96 stroke at 114 rpm

Short grain rice: 75-80 stroke at 124 rpm

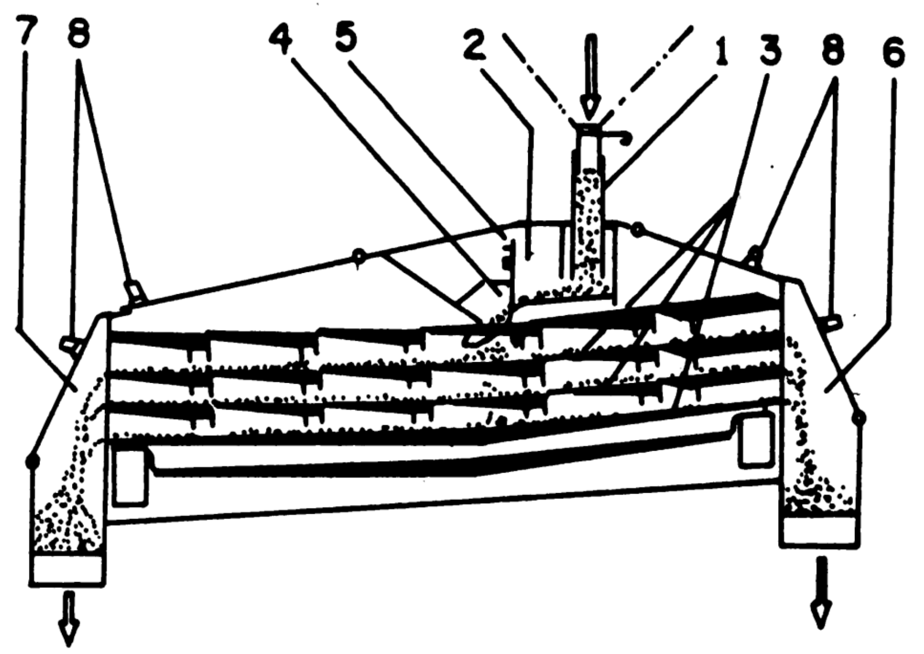


Fig. 5.31 : Cross-section of a compartment type paddy separator
1. feed duct 2. feed box 3. tiers 4. feeding gate
5. feed regulating gate 6 and 7 discharge troughs 8. inspection doors

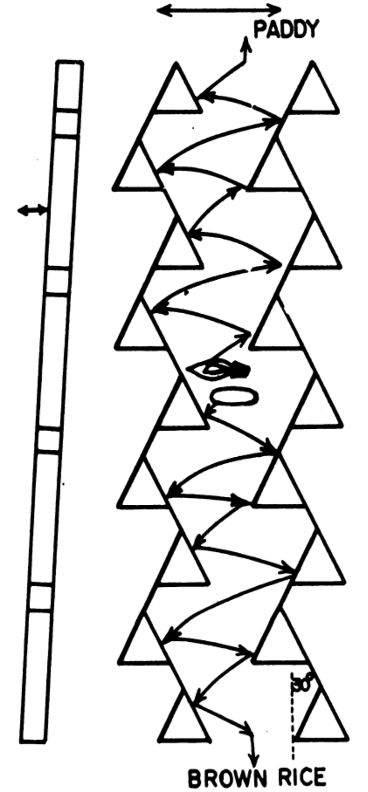
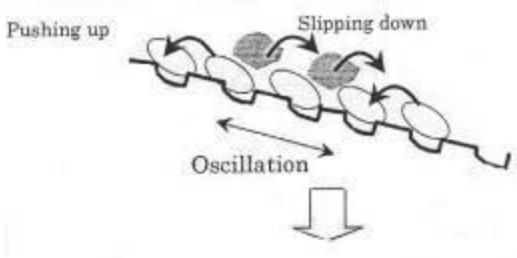


Fig. 5.32 : Internal construction of one compartment of the paddy separator

Tray separator

- Consists of indented trays mounted one above the other about 5 cm apart
- Typical model has 2270 kg/h for long grain and 3180 kg/h for short grain with 1 hp motor
- Power requirement of such machine is about half of the power required for compartment type separators.



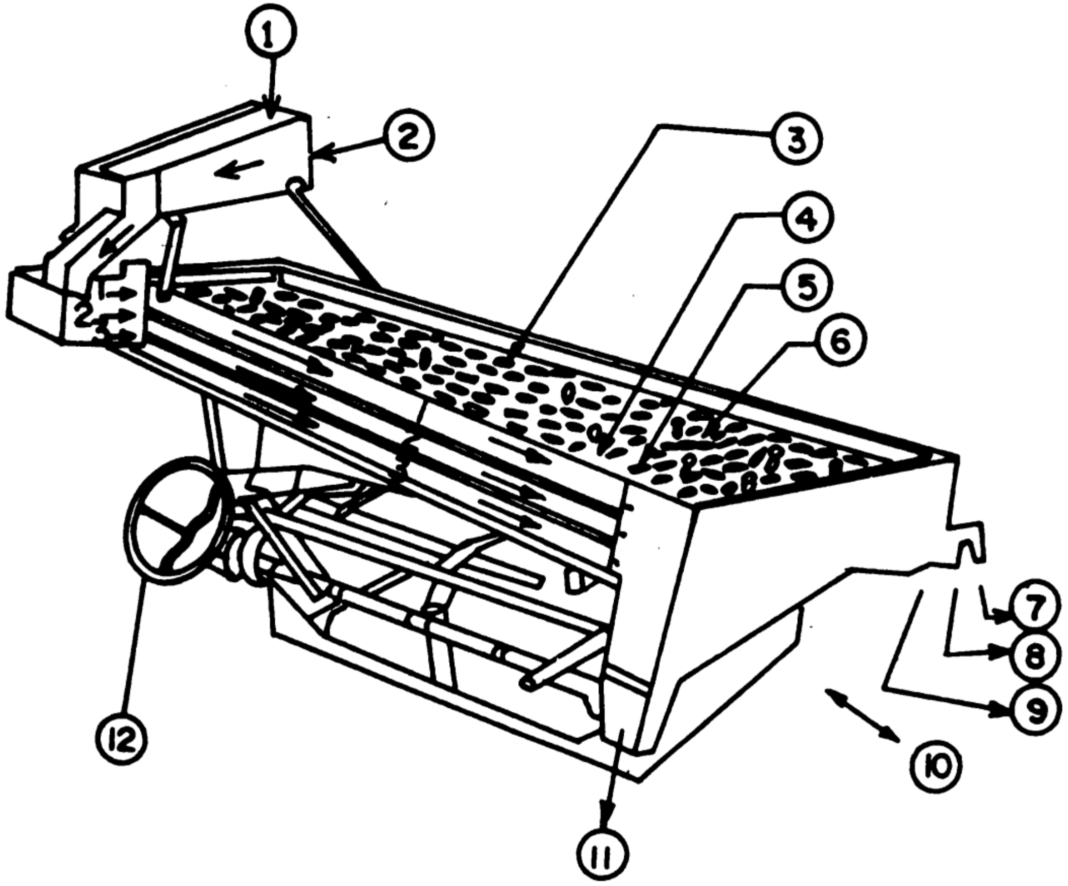


Fig. 5.33 : Tray type paddy separator
1. paddy-brown rice 2. hopper 3. paddy 4. dust 5. brown rice 6. paddy-brown rice mixture 7. paddy 8. mixture 9. brown rice 10. tray slope 11. dust 12. hand wheel to adjust the slope of tray assembly

Removal of bran

- In this process, the silver skin and the bran layers of the brown rice are removed. It is also termed as **"whitening".**
- The two processes used to remove the bran layer from the brown rice are **abrasion and friction**.
- **Abrasion** process uses a rough surface which may be an abrasive stone to break and peel the bran off the grain.
- The **friction** process uses the friction between the grains themselves to break and peel off the bran.

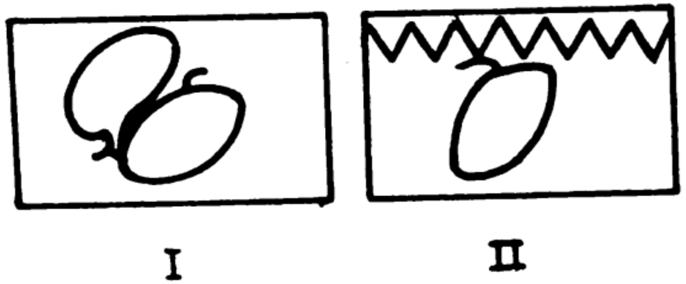


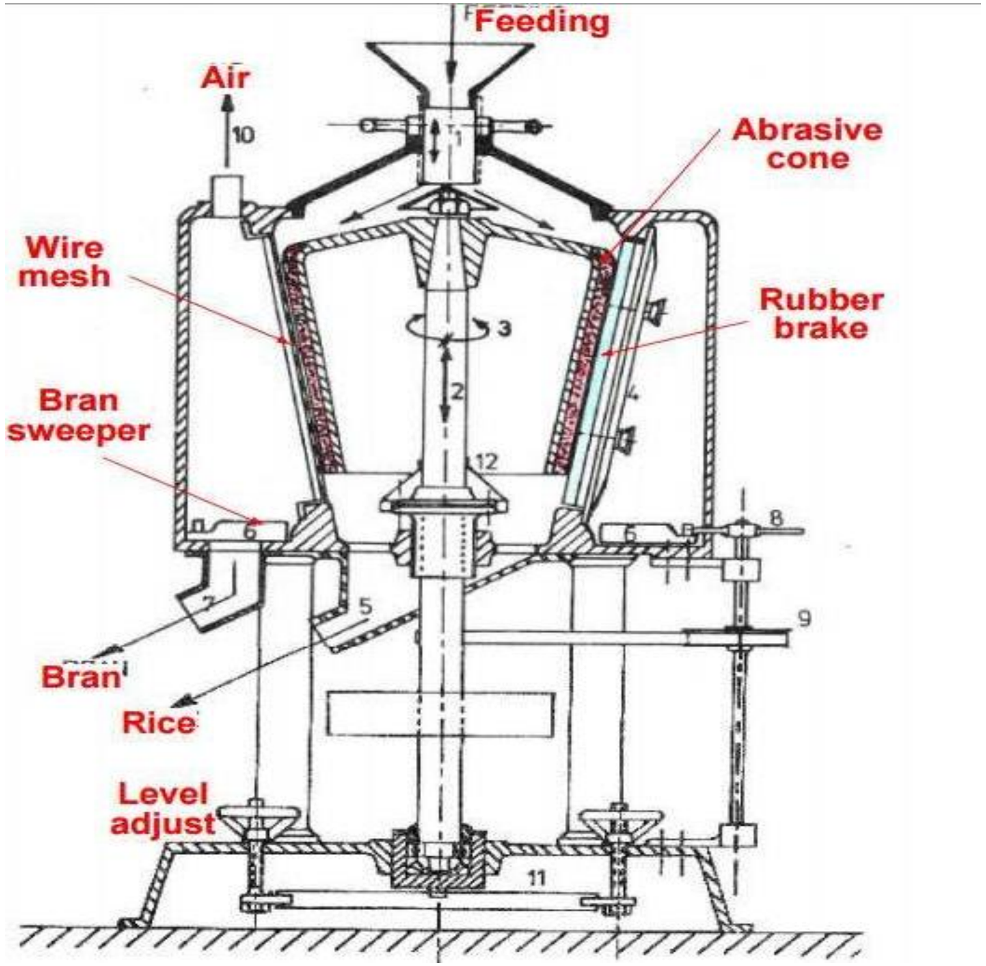
Fig. 5.34 : Bran removal processes
I. friction II abrasion

Three kinds of whitening machines are widely used in the rice processing industries,

(1) Vertical abrasive whitening cone,

(2) Horizontal abrasive whitening machine

(3) Horizontal jet pearler



Vertical abrasive whitening cone

Horizontal abrasive whitening machine

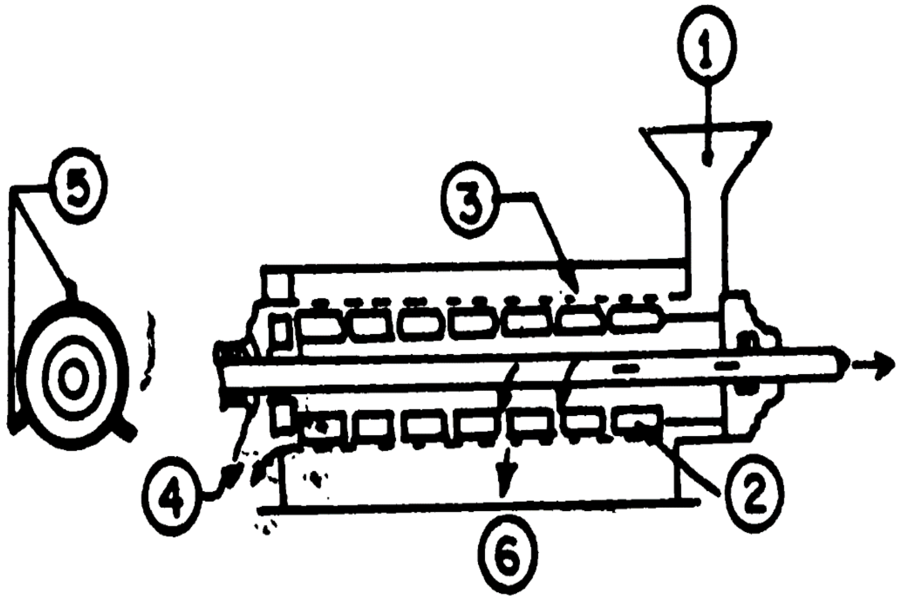


Fig. 5.36 : Horizontal abrasive whitener
1. hopper 2. abrasive roller 3. screened steel cylinder 4. white rice 5. brakes 6. bran

Horizontal jet pearler

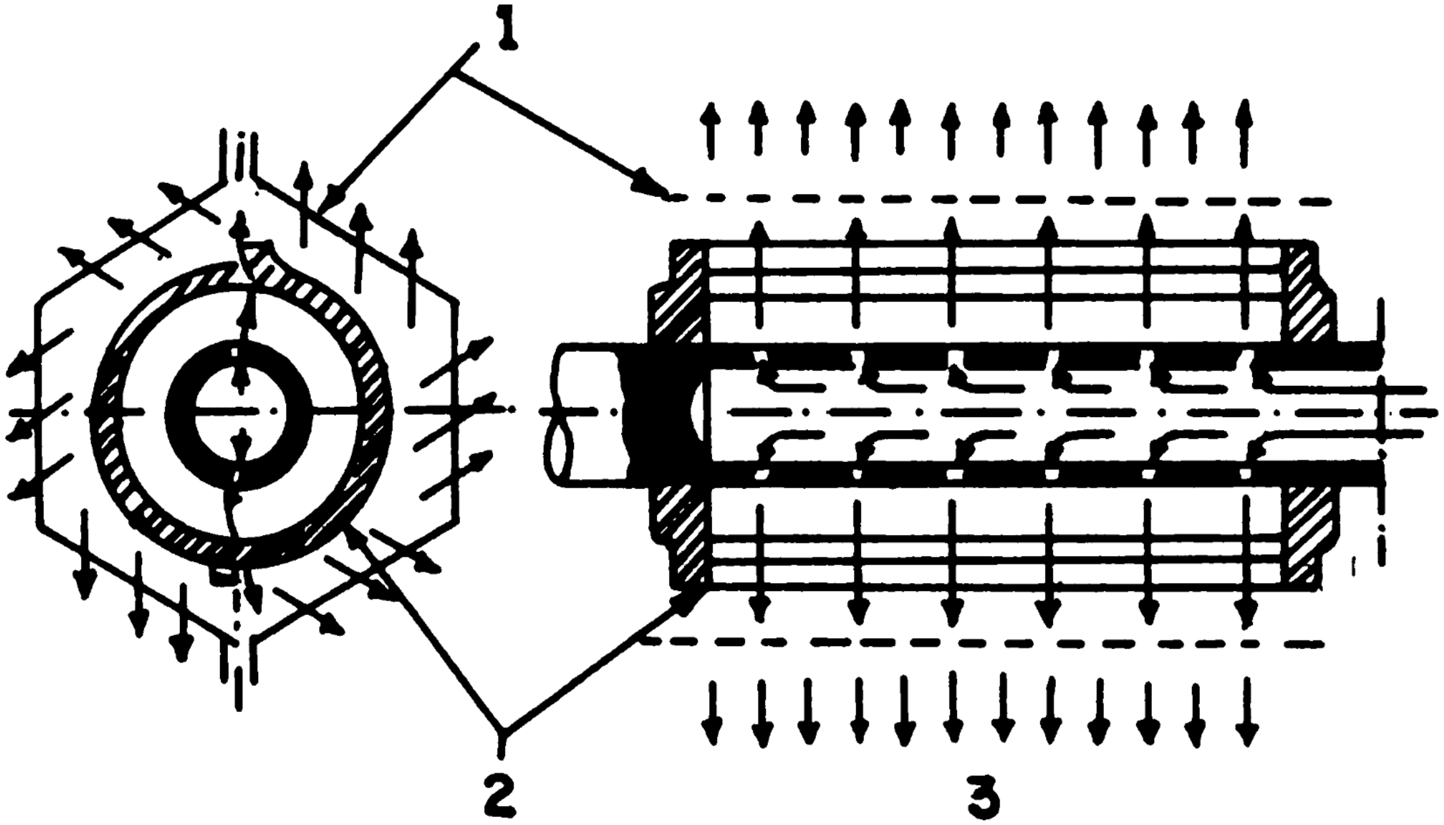


Fig. 5.37 : Cross-section of a jet pearler
1. screen 2. milling roller 3. bran

Grading

1. Adjustable reel grader
2. Indented cylinder grader
3. Oscillating sieves

1.Adjustable reel grader

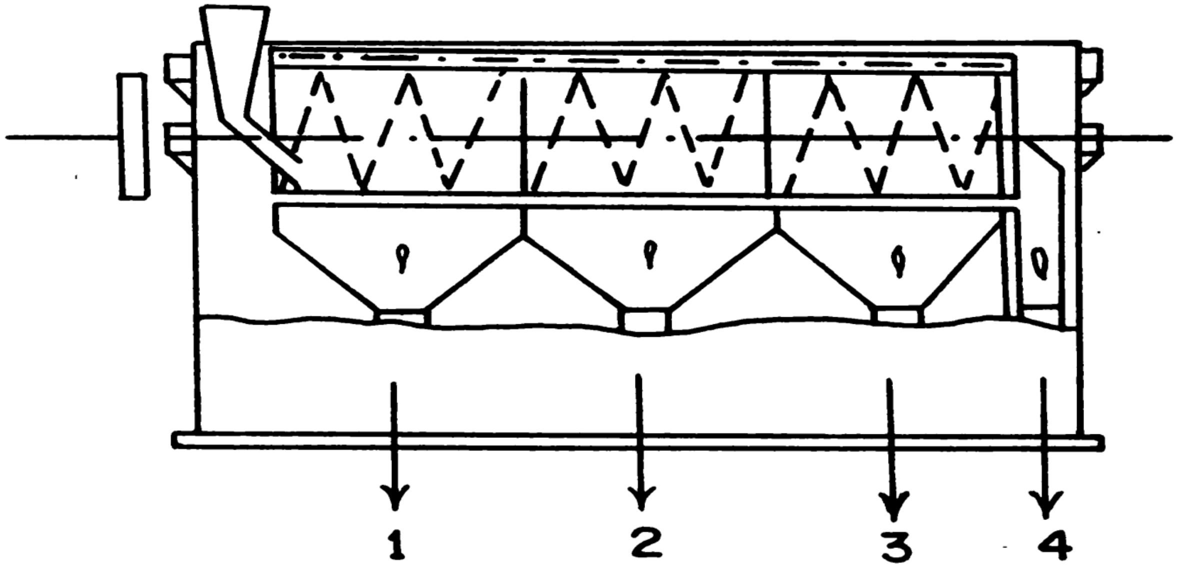
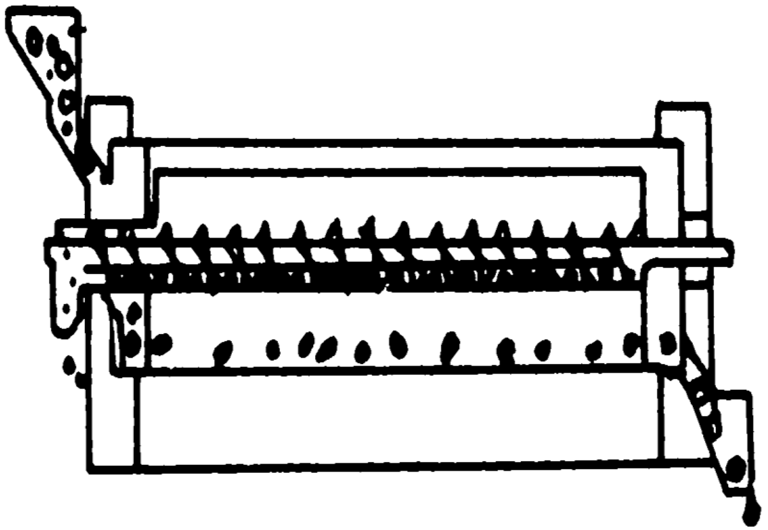
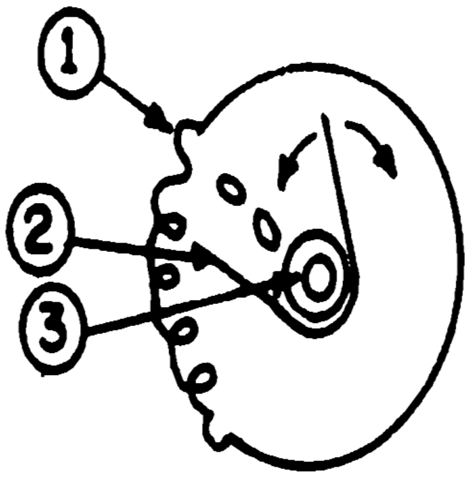


Fig. 5.40 : Rotating reel grader
1 and 2. small brokens 3. big brokens 4. head rice

2. Indented cylinder grader





Cylinder rotates at a low speed of about 30-40 rpm

3. Oscillating sieves

Frequency of strokes varies from 200 to 400 cycles/min

Efficiency of rice milling and quality can be calculated

1. Foreign matter, % $$= \frac{\text{weight of foreign matter}}{\text{total weight of paddy}} \times 100$$

2. Grass and weed seed, % $$= \frac{\text{weight of grasses and weed seeds}}{\text{total weight of paddy}} \times 100$$

3. Dead and immature grain, % $$= \frac{\text{weight of dead and immature grains}}{\text{total weight of paddy}} \times 100$$

4. Broken grains, % $$= \frac{\text{weight of brokens}}{\text{weight of paddy}} \times 100$$

5. Husked rice, % $$= \frac{\text{husked grains}}{\text{total weight of paddy}} \times 100$$

6. Milling recovery, % $$= \frac{\text{weight of total rice}}{\text{total weight of paddy}} \times 100$$

7. Head rice, % $$= \frac{\text{weight of head rice}}{\text{weight of milled rice}} \times 100$$

8. Broken rice, % $$= \frac{\text{weight of broken rice}}{\text{weight of milled rice}} \times 100$$

Milling efficiency

$$\text{Milling efficiency, \%} = \text{Coefficient of hulling} \times \text{coefficient of wholeness of kernel} \times 100$$

$$\text{Coefficient of hulling} = \frac{\text{weight of brown rice}}{\text{weight of paddy fed to machine}} \times 100$$

$$\text{Coefficient of wholeness} = \frac{\text{weight of brown head rice}}{\text{weight of total brown rice}} \times 100$$

WHEAT MILLING

- Wheat is the principal food grain in many countries of the world.
- It is one of the most important cereals and is used as staple food in the form' of flour.
- In India, a large proportion of wheat is used as the familiar atta and maida (white flour).
- The hard wheats are also ground into suji (semolina).
- Whole wheat is ground into atta by the traditional stone grinder without prior separation of bran and germ from it.

Flour Milling

- The objective of modern flour milling is to obtain the maximum amount of white flour from the wheat endosperm without any bran or germ content.
- Conditioning of wheat by hydrothermal treatment prior to milling helps in the separation of barn and germ from the endosperm.
- If wheat is conditioned by hydro- thermal treatment, bran and germ become rubber-like while the endosperm becomes soft.
- It also eliminates the difference in grinding characteristics between soft and hard wheat.
- When the conditioned wheat is sheared by the corrugations of first break roll during the milling operation, it splits open releasing small endosperm pieces and thus exposing the remaining endosperm which could be carefully scraped off the bran in successive break rolls.

- Wheat consists of bran (12 per cent), germ (3 per cent) and endosperm (85 per cent).
- Modern flour milling consists of six steps: (1) receiving, drying and storage of wheat, (2) cleaning, (3) conditioning, (4) milling into flour and byproducts, (5) packaging and storage of finished products and (6) blending.

Cleaning

- Wheat is thoroughly cleaned to remove all fine impurities and the dirt sticking to the surface of the grain. The small pieces of sticks, stones, sand, loose fine impurities are removed by sieving and the light impurities like chaff are removed by aspirations.
- Then the wheat is allowed to pass over powerful magnetic separators to remove pieces of ferromagnetic materials. The seeds of other food grains, defective grains and weed are removed by disc separators.
- The next step in the cleaning operation is the removal or dirt sticking to the surface / by scouring. Usually, wheat is moved by paddles against stationary emery-coated surface.
- The final cleaning step is washing by water which allows the dirt and bits of metal to sink. The moisture content of wheat is increased by about one per cent during washing.

Conditioning/hydrothermal treatment

- The conditioning of wheat can be done either at room temperature, elevated temperature .or at high temperature. But the temperature of wheat grain- should not be raised above 47° C otherwise the gluten quality will be affected which deteriorates the baking quality of the flour.
- Generally the moisture contents of soft and hard Wheats are increased to 15 to 17 % and 16 to 19% respectively by soaking and then the moisture of the grain is equilibrated by tempering for 18 to 72 hours in the tempering bin.
- The conditioner mainly consists of three sections, namely, preheating section, moistening section and cooling section. In the first section wheat is preheated to the proper temperature, in the second section wheat is moistened to the desired moisture level and in the third section soaked wheat is cooled to the room temperature, finally the treated wheat is kept in a separate tempering bin for 18 to 72 hours.

Grinding (milling)

- Milling of wheat is carried out-by roller mills. The roller milling- system is mainly divided into the break roll and reduction roll systems.
- The surface of the reduction roll is smooth whereas the surface of break roll is corrugated.

Storage of Finished Products

- The flour and the mill feed (bran, germ and shorts) are bagged in waterproof bags, stitched and stored in cold dry condition in flat godowns.

COMPONENTS OF A WHEAT MILL

(1) Break roll

Break roll consists of, twin pairs of corrugated steel rolls. One roll of a pair revolves faster than the other, differential speed being in the proportion of 2.5 to 1.

(2)Break sifting system

This can be divided into two parts-plan sifters and purifiers.

(a) Plan sifter. Plan sifter is a scalping system removing large bran pieces adhering with endosperm at the top. The next series, which are finer, remove the bran and germ. The next layer of still finer sieve removes the -endosperm middling and the bottom rough flow.

(b) Purifier. The middling containing finer bran particles are removed by purifer before they move to reduction roll.

(3) Reduction rolls

The reduction roll contains of two smooth rolls, the rolls in the reduction system are further divided into coarse rolls and fine rolls depending on the clearance between, the rollers. It is possible to grind flour into very fine particles by gradual grinding. But under high grinding pressure the starch is ruptured and this should be avoided.

COMPONENTS OF A WHEAT MILL

(4) Reduction sifting system

The same plan sifting system is used here. After each reduction the product is separated by plan sifters where the finished flour is sifted by 120 mesh sieve and removed and oversized material is sent back to the reduction rolls for further processing.

(5) Scratch system

If the mill is functioning properly, i.e., good release of endosperm is obtained on the break rolls, the scratch system can be bypassed, if not, the scratch system is employed to maintain proper release of endosperm from bran. The scratch system is an extension of the break system and thus used as stand-by system only.

Milling of pulses

- Pulses are the major source of protein (**17-25% by weight**) in Indian vegetarian diet.
- Pulses are consumed in dehusked and split form which is termed as dal. The operation of dehusking and splitting pulses is termed as **Dal milling**.
- The hard seed coat remains tightly glued to kernel with a natural gum which makes it difficult to remove the seed coat.
- It is necessary to loosen this bondage before dehusking as otherwise the kernel may get damaged during milling resulting in reduced recovery of dal.

Important Unit Operations in Pulse Milling

In general, the pulses have to undergo following unit operations for milling:

i. Cleaning and grading

ii. Drying

iii. Conditioning (loosening of husk)

iv. Dehusking

v. Splitting

vi. Polishing

Cleaning and Grading

- This is an important unit operation in pulses milling industry. The raw pulses received by the plant needs to be cleaned and size graded for getting good quality dal and higher recovery.
  - In cleaning, various inorganic and organic impurities present in the grain mass is removed with the help of air draft and screens.
  - **Destoners** are also used to separate mud and stones.
  - The cleaned grains are then graded as per their size mostly by a **reel grader.**

Conditioning

- The main objective of the conditioning is to loosen the husk to facilitate its separation from the kernel, thus reducing the milling losses.
- Conditioning of grains can be achieved by water treatment, hydrothermal treatment, use of salts and chemicals and use of heat alone.

De-husking and Splitting

- Dehusking of pulses generally carried in an **abrasive roller mill**.
- In some pulse milling plants, **vertical stone chakki** is also used to dehusk and split the grains.
- For splitting of the dehusked and moistened grains, **vertical disk burr mill** is used or the grains are allowed to fall on a hard or **cemented surface from sufficient height due to impact with hard surface** the dehusked grains are splitted.

Polishing of dhal

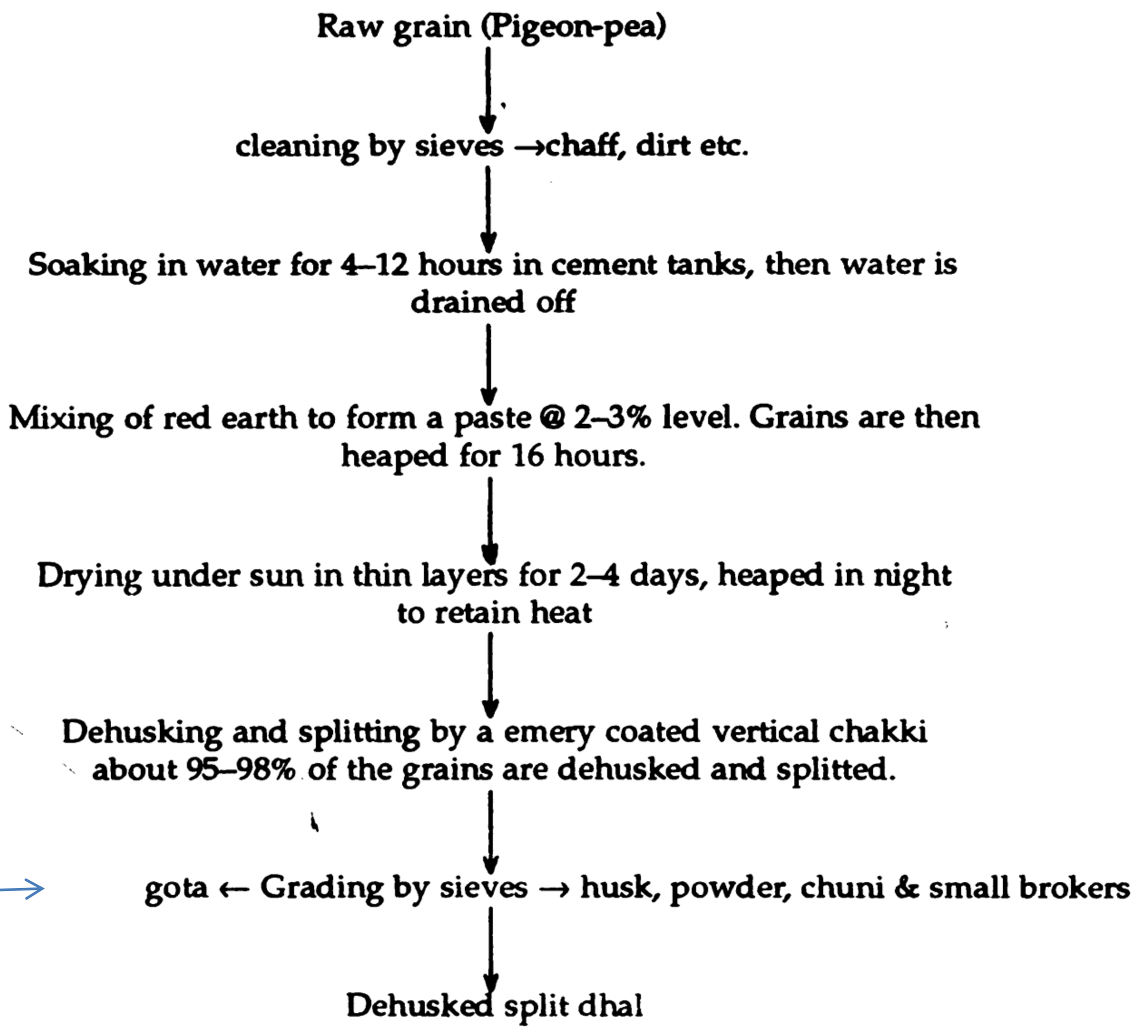
- During this process a pre-desired quantity of edible oil and water is mixed with dhal by passing them through a screw conveyor.
- The presence of oil and water imparts desirable color and shine to milled pulses.

Methods of pulse milling

In home scale as well as commercial practice, there are two methods of milling:

1. Wet Method
2. Dry Method

Wet Method →



Dry Milling method

Raw pigeon-pea

↓

cleaning and grading by sieves → chaff, dirt etc.

↓

Pitting or scratching by emery roller → dust, chuni

↓

Grains with cracks in the husk are mixed with edible oil like linseed @ 1.5 to 2.5 kg/t of pulses in an anger mixer, then held for 12 hours

↓

Oiled grains are spread in 5–10 cm thick layers for sun-drying, heaped in nights, After 2–4 days of drying on last day the grains are sprayed with 3–5% water and heaped overnight

↓

Milling by 1st roller. About 40–50% of grains are dehusked in the process

↓

Dhal separating sieves →husk, chuni, brokens

↓

Whole dehusked grains

↓

Sun drying and addition of water

↓

Dehusking and splitting in 2nd roller

↓

Sieving

↓

Grade I dhal

- Dhal produced by the dry method is said to cook better while dhal produced by wet method tastes better but takes longer time to cook.

CFTRI Method

Pigeon pea

↓

cleaning by rotary reel cleaners

↓

Pre conditioning : Pulses are conditioned in 2 passes through LSU dryer with 120°C hot air. After each pass the hot pulses are tempered in bins for 6 hours.

↓

Dehusking : By roller machine. Then moisture is added to whole dehusked pulses.

↓

Lump breaking : Some of the moistened gota form lumps. These are fed to lump breaker

↓

Conditioning and Splitting : Gota is conveyed to LSU dryer and exposed to hot air for few hours. The hot conditioned and dried gota are split by emery roller

↓

Grading → brokens

↓

Dhal

Oil Expression And Extraction

- Oils and fats are essential constituents of all forms of plants and animal life. Most of these are derived from,

(1) annual oil crops,

(2) perennial oilseed plants,

(3) minor oilseeds and

(4) agricultural by products.

- The largest source of oil at present is the seeds of annual **plants such as groundnut, soybean, mustard/rapeseed, sunflower etc.**
- **Edible oil** is the main source of fat taken in daily meals.
- The need per head per **day is 30 g oil** to meet the minimal dietary requirement where as at present the availability is only **11 g per head per day.**

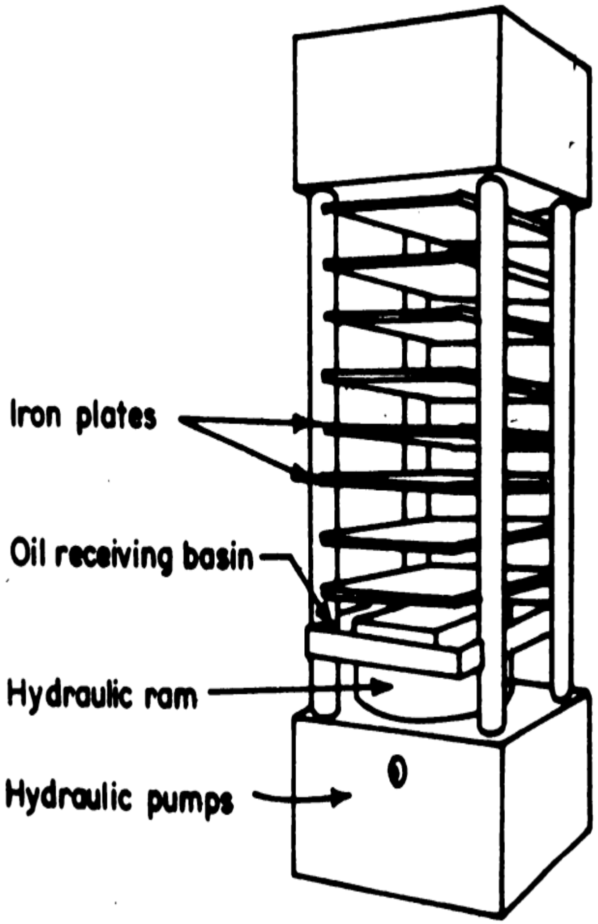
- Expression is the process of mechanically pressing liquid out of liquid-solid.
- Screw press, hydraulic press, roll presses, juice extractors, juice reamers, are examples of the wide variety of equipment available for expression process.
- There are two steps involved in the expulsion of oil through the expeller, **(1) disintegration and (2) pressing.**
- Under the disintegration process, **oil globules are separated**.
- The tough membrane surrounding the oil droplet is exposed and burst under pressure enabling the oil to ooze out.
- During the process of mechanical expression the oilseeds are compressed in various types of **compression devices/equipment.**

- Extraction is the process of separating a liquid from a liquid – solid system with the use of a chemical.
- Vegetable oils are examples of liquid –solid mixtures which can be recovered from either operation of expression and extraction or combination of the two processes.
- Apart from expellers , **solvent extraction** plants play an important role. The solvent extraction **plants extract oil from rice bran, soybean and expeller pressed cakes.**
- The advantage of mechanical expression system over chemical extraction is that it gives the **liquid free of dissolved chemicals** and thus a safer process.

Mechanical expression devices

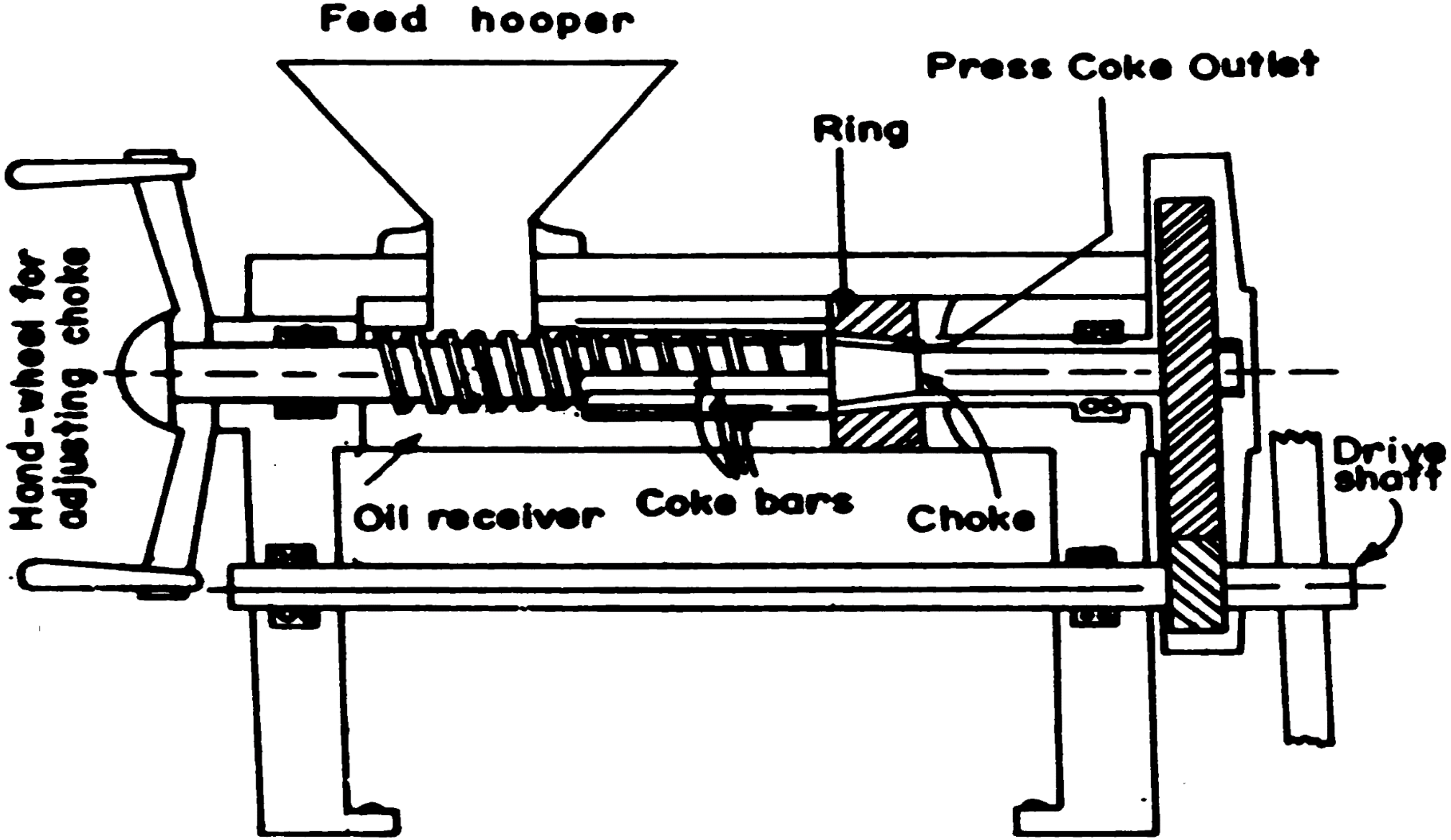
Hydraulic press :

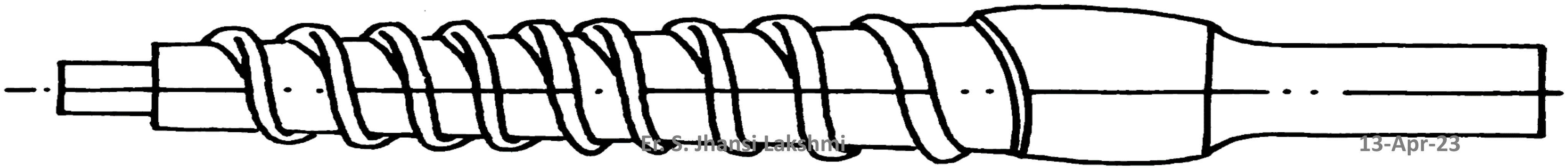
- The hydraulic press is considered of a series of horizontal corrugated iron plates .
- In the first stage the oil samples are pressed at approximately 5 MPa for 15-20 minutes. Afterwards a pressure of 28 MPa is applied for 5-10 minutes to complete the expression process.
- Commercial level processing of hydraulic press has been replaced by screw type presses.



Screw press :

- The press has a horizontal main shaft. The screw assembly is formed integrally with this shaft. This screw rotates within a cage or barrel.
- The barrel is made of case-hardened, tool steel bars.
- The configuration of screw is such that‘ **the volume displacement at the feed** end of the press is considerably greater than **at the discharge end**.
- As the material is conveyed from feed end to discharge end, it is subjected to **increasing pressure**.
- The "**compression ratio**" or a press is simply volume displaced per revolution at feed end divided by volume displaced per revolution at discharge end.


Feed hooper
Press Coke Outlet
Ring
Hand-wheel for adjusting choke
Drive shaft
Oil receiver
Coke bars
Choke



- The compression curve of a press is a plot of volume displacement to a base of length along the barrel.
- This curve is split into three sections feed section, the ram section and the plug section. By the action of screw and compressed material, radial pressure is generated along the barrel.
- This radial pressure can be measured by using strain gauges.
- The maximum radial pressure is generated at the feed end of the ram section. The axial pressure follows the radial pressure upto the beginning of the plug section.

$$\text{Compression ratio} = \frac{(D_{B^2} - D_{F^2})}{(D_{B^2} - D_{E^2})}.$$

Where, D_B = barrel diameter
D_F = root diameter of screw feed at feed section
D_E = root diameter of screw at inlet of plug section.

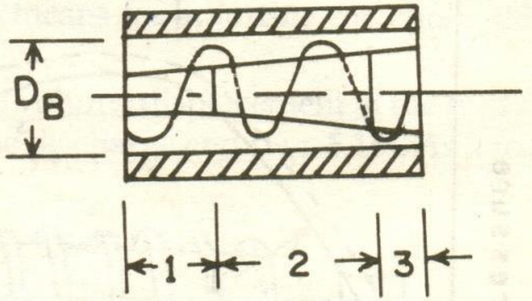


Fig. 5.19B : Cross-section of screw and barrel
1. feed section 2. ram section
3. plug section

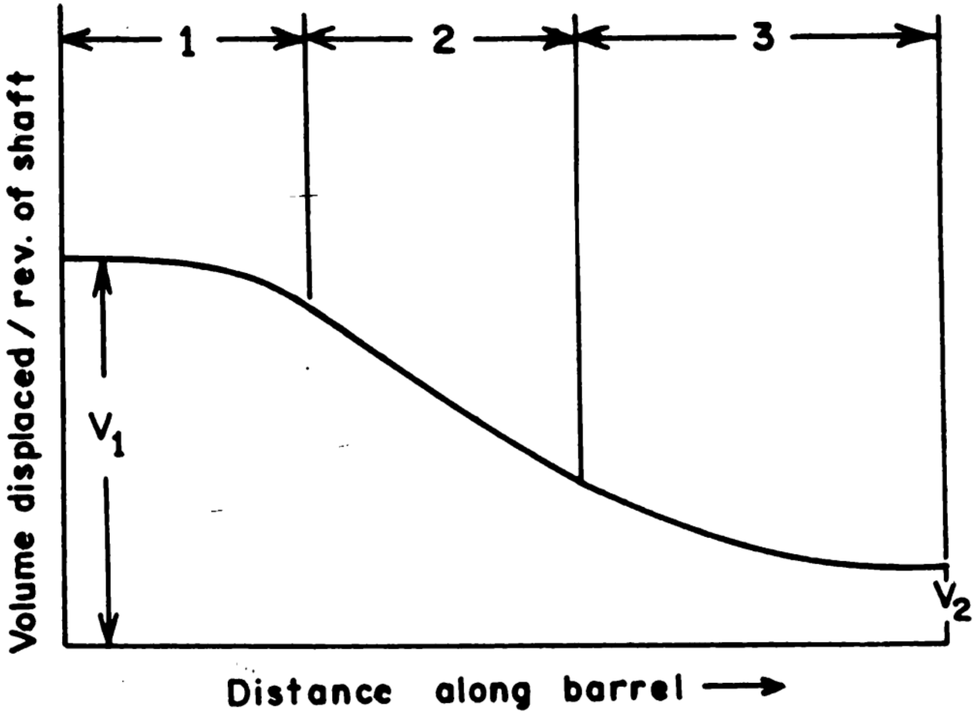


Fig. 5.17 : Compression curve of a screw press
1. feed section 2. ram section 3. plug section

compression ratio $= \frac{v_1}{v_2}$

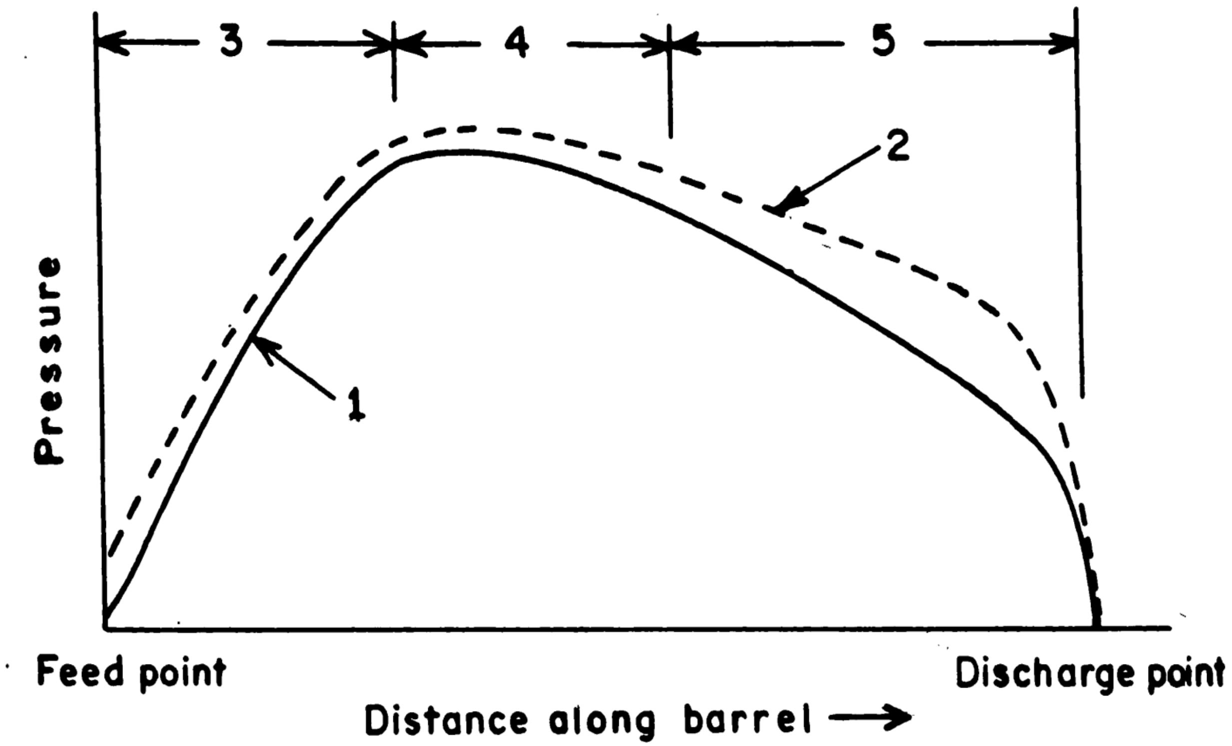


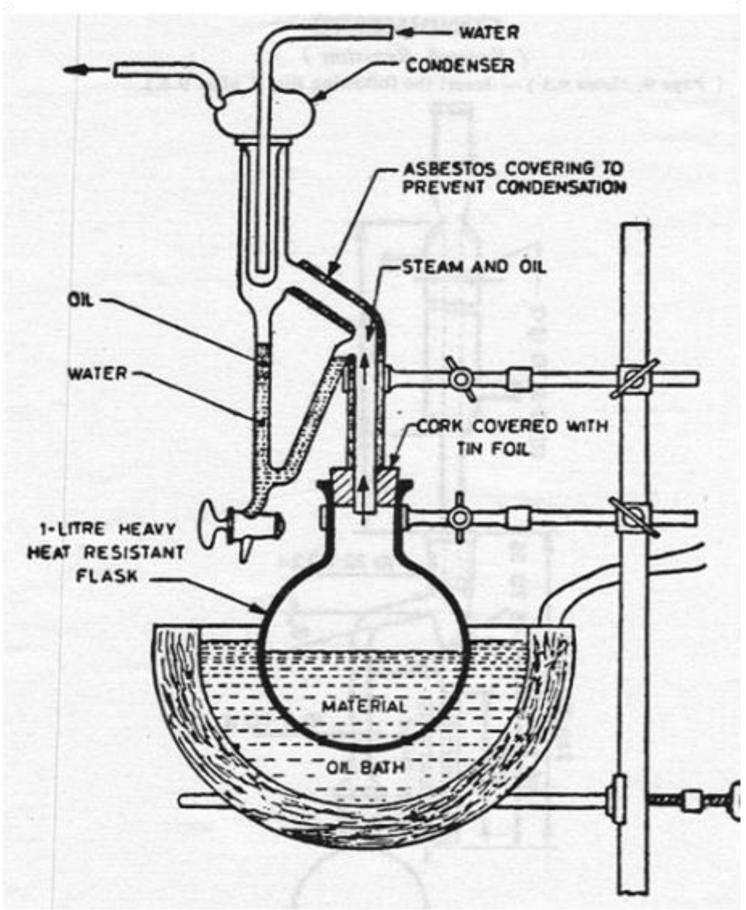
Fig. 5.18 : Radial and axial pressures in a screw press barrel
1. radial pressure 2. axial pressure 3. feed section 4. ram section 5. plug section

Oil extraction

- Extraction is the process of separating a **liquid from a liquid-solid system** with the use of a solvent.
- Extraction may also be said as a process to extract oil from oil bearing materials through the process of **diffusion** with the help of low boiling point solvent.
- Extraction processing, or solvent extraction is capable of removing nearly **all of the available oil** from oilseed meal or flakes.
- In the solvent extraction process, **the solvent is added** to the well prepared materials.
- It is then followed by the **diffusion of oil solvent mixture** to the surface of solid for recovery of oil.

Oil extraction

- The most commonly used solvent in the Indian Plants is the **n-hexane**. The boiling point of n-hexane is about **65.5°C**.
- The deoiled cake coming out of the extraction unit has 25 to 40% solvent by weight.
- This has to be removed and recovered by evaporation either through the direct or indirect heating by steam.



MATERIAL HANDLING

Material Handling and Transportation

- Material handling includes a number of operations that can be executed either by hand (manual) or by mechanical means or devices to convey material and to **reduce the human drudgery.**
- Mechanical handling devices aim to **lighten the work of human labour.**
- The most common types of mechanical devices for grain handling are;

  1. Belt conveyor
  2. Bucket elevator
  3. Screw conveyor
  4. Pneumatic conveyor

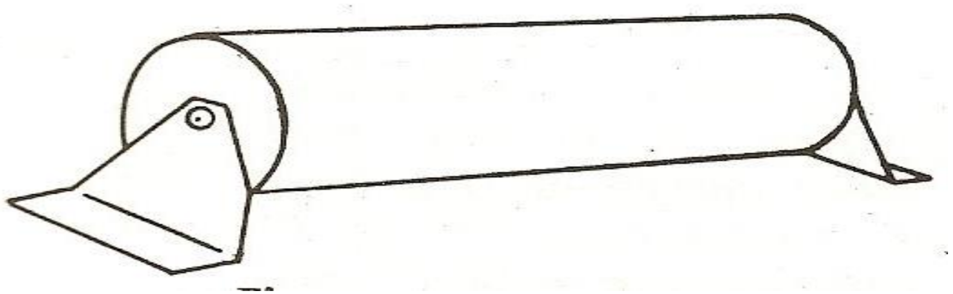
Selection of a conveying system

Before selecting a conveying system, the following principles should be taken into account.

1. The conveying device has to be selected according to the characteristics of the product being conveyed.
2. The stability of the conveyor must be ensured under all normal working and climatic conditions.
3. The capacity of conveying and speed rating should be maintained at specified limits.
4. The dead load of the conveyor should be low in relating to the weight of transported product.
5. In a conveying system possibility of use of gravity should be taken into consideration.
6. The capacity of handling/conveying equipment should match with the capacity of processing unit or units.
7. Spillage of conveyed products should be avoided. Pollution of the environment due to noise or dust by the conveying system should also be avoided.

Types of idlers

- Flat belt idlers
  - Used for granular materials having an angle of repose of not less than 35°
  - Preferred for low capacity requirements where inexpensive or low cost conveying is desired.



- Troughing idlers with 20° trough
  - It is used for conveying all kinds of bulk materials.

- Troughing idlers with 35° and 45° trough
  - Used for transportation of small particle light weight materials like grain, cotton seed etc

BELT CONVEYORS

- A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers.
- The belt may be flat for transporting bagged material or V-shaped or some other enclosed shape for moving bulk grains.
- The belt conveyor consists of a belt, drive mechanism and end pulleys, idlers and loading and discharge devices.
- Belt conveyors have antifriction bearing, therefore these have high mechanical efficiency.

- For transportation of grains, the belt speed should not increase 3.5 m/sec
- Generally, for grain conveying, belt speed of 2.5 to 2.8 m/sec.
- The selection of belt width will depend upon the capacity requirement, speed of operation, angle of inclination of belt conveyor .
- Capacity of belt conveyor(m^3/hr) = (area of cross-section, m^2) x (belt-speed m/min) x60

Power requirement

$$HP_1 = \frac{\text{Belt speed, m/min}}{0.3048} \times \frac{(A+B)\ (3.281\ L)}{100}$$

$$HP_2 = \text{Capacity, } t/hr \times \frac{0.48 + 0.01\ L}{100}$$

$$HP_3 = \frac{\text{Lift, } m}{0.3048} \times 1.015 \times \frac{t/hr}{1000}$$

where L = length of belt, m

A and B = constants

Idler spacing

- The spacing between the idlers influences the retention of correct troughing.
- The incorrect idler spacing may result in belt undulation
- The pitch of idlers is determined by the idler load rating or the carrying capacity of each idler, on the sag of the belt between the idlers, belt tension and belt speed.
- The space between the successive idlers should be approximately equal to the width of belt. The spacing should not exceed 1.2m.
- The main functions of rollers are to withstand the designed work loads and to protect the bearings.

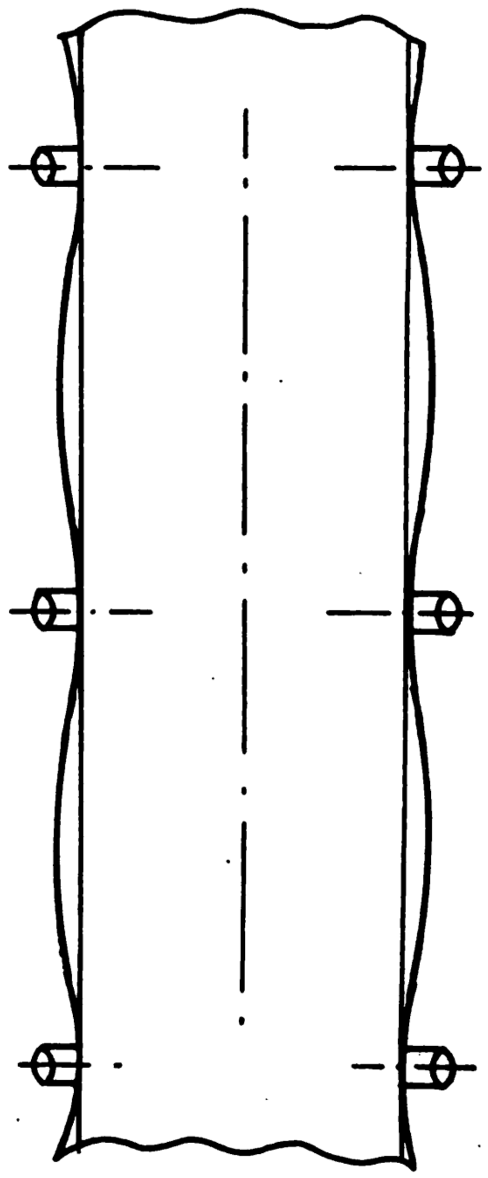


Fig. 6.6 : Sagging of belt conveyor

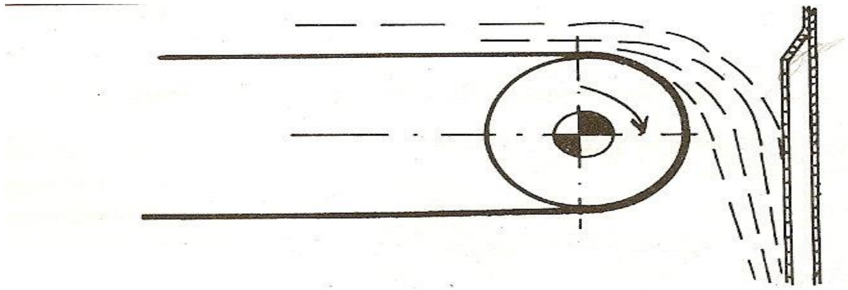
Belt tension

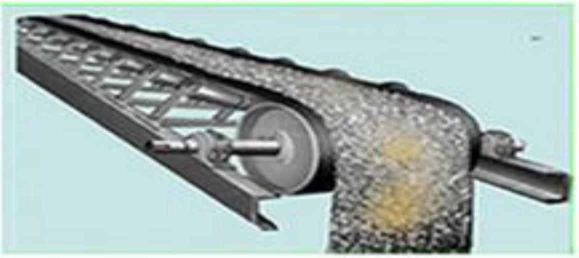
- The tension developed at the drive pulley in transmitting the required power to move the loaded belt is known as effective tension.
- The effective tension is the sum of
  - tension to move the empty belt
  - tension to move the load horizontally and
  - tension to lift the material
- The effective tension is related with the power required to move the belt and belt speed in the following manner

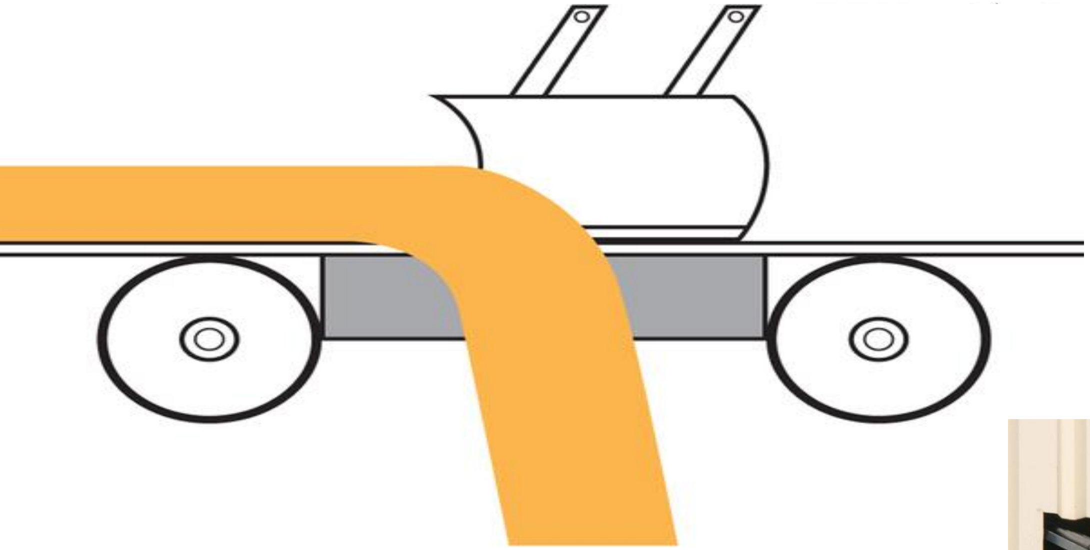
Effective tension, $$T_e = \frac{Power(kw)}{BeltspeedS\,(m/s)}$$

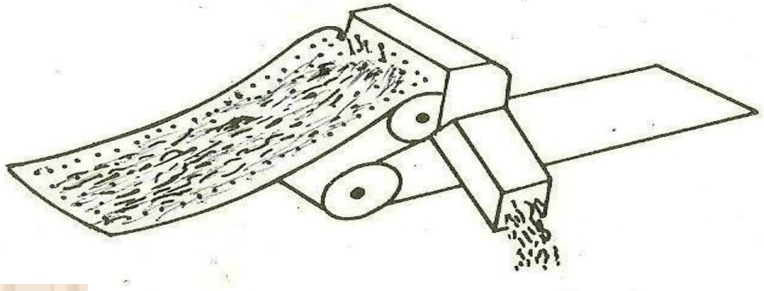
Discharge mechanisms

- Grains are mostly discharged from the belt conveyor over the
  - End pulley
  - Scraper plough
  - Tripper



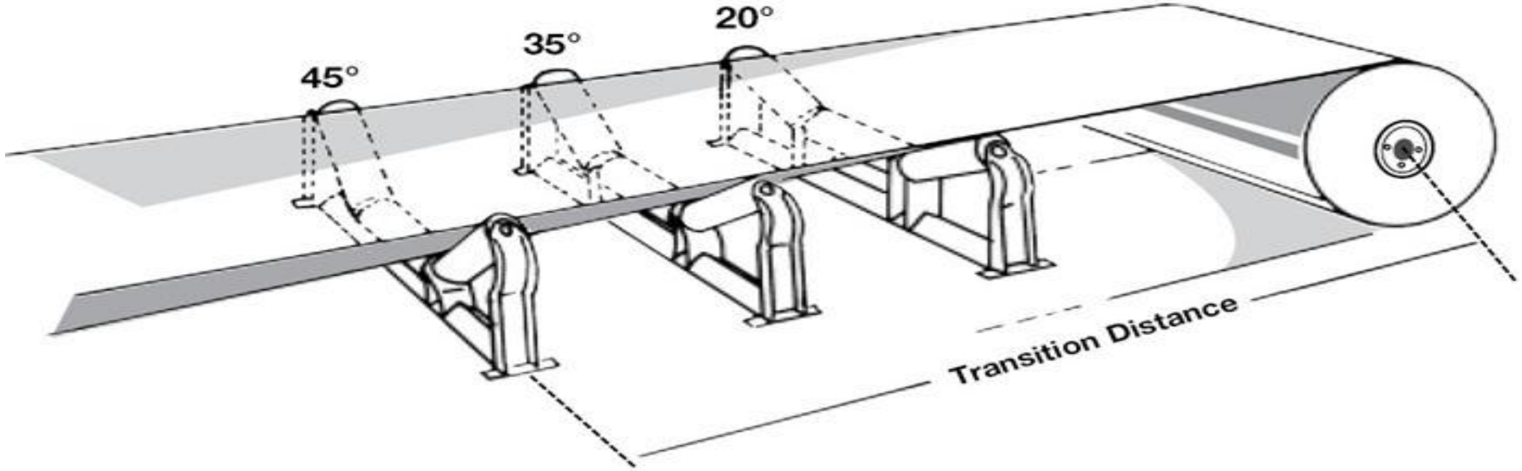






BELT

- Conform to pulley
- Wide enough to carry quantity
- Strong to take desired quantity
- Material Of Construction
    - ➢Balata
    - ➢Stitched canvas
    - ➢Rubber belt



ADVANTAGES

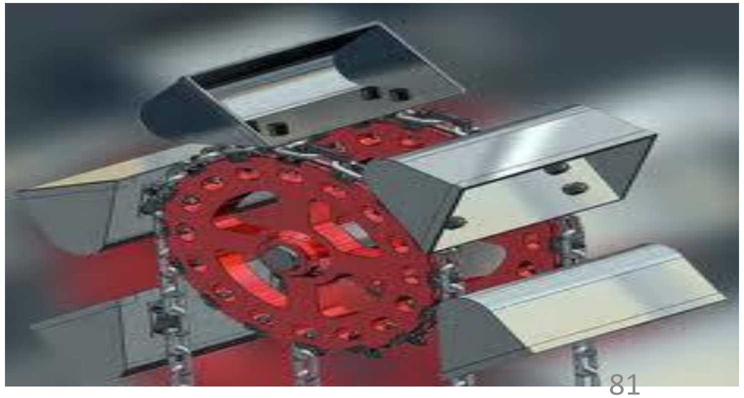
- Belt conveyors have antifriction bearing, therefore, these have a high mechanical efficiency
- There is no relative motion between the product and belt
- There is no damage to material
- Large carrying capacities
- Low operating costs

LIMITATIONS OF BELT CONVEYOR

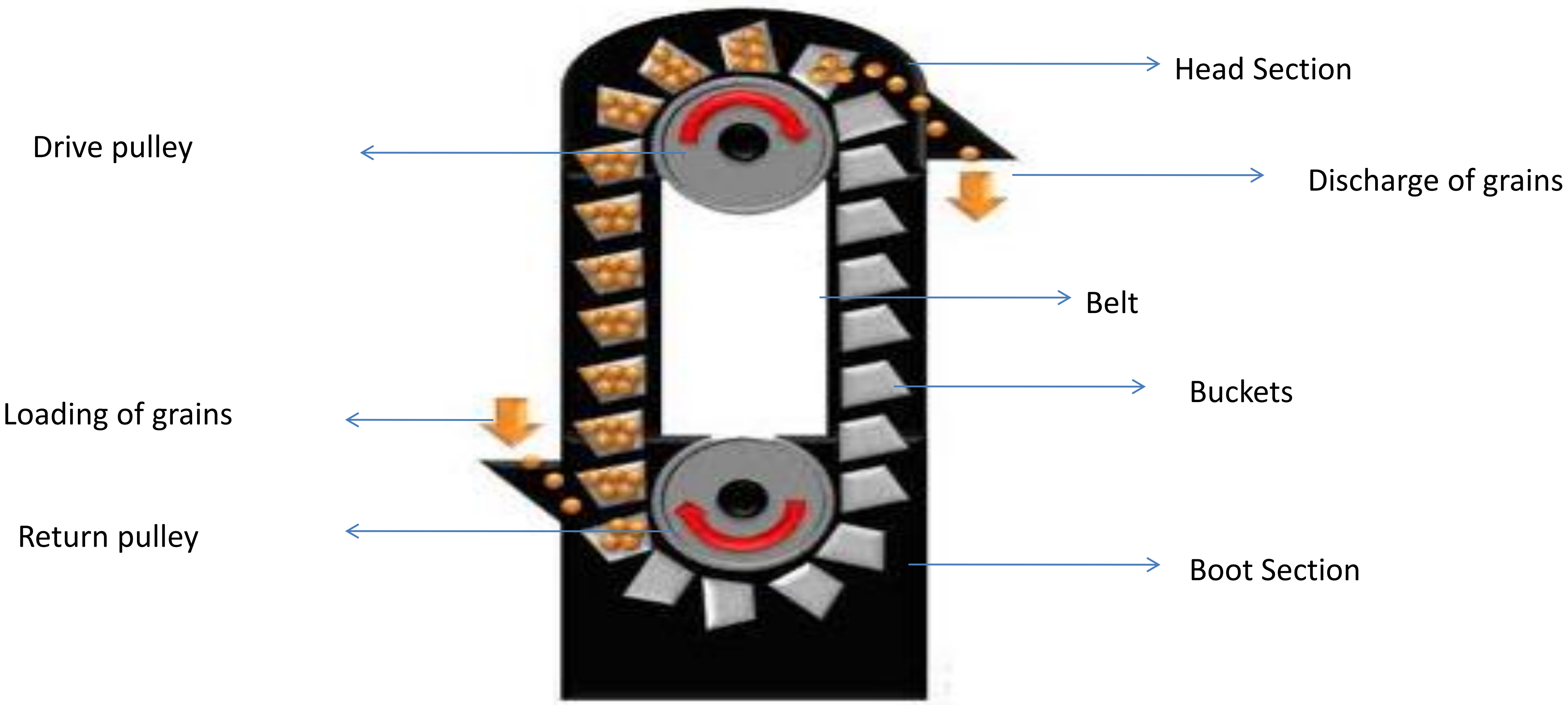
- Limitation to the angle of inclination
- High installation cost

BUCKET ELEVATOR

- Buckets are attached to a chain or belt that revolves around two pulleys one at top and the other at bottom
- The vertical lift of the elevator is few meters to more than 50 m
- Capacity of bucket elevators may vary from 2 to 1000 ton/hr
- The spaced-bucket centrifugal discharge type is commonly used for elevating the grains
- The device bucket elevator is a very efficient device for the vertical conveyance of bulk grains
- These are usually mounted at a fixed location,
  but they can also be mounted in a mobile frame

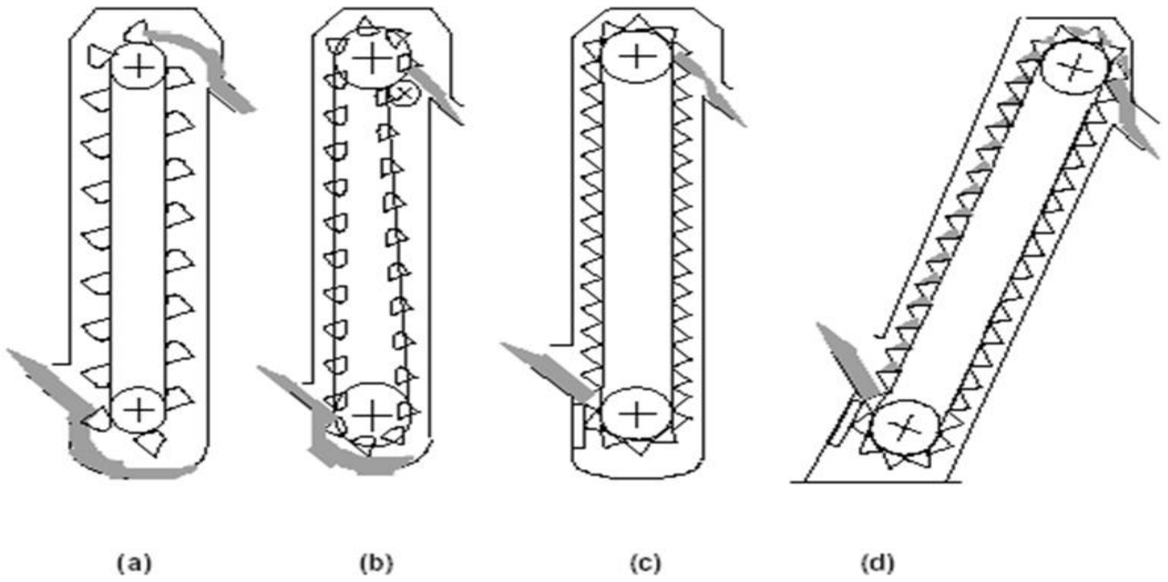


Parts of bucket elevator

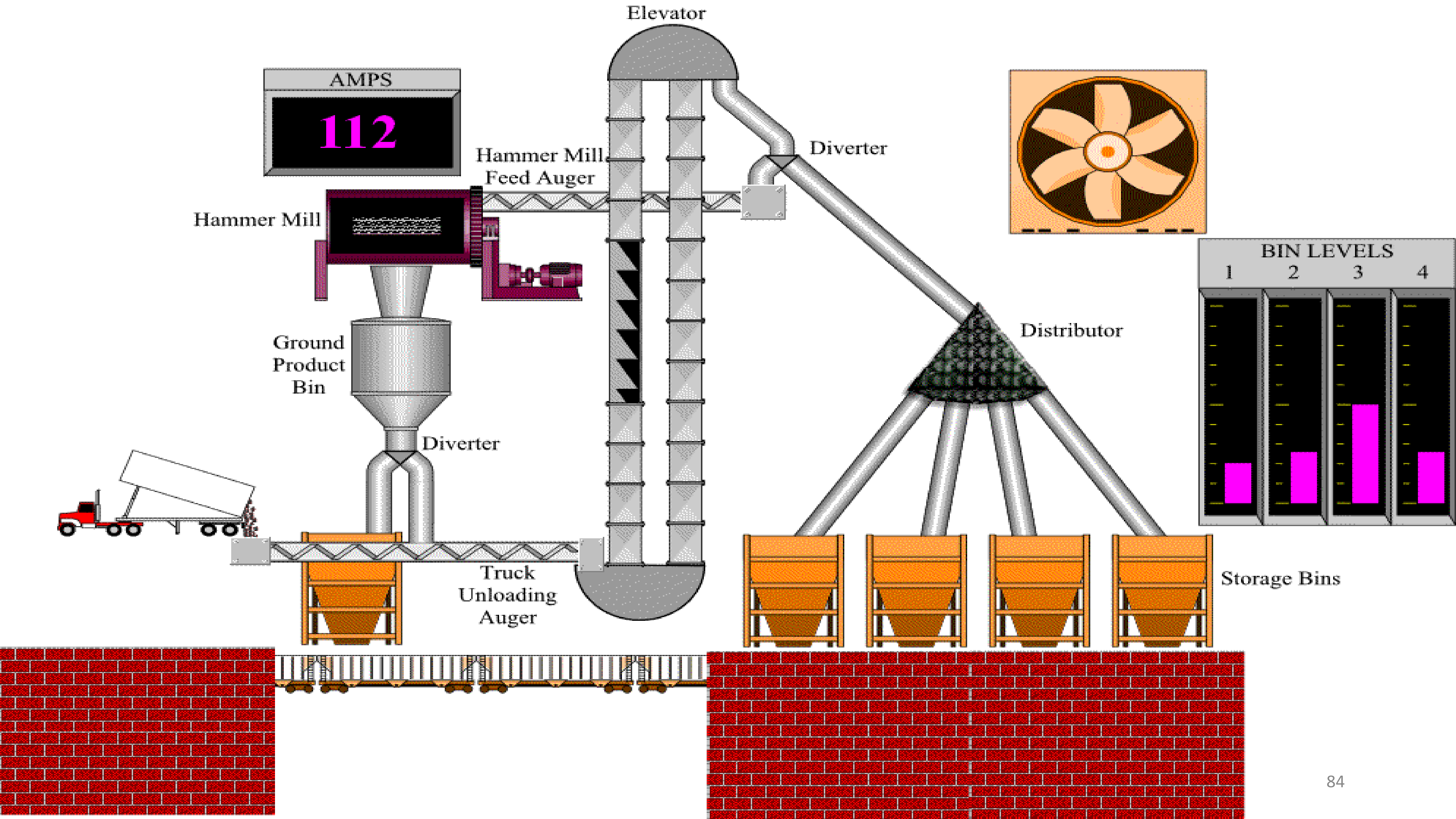


CLASSIFICATION OF BUCKET ELEVATORS

- ❖ **Spaced bucket elevators**
  - Centrifugal discharge elevator
  - Positive-discharge elevator
  - Marine leg elevator
  - High-speed elevator
- ❖ **Continuous bucket elevators**
  - Super capacity bucket elevator
  - Internal-discharge bucket elevator

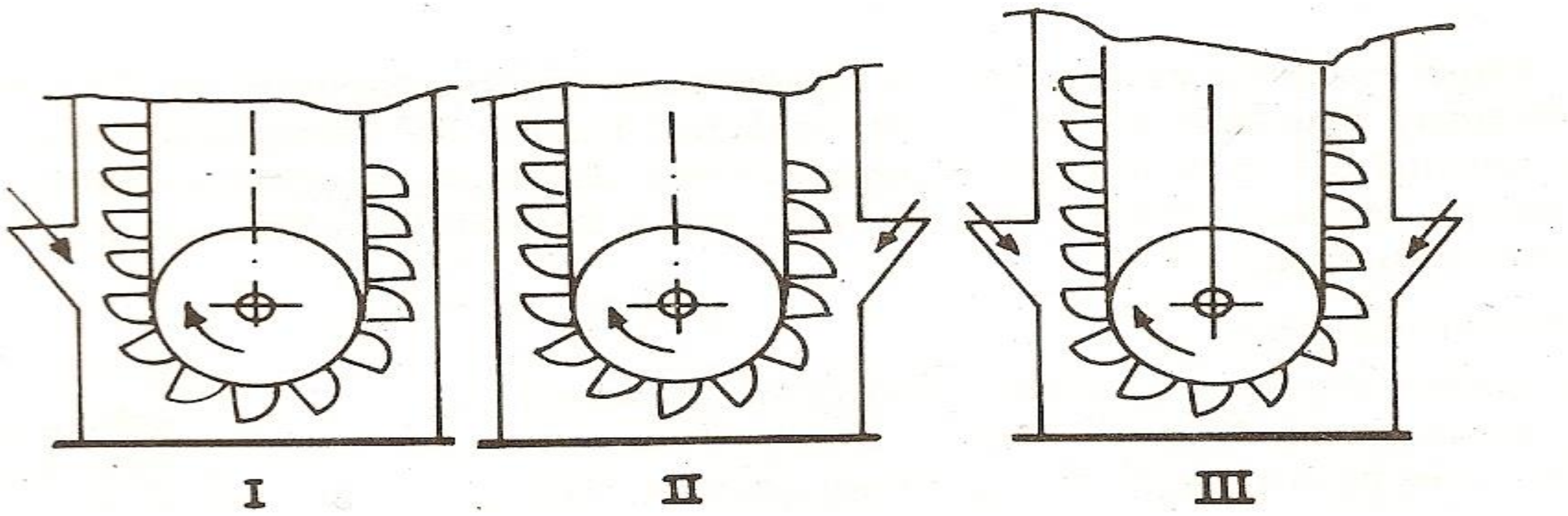


Bucket elevators: (a) centrifugal-discharge spaced buckets, (b) positive-discharge spaced buckets, (c) continuous bucket, (d) super-capacity continuous bucket.


Elevator
AMPS
112
Hammer Mill Feed Auger
Diverter
Hammer Mill
BIN LEVELS
1
2
3
4
Distributor
Ground Product Bin
Diverter
Truck Unloading Auger
Storage Bins

- The bucket elevator's capacity mainly depends on bucket size, conveying speed, bucket design and spacing, the way of loading and unloading, the bucket and the characteristic of bulk material.
- Belt speed is the first critical factor to consider.
- Bucket elevators with a belt carrier can be used at fairly high speeds of **2.5 to 4 m/s.**
- The speed of the belt depends on the **head pulley speed**.
- If the belt speed is too **low**, the discharge of the grains **becomes more difficult**, with too high speed the buckets are **not fed well.**

FEEDING TYPE



I.front feed, II. Back feed, III. Combined feed

METHOD OF DISCHARGE

- Gravity Discharge
- Centrifugal Discharge

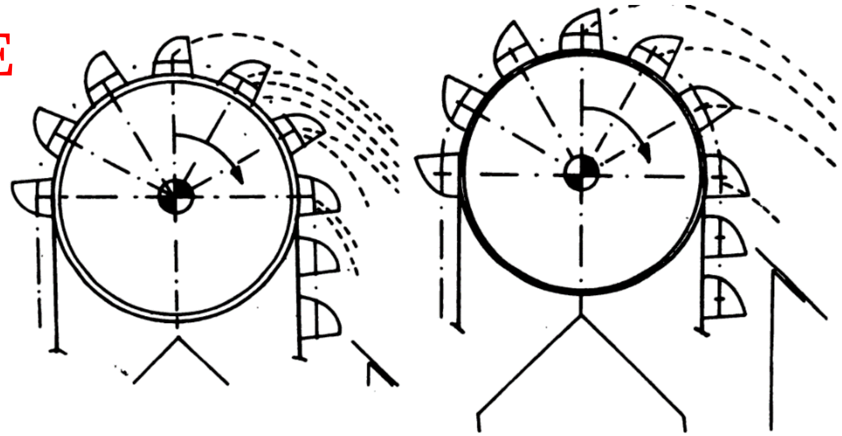
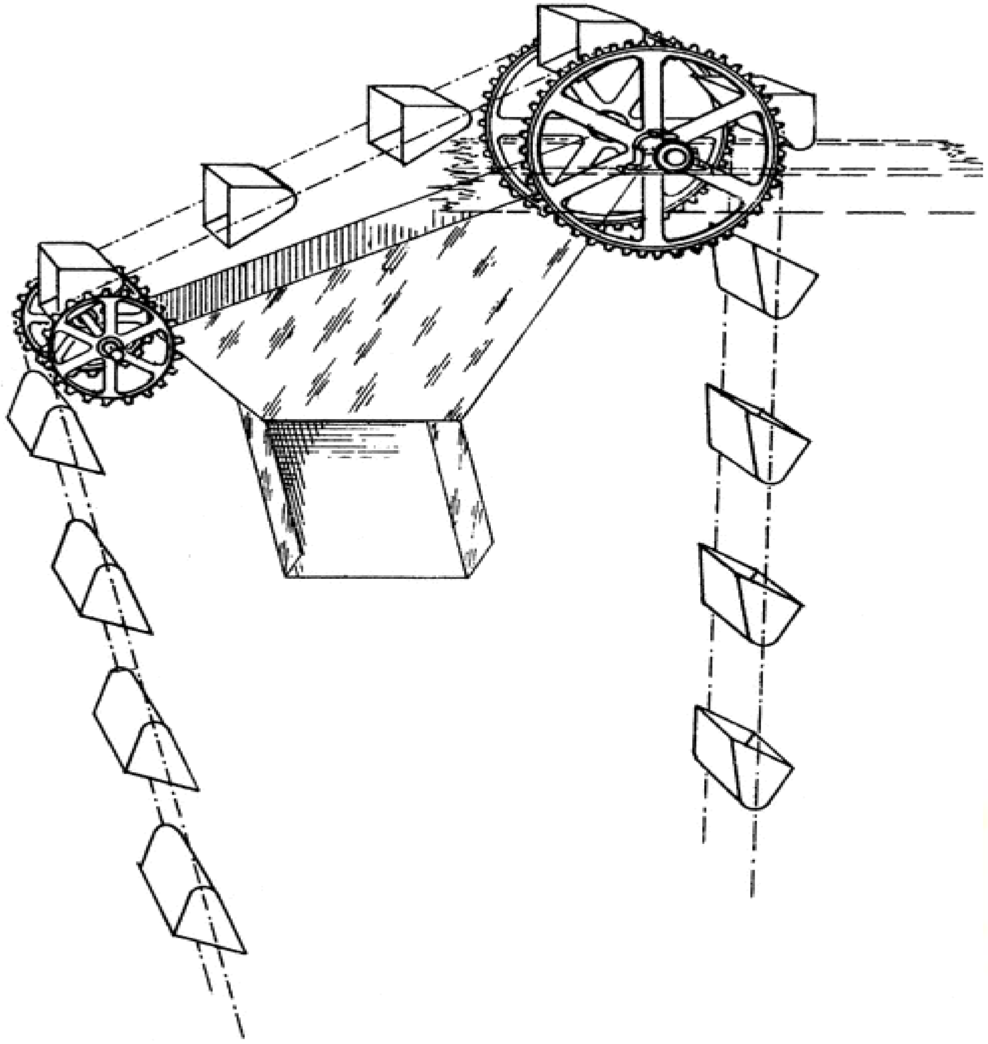
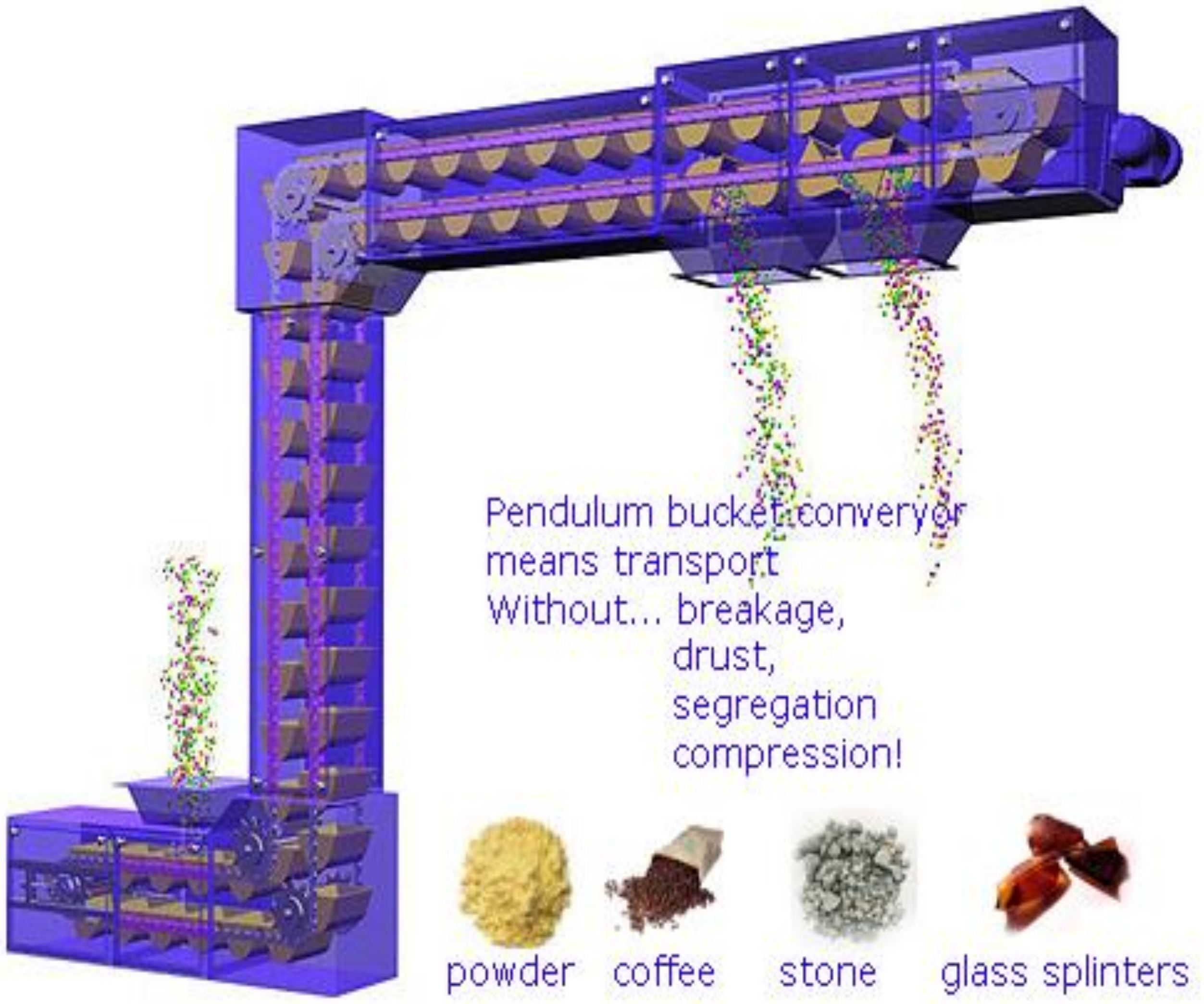


Fig. 6.11 : Bucket elevator's discharge methods
1. low speed gravitational discharge 2. high speed centrifugal discharge

Gravity Discharge





When a product mass turns around a pulley, it is influenced by two forces,

- Gravitational force, which is oriented downwards and
- Centrifugal force

$$c_f = \frac{WV^2}{gr}$$

where, W = weight of grain
V = velocity of product mass
g = acceleration due to gravity
r = radius of the wheel plus one-half of the projection of the bucket

➢ For optimum centrifugal discharge and calculation of the speed of head pulley, the resultant force is zero, it means that the centrifugal force is equal to the force of gravity or $c_f = W$

$$W = \frac{WV^2}{gr}$$

$$V = \sqrt{gr} \qquad V = \frac{2\pi nr}{60}$$

$$n = \frac{60\sqrt{g\sqrt{r}}}{2\pi\sqrt{r\sqrt{r}}} = \frac{29.9}{\sqrt{r}}$$

- Elevator capacity, m^3 / h = bucket capacity, m^3 x number of bucket per meter of belt x belt speed, m / min. x 60

Capacity, t / hr $$= \frac{capacity, m^3 / hr \times material\ density, kg / m^3}{1000}$$

$$hp = \frac{QHF}{4562}$$

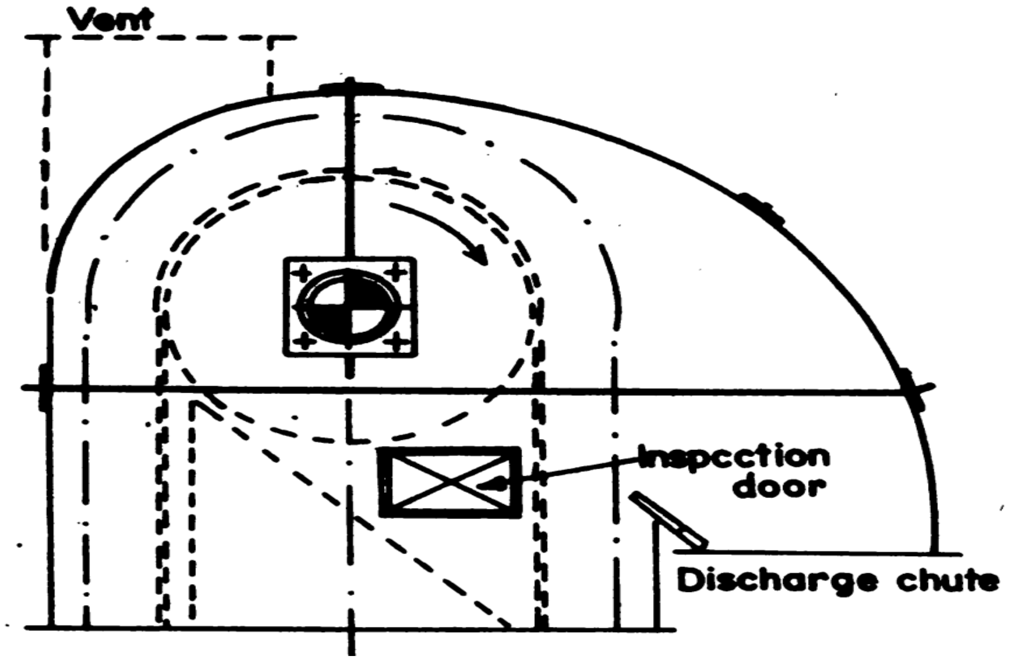
where, Q = capacity of bucket elevator, kg / min.

H = lift of elevator, m

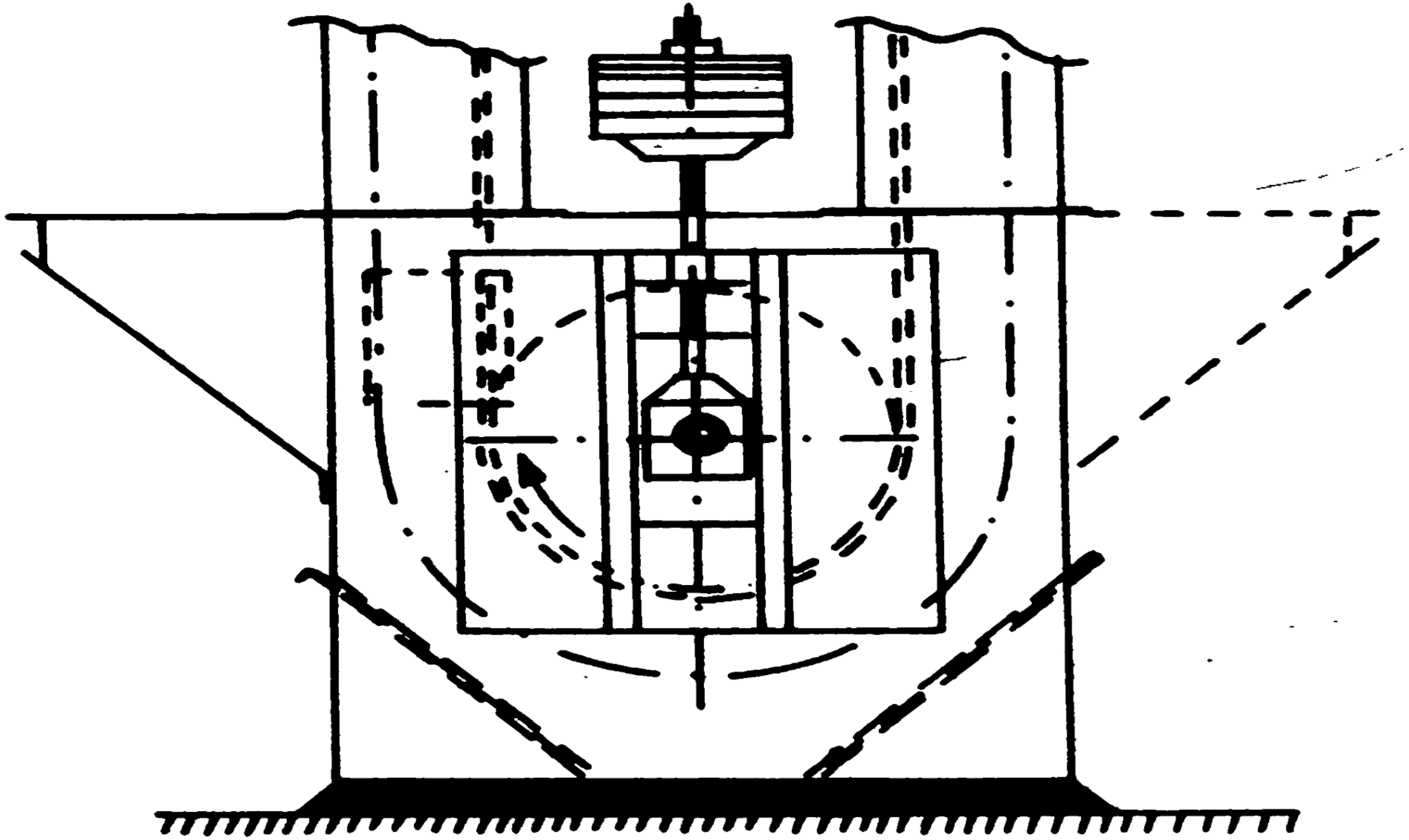
F = factor; 1.5 for elevators loaded on the upside and 1.2 for elevators loaded on the bottom side

Head Section

- The discharge side of the head should be shaped so that material thrown from the **buckets may not deflect into the down leg.**
- When the product is not thrown well clear of the buckets into the discharge chute, it will fall in the down leg. This is called as "**back logging".**
- The back logged material has to be reelevated, thus it **reduces the capacity** of the elevator.
- To avoid back-logging, an adjustable **cut off plate** is provided close to the lip of bucket.



Boot section



Elevator legs

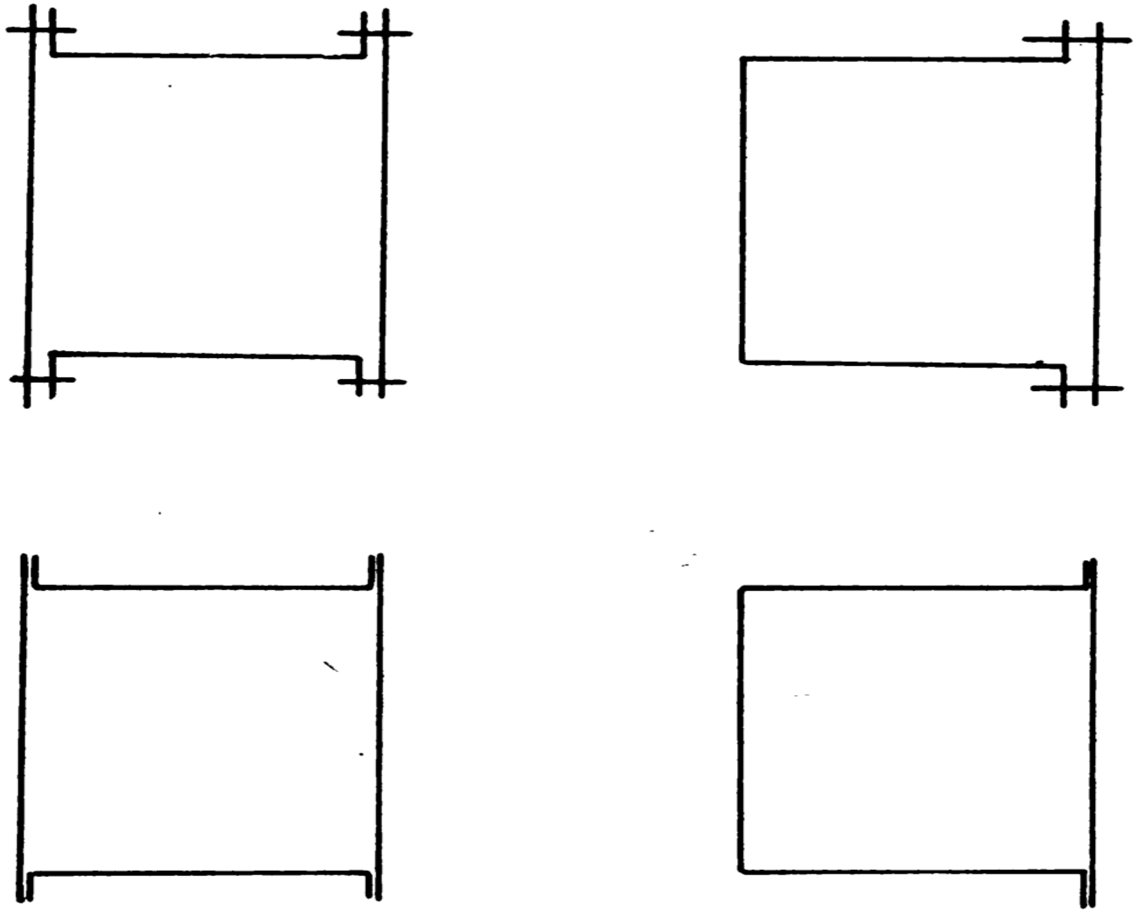


Fig. 6.14 : Cross-section of few types of elevator lags

ADVANTAGES

- These are very high capacity
- It is a fairly cheap means of vertical conveyance
- It requires limited horizontal space
- It is dust free and fairly quite
- Highly corrosion resistant with a powder coat finish for lasting durability and superior appearance
- Years of reliable operation for a variety of grain delivery requirements

SCREW CONVEYOR

- Consists of tubular or U-shaped trough in which a shaft with spiral screw revolves
- The screw shaft is supported by end and hanger bearings
- The rotation of screw pushes the grain along the trough
- This is used in grain handling facilities, animal feed industries
- This requires relatively high power and is more susceptible to wear than other types of conveyors

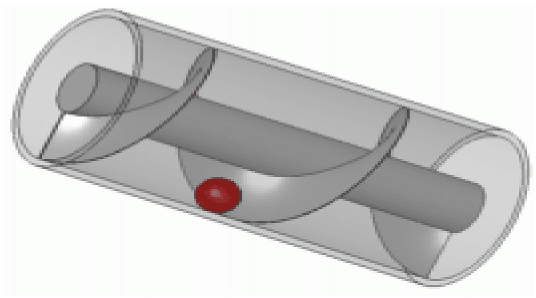
SCREW CONVEYOR

- The pitch of a standard screw which is the distance from the centre of one thread to the centre of the next thread, is equal to its diameter
- The screw conveyor is generally used to move grains horizontally and it can also be used at any angle up to 90^0 from the horizontal
- Mostly used for fine powder, damp and stick material, heavy viscous material.

Types of troughs of screw conveyor

1) U-Shaped trough
2) Flared trough:

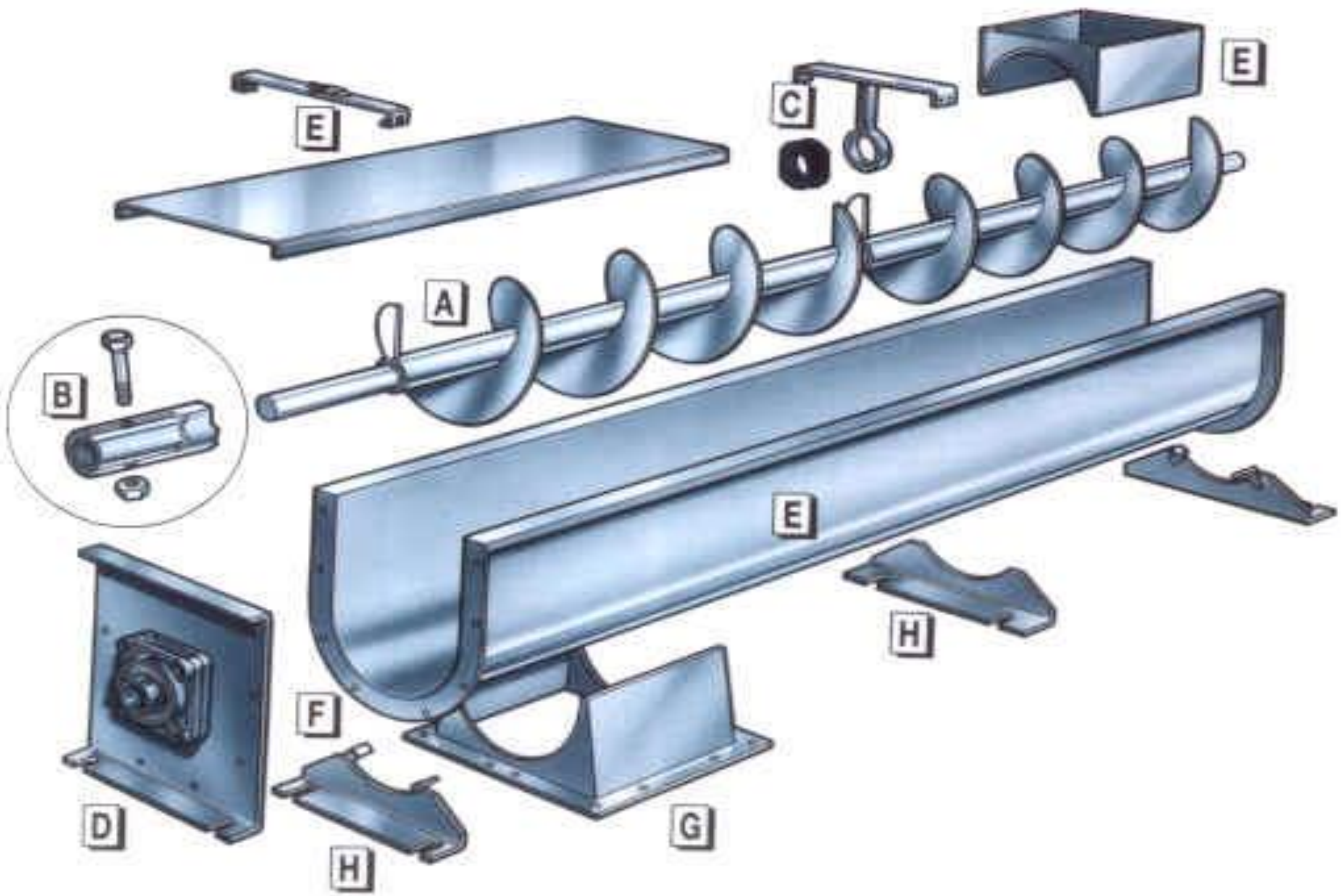
- The side walls become wider at the top
- This type of trough is usually used for conveying non easy flowing materials which may have lumps



3) Tubular trough:

This type of trough is completely closed with circular cross-section and mostly used for conveying materials at inclination or vertical lift

Parts of screw conveyor



A. Conveyor Screw
B. Couplings,
C. Hangers and Bearings
D. Trough Ends
E. Troughs, Covers, Clamps and Shrouds
F. Flange
G. Feed and Discharge Spouts
H. Supporting Feet and Saddles

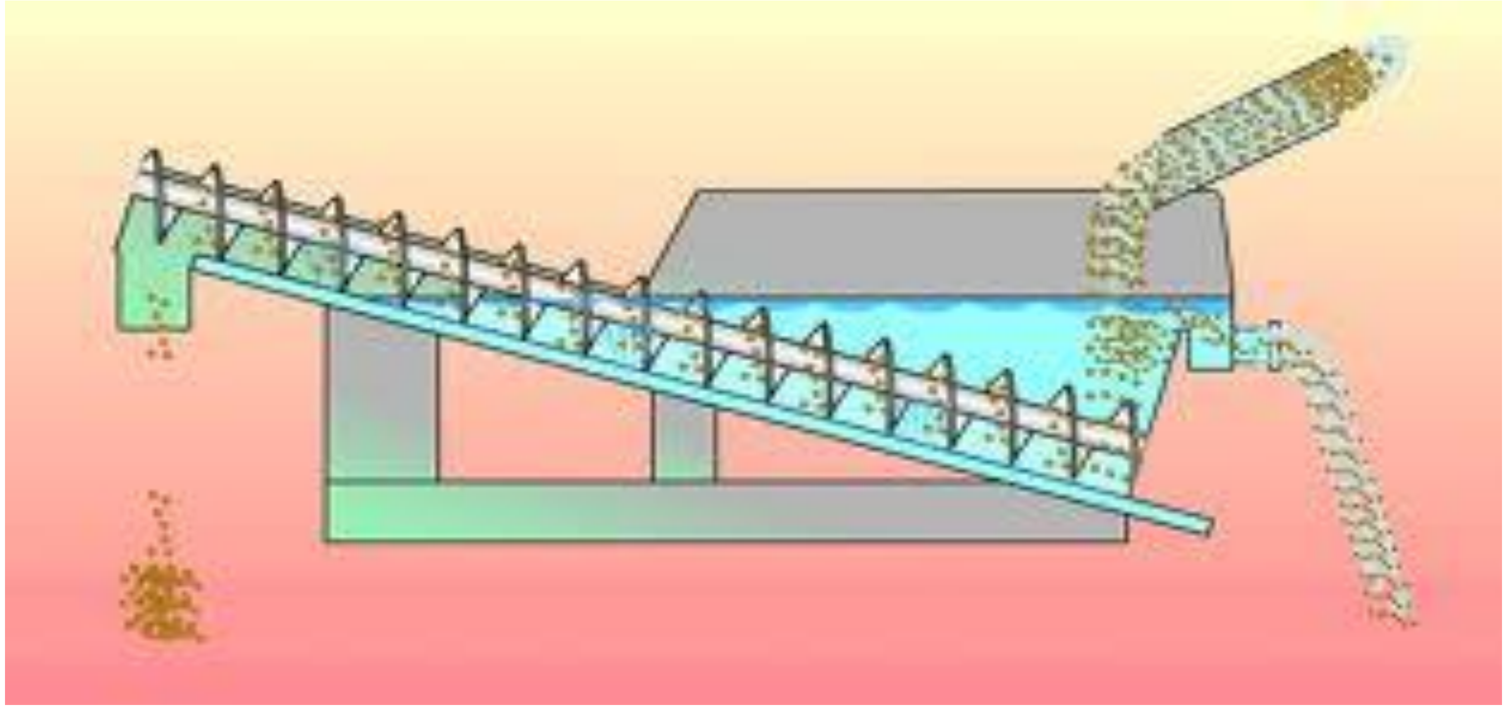
SCREW CONVEYOR MATERIAL

A Wide Choice Of Materials :

- Stainless Steel Screw Conveyors
- Corrosion Resistant Conveyor Screws
- Wear Resistant Conveyor Screws

TYPES OF PITCH

- Standard Pitch
- Half Standard Pitch
- Variable Pitch
- Stepped Pitch
- Special Cut Flight
- Ribbon Screw



STANDARD PITCH:

- For Conveying Up to 20 Inclination
- Pitch = Diameter
- Square Threaded Screw

HALF STANDARD PITCH:

- For Inclination More Than 20

THEORITICAL CAPACITY

$$\text{Capacity } Q,\ \text{m}^3/\text{hr} = 47.2\ (D^2 - d^2) \times p \times n$$

where, D = screw diameter, m

d = shaft diameter, m

p = pitch, m

n = rpm

HORSE POWER REQUIREMENT

$$\text{Horse power} = \frac{Q\,L\,W\,F}{4560}$$

where, Q = conveyor capacity, m^3/hr

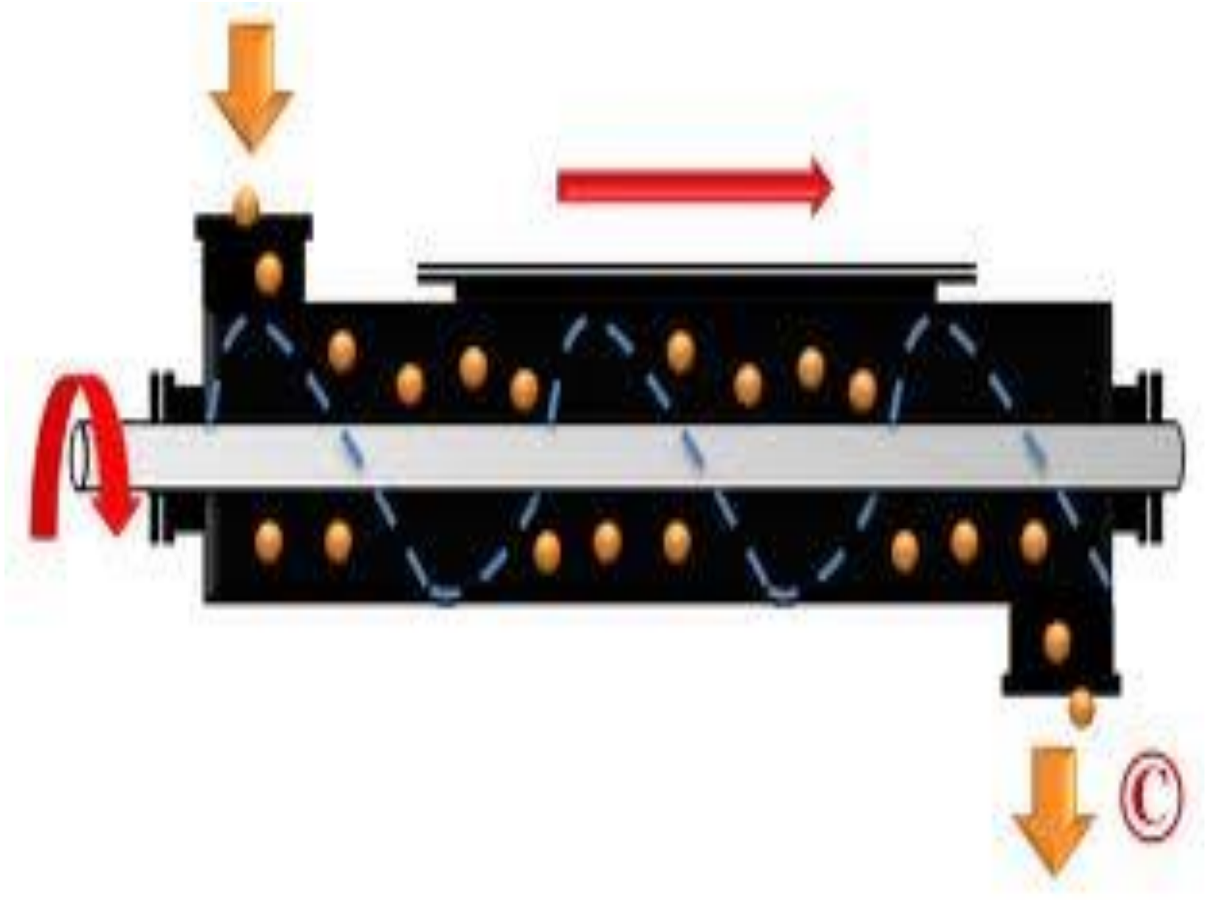
L = conveyor length, m

W = bulk material weight, kg/m^3

F = material factor (for paddy 0.4)

ADVANTAGES OF SCREW CONVEYOR

- Simplicity
- Freedom from cracks
- Freedom from dust
- Relatively inexpensive
- Ease in dismantling
- Accurate feed rate
- Conveying and elevating

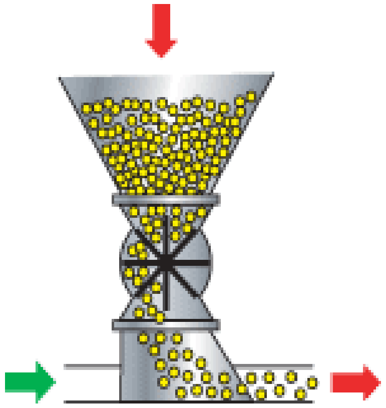


Disadvantages

- High power requirement
- High wear factor
- Product damage
- Noisy

PNEUMATIC CONVEYING

- The pneumatic conveyor moves granular materials in a closed duct by a high velocity air stream.
- Pneumatic conveying is a continuous and flexible transportation method.
- The material is carried in pipelines either by suction or blowing pressure of air stream.
- The granular materials because of high air pressure are conveyed in dispersed condition.
- For dispersed of bulk material, air velocities in the range of 15-30 m/s necessity.



Rotary feeder for pneumatic conveyor

PNEUMATIC CONVEYING

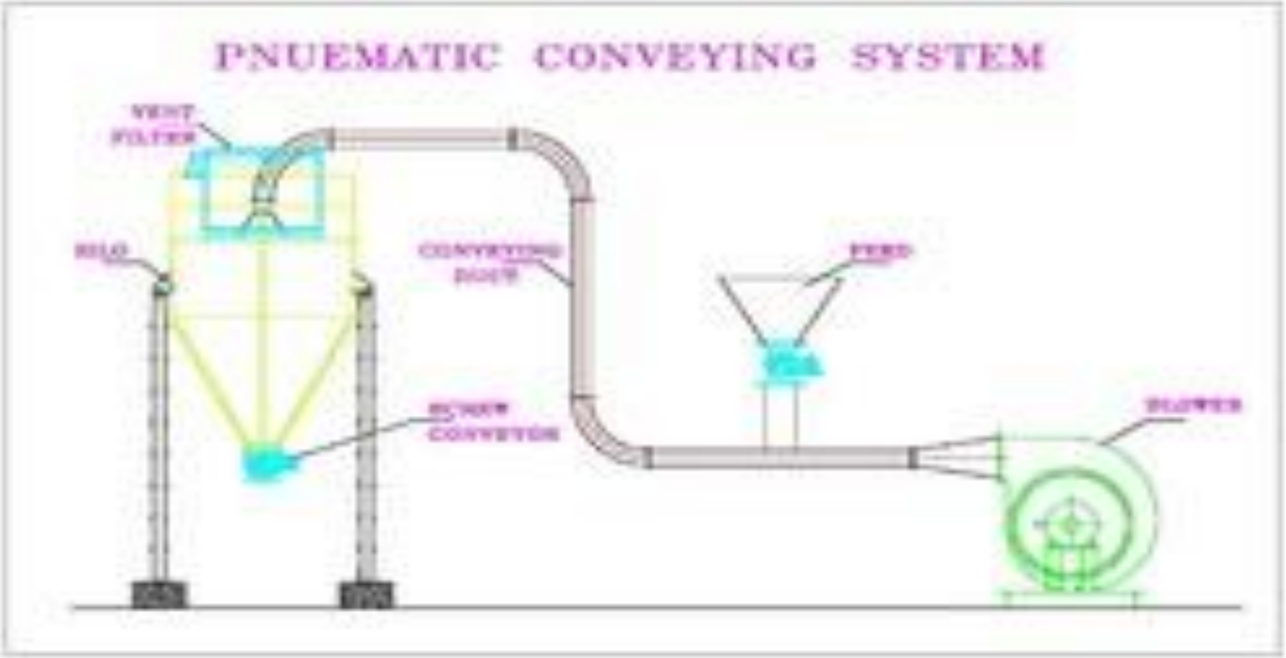
- There are three basic systems of pneumatic conveying. These are pressure or blowing system, suction or vacuum system, and combined push-pull or suck-blow system.
- In blowing or positive pressure systems, the product is conveyed by using air pressures greater than the atmospheric pressure.
- This system consists of a fan or blower, an air-lock feeder for introducing the product into the system, ducts and suitable air and product-separating device. The product is fed into the pneumatic conveying system from the bottom of a hopper.

PNEUMATIC CONVEYING

- Relatively low initial cost
- Mechanical simplicity
- Conveying path may be random
- Path can be changed easily
- Wide variety of materials can be handled, ex dusts, fibers, sand, grain, cotton
- Self cleaning system
- High power requirement and damage to the product

SYSTEMS

- Suction system
- Low pressure
- High pressure
- Fluidized system



MOVEMENTS

- Horizontal

- Vertical

Limitations of Pneumatic Conveying

1.Erosion of solid surfaces and equipment surfaces by solid particles with conveying air stream. The rate of erosion of solid surfaces increased remarkably with conveying of abrasive products.

2. In case of bends or misaligned sections, the erosion problem becomes severe. In industrial installations, the erosion of duct system poses major problem in the operation of pneumatic conveying system.

3. In a pneumatic conveying system, chances of repeated impacts between the particles and the solid surfaces are high. Due to such impacts, product degradation results, because of this changes take place in the product size distribution and consequently the market value diminishes.

THANK YOU