Oilseed Handling and Preparation Prior to Solvent Extraction

N. HUNT MOORE, N. Hunt Moore & Associates, Inc., 3951 Senator St., Memphis, TN 38118

ABSTRACT

This paper describes cleaning of soybeans, present methods of drying soybeans to facilitate easy hull removal for the production of high protein meal, latest methods of air recirculation for energy efficiency in process drying, latest methods of handling soybeans to facilitate dust control in storage and conveying, conventional methods of dehulling with an emphasis on potential energy savings, cracking of soybeans with high capacity mills with special corrugations to give ideal particle size distribution for efficient dehulling, flaking of soybeans with high capacity mills; and latest innovations in the drying, dehulling, and conditioning of soybeans by use of the fluidbed drier and the microwave vacuum process.

Solvent extraction of soybeans started over 50 years ago with relatively small capacity plants. The soybeans were prepared prior to solvent extraction by cleaning, cracking, conditioning and flaking. The process was expanded from the early small plants to plants with a capacity of more than 3,000 tons per day. The major change in preparation came with the introduction of dehulling in the late 1950s, due to the demand for high protein soybean meal in the poultry industry. Dehulling systems were installed in the larger soybean processing plants and were of a number of different designs. At present, almost all plants have head-in dehulling that employs screeners and aspirators.

Cleaning of soybeans prior to drying and preparation is very important from the process viewpoint for the protection of the equipment and the production of high protein, lower fiber meal (Fig. 1). The conventional cleaning consists of a series of screens that remove particles larger or smaller than the soybeans. Usually the soybean stream is aspirated by a nozzle located above the beans being discharged from the screener. As the demand became greater for soybeans with less dust and loose trash, the idea was introduced to run the middle stream of the cleaners through a multiaspirator. This is being used in both the receiving scalper cleaners preceding the drier and in the process cleaner in the preparation room.

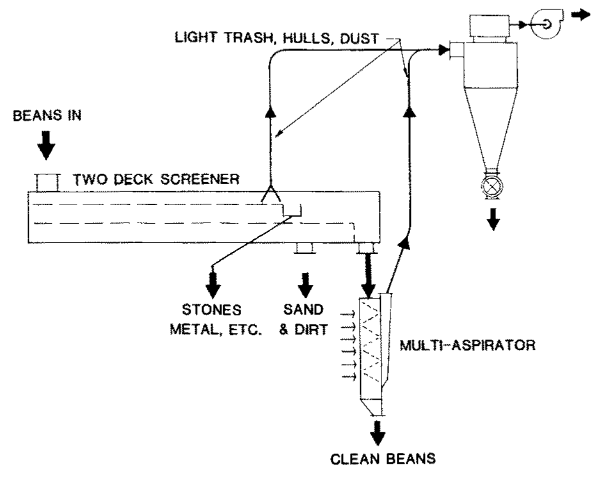

FIG. 1. Conventional cleaner with a multiaspirator.

The soybeans received into the grain elevators and the processing plant storage are dried if the moisture is greater than 14%. This is necessary in order for the beans to be stored for a period of time without damage to the grade and quality of the beans and soybean products. These driers are usually very large as they are required to handle the soybeans in large quantities during the harvest season. With the production of high protein, low fiber meal, it was also found necessary to dry the soybeans further after storage to a 10% level in order for the hulls to be removed easily by conventional dehulling systems. This drying was done in the conventional type drier, and in most cases the same drier was used that is used as the receiving drier.

The conventional drier brings in outside air, heats it to a drying temperature, and forces it through the bed of soybeans. This heats the soybeans to a point where they will release part of their moisture. The soybeans are then subjected to a stream of ambient air that removes the hot, moist air from around the soybeans and cools them to a point where they can be efficiently stored in conventional storage. All of the air is exhausted to atmosphere, and the energy it contains is wasted. With the high costs of energy—gas and oil—work has been done to improve the efficiency of the grain drier (Fig. 2). This procedure involved taking the air from the cooling section with part of the air from the drying section and circulating it through an efficient filter that would allow this air to be reintroduced through the burner and then return it to the drying section. This reduced the fuel consumption by ca. 25% and was beneficial in improving efficiency, particularly in areas with very cold air.

The conventional preparation system (Fig. 3) consists of a receiving drier, soybean storage, a processing drier, tempering bins, a cleaner, scales for metering the beans through the plant, cracking mills where the beans are broken into particles ca. one-fourth to one-sixth the size of the bean, and the dehulling system where the cracked beans are graded by size and aspirated in multiaspirators to remove the hulls. The secondary dehulling system is used to separate the hulls that were aspirated off in the primary system from the meats that are picked up with these hulls during the aspiration. The dehulled meats then go to a conditioner that could either be a rotary system tube drier or a stacked steam-heated conditioner where the beans are heated to ca. 155 F (68 C). Beans from the conditioner proceed to the flaking mills to be rolled into flakes of 0.010-0.015 in. (0.25-0.37 mm), depending on the type of extractor. These flakes are then conveyed to the solvent plant.

Soybeans have been prepared in this conventional manner for 30-40 years. In the last two years, new processes have come to the attention of the processing industry. One procedure is the use of fluidbed driers for the drying, dehulling, and conditioning of soybeans. This system is known as the Escher Wyss hot dehulling system (Fig. 4). In this system, the air is interchanged between the different units to give the minimum usage of energy. The energy required for this process can be either direct-fired heat exchangers for the heating of the air, steam coils for heating the air before introducing it into the fluidbed drier, or the

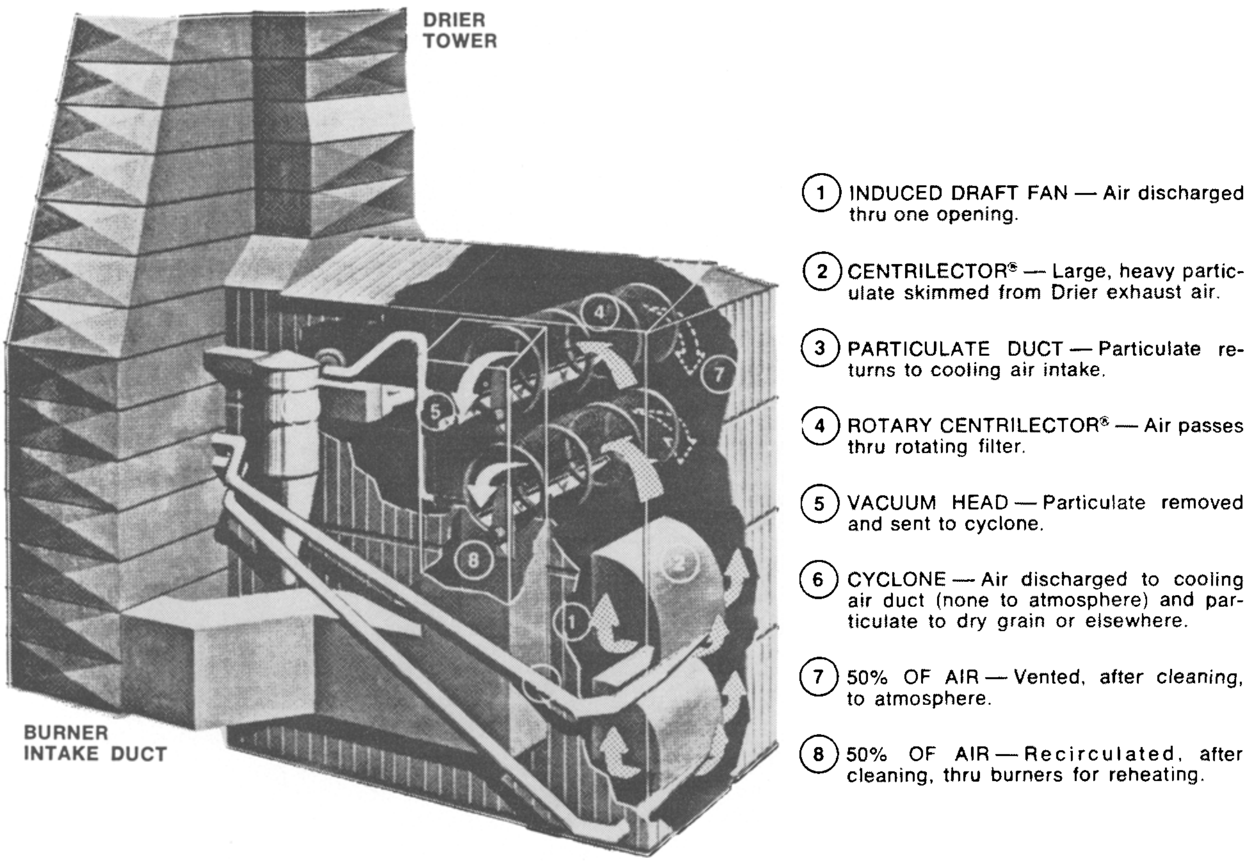

FIG. 2. Bean drier with recirculating air.

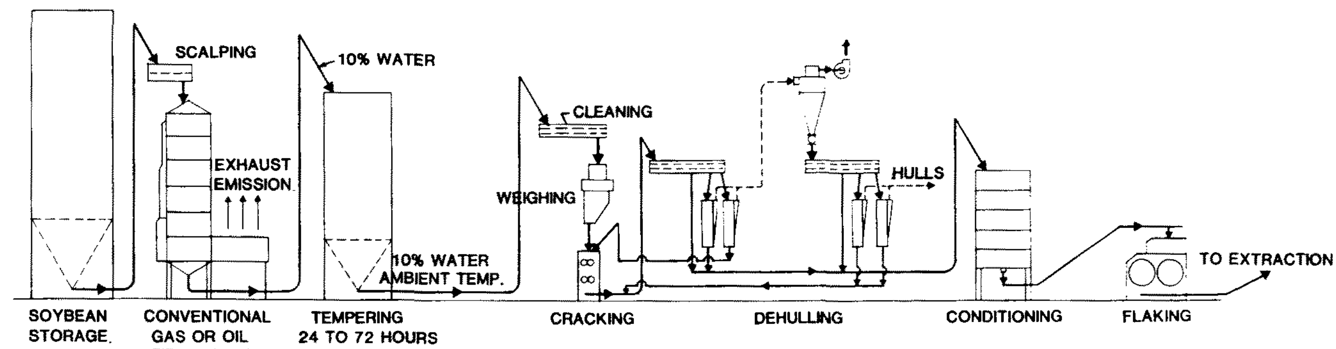

FIG. 3. Conventional preparation system.

use of steam tubes installed directly into the fluidbed drier. In this process the beans are taken from storage, cleaned, and introduced directly into the fluidbed drier. This system can handle beans with up to 15% moisture. The beans are then heated in the fluidbed drier where moisture is reduced by 1-3%. The beans then go to a one-pair high cracking mill to be broken into halves which fall into an impactor to assure the loosening of the hulls from the half-beans. These cracked beans are then introduced into multiaspirators where the air being circulated in the conditioner removes the hulls from the half-beans. Next, the half-beans are given sufficient time in the fluidbed conditioner to allow heat to penetrate the beans to facilitate flaking. The beans then leave the fluidbed conditioner and continue through a one-pair high cracker to give the correct particle size distribution for the flaking mills. The cracked beans then go directly to the flakers, and the flakes at a temperature of up to 150 F (65 C) proceed directly to the extraction plant. In this process, the beans are heated in the drier and retain heat all the way to the extractor.

The other system that has been introduced into the industry and is now ready for pilot plant study uses microwave and vacuum in the drying and preparation of soybeans. This process is known as MIVAC drying (microwave-vacuum) and was developed by McDonnell Douglas Corporation in cooperation with the Aeroglide Corporation (Fig. 5). In this process, the soybeans are introduced, after cleaning, into the drier where they come into contact with microwave under vacuum. The beans come from the drier where the moisture has been reduced by at least 1%. The beans are then cracked, dehulled with conventional methods, and go directly to flaking. The waste heat that is generated in the magnitrons that produce the microwave is utilized in heating the air used in the dehulling process. This keeps the temperature of the beans to a point where they can be flaked and sent to the solvent plant. This system uses electrical energy for drying and conditioning.

In the early plants, the soybeans were cracked with corrugated roller mills of ca. 10 in. (25 cm) diameter x 42 in. (107 cm) long with fluted roll feeders. These mills were usually two-pair high or three-pair high, depending on the type of extractor and the size of flake required for the process. The capacity of each mill was in the 200-250 ton/day range. The present trend in the soybean industry is for high capacity cracking mills with capacities in the 500-600 ton/day range. These mills are usually equipped with vibrating feeders to give uniform distribution and also to allow electrical interlocking with the system. The high capacity has been gained by using a longer roll and higher peripheral speed. This higher peripheral speed in some cases has been obtained by using larger diameter rolls, and in other cases by using the 10 in. (25 cm) roll running at a much higher speed. Experience has shown that by using the 10 in. (25 cm) roll and running at a higher speed, a new type of corrugation was required in order to produce the proper particle size distribution in the cracked beans.

Figure 6 depicts a corrugation form that is now being used successfully in a large number of oil mills and produces an ideal particle size for dehulling. Due to the high speed, it is necessary to go to this special, coarser corrugation to prevent the production of too many fine particles.

Flaking mills have gone through quite a change in the last few years. With the demand for larger plants, there has been a demand for greater capacity flaking mills. With the high cost of building and land, maximum flaking capacity is desirable in a given size building. To acquire this additional capacity, the rolls in the flaking mills have been made larger in diameter, longer in length, and the peripheral speed has been increased. With this increased capacity, industry has experienced an increase in maintenance costs, shorter life of chills, etc., caused by more wear on the rolls and vibration set up in the frames. To reduce the overall maintenance, flaking mills are being built with greater weight to minimize the vibration.

An important innovation is flaking mills has been the use of the overflow system (Fig. 7) that eliminates the use of the cheek plates or end dams. By this system, the excess material flows over the end of the rolls, is collected, and

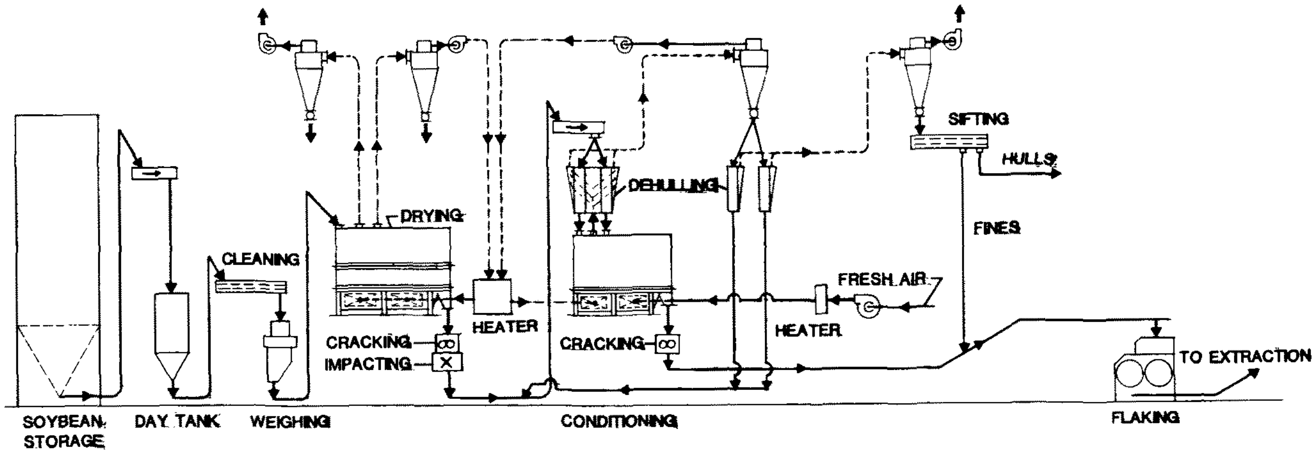

FIG. 4. Escher Wyss 'hot' dehulling system.

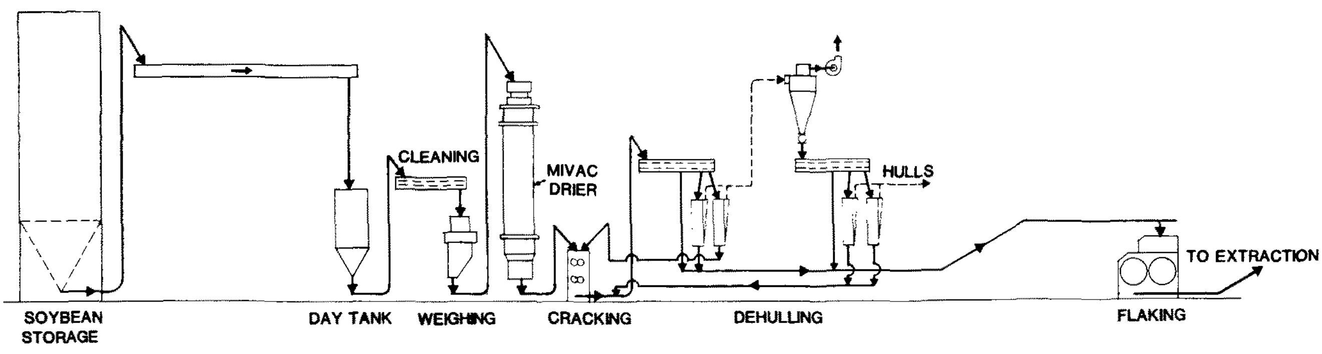

FIG. 5. MIVAC preparation.

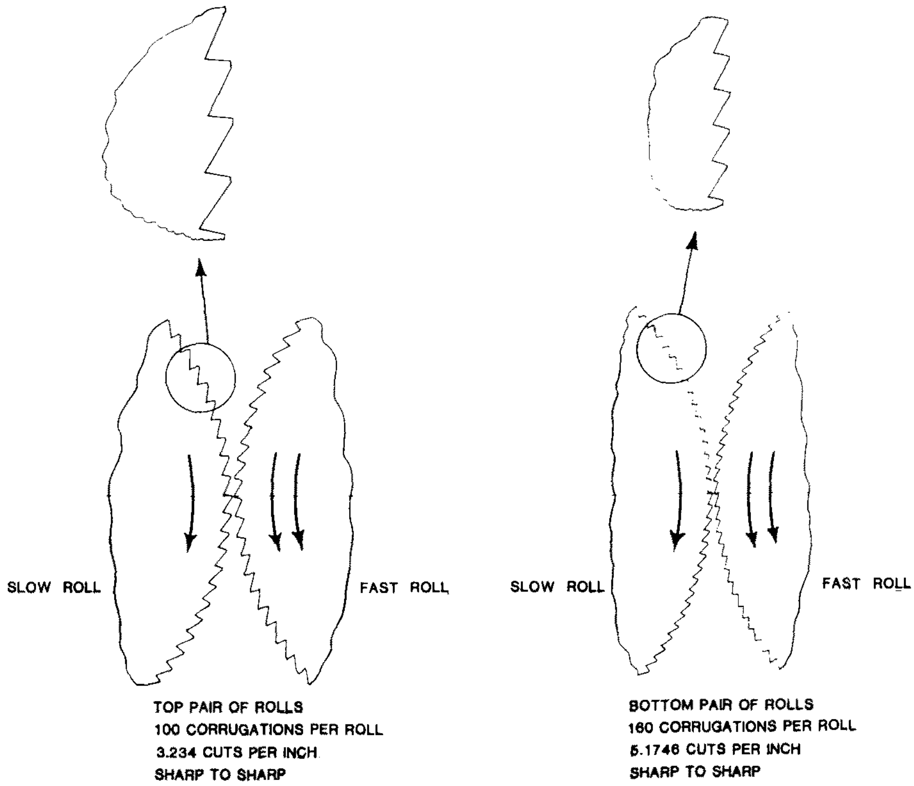

FIG. 6. Corrugations design for high-speed soybean cracking mills.

returned to the system. This means that the flaking mill is producing flakes to the very end, and uniform wear is achieved on the entire face of the rolls. Due to this uniform wear, it is unnecessary to relieve the ends of the rolls as often; therefore, there is less likelihood of breaking off the ends of the rolls due to the build-up of excessive pressure on high ends.

In recent years, an expander has been introduced into the oilseed industry that takes the flaked beans from the flaking mills and produces a full fat cake or pellet that is sent to the extractor. This material has unique properties that give the extractor 20-30% increased capacity with the same residual oil. This also increases the capacity of the desolventizer-toaster. Due to improved draining characteristics of this cake, less solvent is carried to the desolventizer-toaster. This has allowed processors to increase the capacity of existing plants by installing expanders and cake coolers.

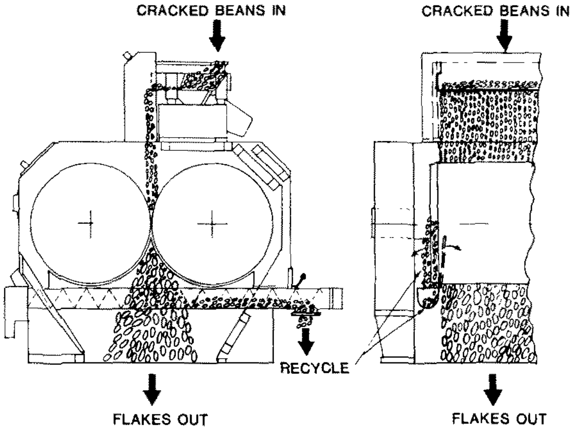

FIG. 7. Overflow system.

The electrical consumption of these expanders is quite high. Maintenance is another factor that has to be weighed against the advantages of this equipment. Since dehulling has become an integral part of most preparation rooms, the hull toaster has gone through some changes in the last few years.

The conventional hull toaster, which consisted of a series of steam heated trays, is being replaced with a vertical hull toaster and cooler. In this unit, direct steam is blown upward through a deep agitated bed of hulls. This direct steam heats the hulls and increases their moisture to give the proper toasting. The hulls are then dropped into the lower section of the unit where ambient air is blown through the bed, and excess moisture and heat are removed. With the hulls cooled, they can be ground and sent to storage. This system has saved space and produces well toasted and cooled hulls.

The last five years have seen a larger number of changes in the preparation of soybeans than in any period since the beginning of solvent extraction.

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