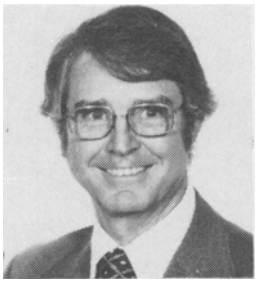
Cleaning, Cracking, Dehulling, Decorticating, and Flaking of Oil-bearing Materials



J.P. GALLOWAY, Manager of Export Operations and Branch Manager, Murray-Carver Division, Rockwell International, Dallas, Texas, USA

ABSTRACT

Techniques and equipment for cleaning, cracking, dehulling, decorticating, and flaking of oil-bearing materials are described. Particular methods and cautions for unusual materials are discussed.

INTRODUCTION

It has been said that the most important step in processing oilseeds/materials is preparation. It is the most complicated, because the *best* preparation is somewhat different for each oil-bearing seed/material. It is hard to give a general presentation on oil-bearing seeds/materials, so I will try to confine my discussion generally in line with a few seeds/materials.

The cleaning of certain oil-bearing seeds/materials (e.g., cottonseed, soybeans, sunflower, and safflower) is relatively simple in concept: simply remove the foreign matter (such as dirt, sand, stones, tramp iron, sticks, and burrs) in the cleaning process by mechanical and/or pneumatic systems.

SEED CLEANING (Fig. 1)

A mechanical system can consist of reels and/or shakers, both with perforated metal and/or screens, which are simple in that the material flows over the tray/drum of these machines, with the small foreign matter removed by sifting through the metal; or, as the case may be, the large foreign matter retained on the metal as the seeds fall through. Magnets for removal of metal should be located in strategic spots and installed for easy access for cleaning.

A pneumatic system can consist of vacuum boxes, air separators, or aspirating nozzles, where the light material is pulled through and the heavies (generally the oil-bearing seed) are gravitated out.

All of these different pieces of equipment can be manufactured or installed in various ways.

When cleaning, it is easy to remove the large particles; but, when removing the fine foreign matter such as lint, dust, or sand, these tend to adhere to some material, and cleaning becomes more of a problem, such as with undelinted cottonseed, where sand becomes imbedded in the lint.

Also, certain foreign matter is the same size and density of the material being cleaned or separated. It cannot be separated by perforated metal, as it is the same size, and it cannot be separated by air, as it is the same density.

DECORTICATING (Fig. 2)

Except for the hullers or cracking rolls, separation of hulls from meats is accomplished with the same basic type machinery as is used in seed cleaning: reels, shakers, pneumatic systems, vacuum boxes, air separators, and/or a combination of some or all. These machines can be built into one unit called a decorticator, or they can be several machines and be called decorticating machinery or dehulling and separating machinery (Fig. 3).

Separating hulls from seed is normally a simple process when storage and drying, as required for each type seed/material, has been properly handled. For instance, in the case of soybeans, they must be dried to the proper percent of moisture and stored the required number of days so the hull will separate from the meat after it has been cracked. With cottonseed, it must be properly stored with adequate seed cooling systems. When very dry cottonseed is processed, it can be humified just before cracking.

The first step in dehulling is to crack the hull (or husk) with machines called bar hullers, impact hullers, disc hullers, cracking rolls, and hammer mills. The idea is to use the most practical machine for the type or kind of seed being cracked which will cut the hull for best separation of meat and hull.

With certain seed, it is best to crack into quarters and

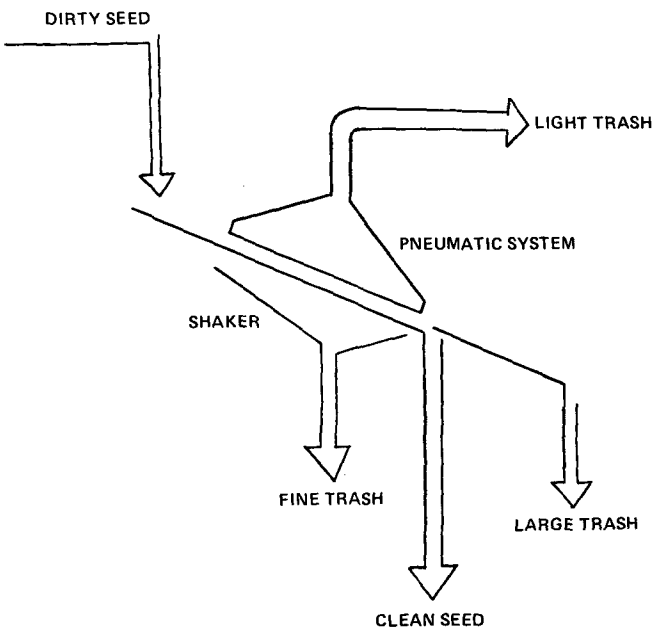


FIG. 1. Seed cleaning.

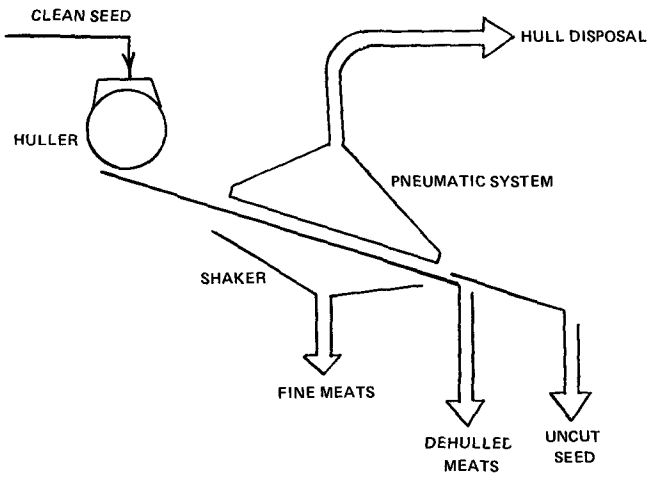


FIG. 2. Decorticating.

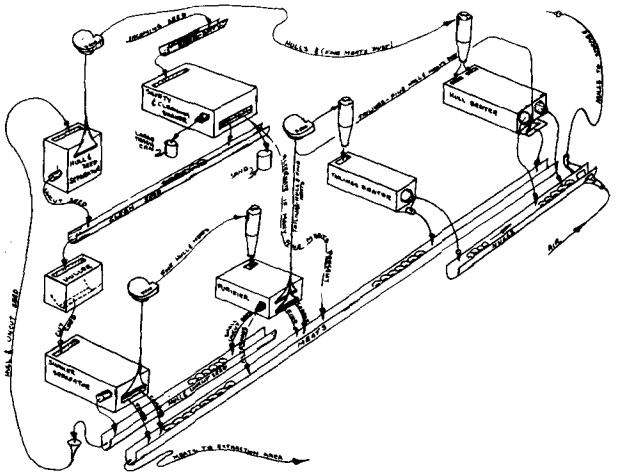


FIG. 3. Decorticating machinery flow chart.

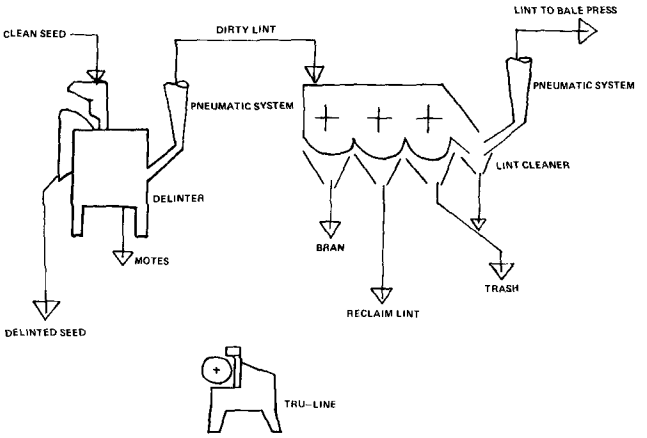


FIG. 4. Lint room.

eighths, such as with soybeans. With cottonseed, safflower, and sunflower, it is best to cut as coarse as possible, preferably in half (e.g., cottonseed cut in half crosswise, leaving two ends; sunflower/safflower cut in half lengthwise, leaving two sides). This will allow the meat to fall out, with a minimum of fines.

Fine grinding of seed, such as in a hammer mill, will make many fine hull and meat particles of the same size, which can make good separation of hull from meat impossible.

We should always be aware that certain seeds/materials, or certain characteristics of the seeds/materials (e.g., moisture), can cause the meat to adhere to the hull, or vice versa, making separation difficult.

With removal of hulls, a certain amount of meats (mainly fines) can be left with the hulls. These hulls are then reworked to remove the fine meats. These fine meats can have fine hulls in them, also necessitating reworking. This can also apply with coarse hulls and meats.

Somewhere down the line of separating the hulls and meats, a happy medium is met as to how many times a material is reworked for the best operation at an acceptable operational cost, with consideration given to the quality of the finished product to be manufactured. For instance, from cottonseed do you need to produce a 36, 41, or 44% protein meal? What decides the final outlay or type of machinery will be whatever is required to produce a finished product that can be sold at a fair market value.

Generally, any meal with the desired protein or fiber content can be produced relatively easily, but at what cost? In other words, how much oil can efficiently be left in the hulls?

Sunflower/safflower can be successfully decorticated to produce a good finished product. Sunflower can be produced with a residual oil in finished hulls from 1 to 4% and protein of 33-46% (ca. 12% fiber). A better product of 8% fiber can be obtained if desired by upgrading the meal after oil extraction. Safflower meal can be produced with a protein of 33-37%, with residual oil in hulls of 4-6%. It is best to produce a 33% protein meal with 4% residual oil in hulls; as, by upgrading the meal after solvent extraction, the total amount produced can result in 75% of the product as 41% protein meal, and 25% of 20% protein meal. The result when upgrading without decortication is 20% of the product as 41% protein and 80% of the product at 20% protein. This indicates that consideration should be given to decortication before extraction of oil.

Soybeans and cottonseed can easily be decorticated to produce a good finished meal product as needed for the industrial market, with residual oil in hulls in the allowable range.

DELINTING
(Fig. 4)

With cottonseed, for the best separation of hulls from meats, it is necessary to delint before decorticating to produce the best product of meal at a minimum of oil loss (oil left in the hull).

After delinting cottonseed, it is desirable to pass the seed over a shaker located between the linter machine and huller machine. The shaker's main function is to protect the huller from damage by removing the foreign matter; and removing lint and fines before the huller allows for better hulling and separation of materials, which produces a better finished product of meal with a minimum of oil loss in the hull fraction.

Best cottonseed decorticating is done with delinted seed of ca. 3% residual lint. Some lint aids in removal of hulls by air and helps in holding the hull together, as black seeds tend to break into small pieces which are hard to remove when trying to produce a high protein meal. Seeds with too much lint left on will tend to overload machinery, reducing tonnage, and thereby creating a high cost of operation.

Also, and most importantly, when too much lint is left on the seed, this lint will go with the hulls, resulting in a loss in money except on very low priced lint (below 1½ cents a pound). Or it will go into the meats (not intentionally), where it can especially be a problem in the solvent extraction plant by sealing the drainage area of the extractor as well as producing a meal with an excess amount of fiber.

Most, if not all, solvent extraction manufacturers will insist on a maximum amount of lint left on delinted seed or in the meats to the extractor (generally a maximum of 4% residual lint on delinted seed).

CONDITIONING AND FLAKING
(Fig. 5)

Manufacturers in the decorticating end of oil-bearing seed/material processing generally leave the conditioning and flaking to the manufacturers of extraction machinery. However, I will comment on this to create an awareness of the importance of proper conditioning and flaking.

Conditioning of meat/material will vary (the same as with cleaning or decorticating) according to the product and according to the method of extraction of oil (screw press, direct solvent, or pre-press solvent).

A conditioner is used in many mills—especially for best flaking of dry meats/materials—before crushing or flaking, so that moisture can be added and proper flaking can be accomplished. Conditioners can be of the vertical stacked kettle type or horizontal rotary type. These both are jacketed and heated with steam, with arrangement to inject live steam and/or water directly into the meats. On some products, an additive can be mixed with the water injected

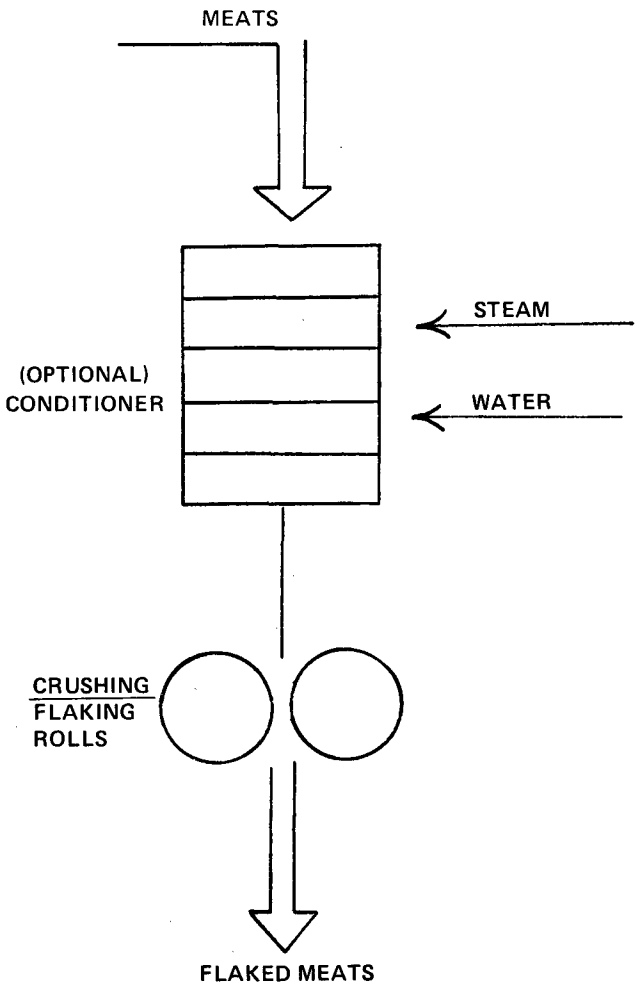


FIG. 5. Conditioning and flaking.

into the meats, which will aid in absorption of moisture by the meats.

In the case of very large capacity plants, horizontal rotary steam tube dryers are used for soybean conditioning. Various types of horizontal dryers or steam jacketed conveyors can be converted to conditioner use.

Flaking of seed/material is accomplished in flaking rolls, with a pair of smooth rolls running against each other on a horizontal plane. One roll is fixed, and the other is adjustable, to produce flakes of a desired thickness.

Crushing is accomplished in crushing rolls, generally five rolls high, stacked on top of one another. Flake thickness is acquired by weight and RPM of rolls.

The kind of seed to be processed and the processing itself (such as straight press, pre-press, or direct solvent extraction) will govern the best kind of rolls to be used. Many mills have substituted flaking rolls for crushing rolls, and these work satisfactorily, especially with hydraulic roll adjustment.

SELECTION AND OPERATION OF MACHINERY

Following are notes that might be of help in the selection and operation of delinting, decorticating, and flaking machinery to properly prepare oil-bearing seeds for the oil extraction process.

Considerations for Selection of Machinery

- Plant size requirements: 100-2,000 tons per day.
- Quality of seed to be processed: E.g., cottonseed, handpicked or machine picked, seed in bag or bulk loads, high moisture seed, or dry seed; available protein in seed.
- Kind of seed to be processed: If only one product, then a plant to process only that material will give best operational result. If it is necessary to process several seed/materials such as cottonseed, soybean, and sunflower, consideration should be given to a plant that will give the best results in finished products, considering all seed to be processed. E.g., a cottonseed decorticating plant can decorticate sunflower, soybean, and peanuts, though it does best on cottonseed. A 2,000 ton soybean plant can process only soybeans.
- Finished products to be produced: E.g., what protein meal is to be produced; can cottonseed lint be exported, such as second cut chemical lint, or will it only be used locally, such as first or mill run cut for batting.
- Proper flaking/crushing rolls for material to be crushed; proper size motor to assure adequate horsepower.
- What delinting equipment for cottonseed: Two-cut, mill run, saw delinter, abrasive delinter. Please note the absence of acid delinted, as it is used exclusively in case of planting seed and has not been used in the delinting of cottonseed for oil processing plants.
- Upgrade on tail end (safflower/sunflower), or leave higher residual oil in hull than is most desirable. Tonnage and selling market will decide.
- Black seed tanks (delinted cottonseed) are a good investment. They allow for shutdown time when repairs can be made. These tanks can be enough for 1-2 day operations to as small as 30 minutes to assure an even flow through the hulling/cracking equipment–separation equipment.
- Meats bin of small capacities are advisable. Size should be governed by capacity of plant so as to assure even flow of material through machines, such as flaking rolls and cookers, so they will not run empty. Free fatty acid begins to build up in cottonseed meats immediately after dehulling; therefore, it is not advisable to have too much meat storage.

General Information for All Equipment

Distribute load to all equipment so all machinery is fully loaded–slight overflow.

Overflow hoppers and/or bins are not always absolutely essential but are good for even and continuous flow through equipment to assure maximum tonnage.

Keep the plant operating. Arrange for bypasses where possible so operation can continue where certain machinery fails. As an example, in the case of lint cleaner in the lint room area, lint can be dropped on floor or thrown outside the plant and later reclaimed. It is much less costly to throw a day's supply of lint away than to shut down a plant for a day, especially in a solvent extraction processing plant.

Regularly check and adjust air flows on all pneumatic equipment to obtain maximum/proper separation of hulls and meats.

On beater and shaker, use minimum size of perforated metal/screen to obtain proper separation of material being cleaned or separated.

Perforated metal and screen on beaters and shakers should be cleaned as often as needed to assure that holes of screen/metal are not plugged or sealed over, preventing sifting of material.

Check perforated metal and screen on beaters and shakers for bent or torn places which allow excess foreign matter to go with the seed, or excess seed to fall with foreign matter.

Machines with pneumatic nozzles should be checked frequently to assure proper adjustment for removing desired amount of product–such as hull from meats or moting out trash from lint.

Control protein on proper machine for best results when

processing materials. Control protein generally on lower tray of huller separator shaker with pneumatic nozzle and specifically on the purifier with the pneumatic nozzle. Do not try to control protein of materials with the hull beaters.

Analyses should be run at scheduled times on prepared and finished materials; e.g., moisture and thickness of flaked meat:

- Sample of delinted seed for residual lint taken at safety shaker.
- Check oil in hull sample taken at hull pile. Be careful, as hull will be on top with meat going to bottom. This will be a sample of all hulls, not just hull beater as in the case of materials where a tailing beater is used.
- Check meal sample for fiber and protein taken at finished meal after meal dryer.
- Note: All samples should be taken at a regularly scheduled time by trained personnel so as to have a truly composite sample for the basic time as needed for best operation. Moisture of flake samples may want to be done each hour. Analyses for protein or fiber in meats may be needed only each 24 hours, as would residual lint on cottonseed.
- Check moisture of incoming seed.

Assure for the seed being processed that correct RPM, metal, air, etc., are being used on equipment when various kinds of seed are processed on same machines.

Price finished products, such as with lint and hull of cottonseed, to decide the most practical residual lint (2-3-4%) to be left on delinted seed. What protein meal is most marketable?

Operational Information—Specific

Delinting

To assure maximum tonnage and lint cut and best quality of lint (linters), make proper adjustments on each linter so tonnage and lint cut are the same on all machines.

Properly sharpen saws at regular intervals to assure maximum tonnage and lint cut.

Keep all saw cylinders the same diameter so any saw cylinder can fit into any linter. Keep all linter adjustments to the diameter of the saws. This assures maximum tonnage and lint cut and easy, fast saw changing.

Maintain uniform speeds (RPM) on all linters for best uniform quality of lint and maximum tonnage with desired residual lint left on delinted seed.

Keep brushes in good trim and properly adjusted to saws.

Naturally, good lint cleaning is advisable to assure maximum price and sales of good quality lint (linters).

Bar Huller/Cracking Rolls

Check and change huller knives on a regular basis, as sharp knives are most important, especially on higher moisture seed. Some of the knives can be removed on certain seeds or moistures. Be sure to replace knives with dummies to prevent excess wear on machine.

Speed (RPM) of huller should be set for moisture of seed being cracked. Huller is normally operated at 400-1,000 RPM; the drier the seed, the slower the machine should operate so as not to produce too many fines.

Set huller to cut 85% of seed on first pass, rerunning uncut seed.

Huller/cracking roll should be properly adjusted and trammed (cutting edge lined up parallel so as to cut evenly across width of the machine).

Rolls–Crushing/Flaking

Check adjustment to give finished flake thickness as required for best extraction.

Check moisture of flakes often as required for proper operation.

Meats bin is essential as a meats overflow to assure adequate flow of meat/material at all times to roll.

Do not operate rolls empty; this will result in damage.

Properly adjust scraper to ensure clean rolls, so as not to overload motors or damage rolls.