Session 4.1: Introduction to Cereal Grains Milling Operations

Cleaning/Separation

- Classification of Separation Methods: Any mixture of solid materials can be separated into different fractions according to their difference in length, width, thickness, density, roughness, drag, electrical, conductivity, color, and other physical properties.

Separation methods

- Separation according to Aerodynamic Properties
- Separation according to Specific Gravity
- Separation according to Magnetic Properties
- Separation according to Electrostatic Properties
- Separation according to Colors (Electronic Separators)
- Separation according to Surface Properties (Frictional Separators)

Effectiveness of the Separation

$$\varepsilon_A = \frac{(X_F - X_D)X_C(X_F - X_C)(1 - X_D)}{(X_D - X_C)^2 X_F(1 - X_F)}$$

where

ε_A is the separating effectiveness for a mixture of two components A and B

F is the rate of feeding to the separator, kg/h

C is the rate of separating the product, kg/h

D is the rate of reject, kg/h

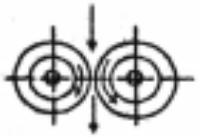
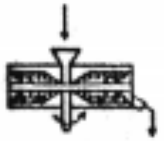
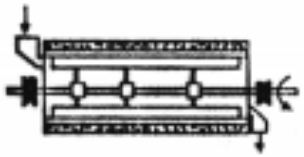
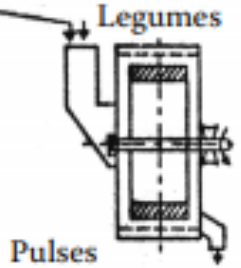
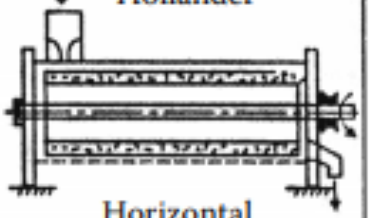
X_F, X_C, and X_D are fractions of component A in the feed, separated product, and reject, respectively

Husking/Scouring/Hulling of Grain

- In general, husking refers to the removal of outer seed coat from the grain kernel. The terms “hulling” and “scouring” are also used in cereal milling. In grain milling, husk is removed from the grain, retaining its original shape, whereas in flour milling bran is removed from the grain to produce flour without any emphasis on its shape. Husking and scouring are the most important operations in grain milling or flour milling technology of cereals.

Methods of Husking

- **Compression and shear**: Compression and shear can compress, split, and strip off the husk from grain. Concave type of husking machine, rubber roll husker, etc., are designed on the basis of this principle.
- **Abrasion and friction**: Hollanders are based on the friction of grain on an abrasive surface (emery).
- **Impact and friction**: Husk can be stripped off by the action of impact and factional force. Centrifugal-type paddy sheller comes under this group

Name, characteristics of hull and kernels (14% moisture content)	For millets with free hulls around non-brittle kernels I	For paddy with free husk around brittle kernels II	For oats with hulls around elastic kernel III	For barley with tightly joined hulls over strong kernel IV	For legumes with tightly held halls with the kernels (to be split into two cotyledons) V
Hulling methods and machines	 Concave huller	 Rubber roll husker	 Under runner, disk sheller	 Blade-type emery scourer	 Legumes Pulses Hollander  Horizontal "Gota" machine
Hulling mechanism	Shear and compression	Shear and compression	Shear, compression, and friction	Impact, abrasion, and friction	Friction and abrasion

Classification of husking/scouring/hulling methods.

Factors Affecting the Effectiveness of Hulling/Husking/Scouring

- Type of grain and its special properties .
- Bond strength between kernel and husk, strength of the kernel, and strength of the husk.
- Sound or cracked grain, grain size, and uniformity of size
- Moisture content of grain and difference in moisture content between husk and kernel
- Extent of hydrothermal treatment given to the grain
- Proportion of husked kernel in the grain
- Ease of separation

Effectiveness of Hulling/Husking/Scouring

The coefficient of hulling E_{hulling} is defined by the percentage of husked grain obtained from the total amount of grain input:

$$E_{\text{hulling}} = \left(\frac{n_1 - n_2}{n_1} \right) = \left(1 - \frac{n_2}{n_1} \right)$$

where

n_1 is the amount of grain before hulling

n_2 is the amount of unhulled grain after hulling

Grinding

- **Plain grinding**: In this type of grinding, hard bodies are ground to a free-flowing material consisting of particles of sufficiently uniform size. This material is either the final product or a product ready for further processing.
- **Selective grinding**: This grinding operation is carried out in a number of stages successively using differences in structural and mechanical properties of the components of the body.

Factors Affecting Grinding

- Type of cereal grain
- Variety
- Moisture content
- Extent of hydrothermal treatment given to the grain
- Mechanical properties.

Effectiveness of grinding

- Degree of grinding, i, is expressed as follows:

$$i = \frac{S_a}{S_b}$$

where

S_a is the overall surface area of the product after grinding, cm^2

S_b is the overall surface area of the product before grinding, cm^2

- "Overall extraction" Ex expressed in percent

Overall Extraction

- The term “overall extraction” Ex expressed in percent refers to the difference between the percentage of undersized particles C1 in the final ground product and the percentage of undersized particles I in the initial feed entering the grinder:

$$E_X = C_1 - I$$

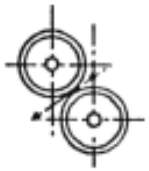
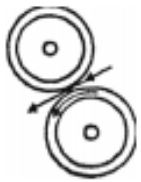
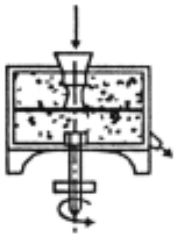
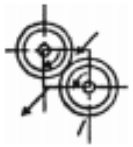
$$C_1 = \left(\frac{u_1}{u_1 + O_1} \right) \times 100$$

$$I = \left(\frac{u_2}{u_2 + O_2} \right) \times 100$$

where

u_1 is the weight of undersized particles obtained by sifting the ground product
O_1 is the weight of oversized particles obtained by sifting the ground product
u_2 is the weight of the undersized particles in the initial product to be ground
O_2 is the weight of oversized particles in the initial product to be ground
E_X depends upon structural–mechanical properties of the material, dimensions of the roll (i.e., diameter, etc.), geometry of the surface of the rolls, kinematic parameters of the rolls, and specific load on the rolls

Machinery Used in Cereal Grinding

Grinding machines	Roller mill	Burr mill	Attrition mill	Hammer mill	Flatting mill
	 Break roll  Reduction roll				
Grinding mechanism	Compression and shear	Compression and shear	Impact and friction	Impact and crushing	Compression

Classification of grinding machinery.