Expander Technology in the Modern Soybean Prep Room

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Introduction

The standard expander that is in operation in the oilseed industry is a tubular barrel with stationary breaker bolts inter-meshed into segmented screw flights. At the discharge, replaceable dies are fitted to produce the required internal pressure. Provisions are made for injecting steam into the barrel through some of the breaker bolts.

In operation, prepared material is fed into the machine either by separate adjustable feeder or choke fed by direct connection to a conveyor.

Conveying the material down the barrel, with the breaker bolts as obstructions, causes a mixing/shearing action that ruptures some of the oil cells in the material.

The directly sparged steam mixes with the product and acts as lubrication to the mass of material, and at the same time elevates its temperature and moisture. Friction of the helicoids and barrel against the meat also helps to increase the temperature. As the product nears the discharge, its bulk density changes and the high pressure forces moisture deep into the matrix of cells. Discharging into atmosphere causes the material to expand instantaneously as the moisture flashes off, leaving a porous, textured meat that is ideally suited for solvent extraction.

The expanded material is sent straight to the extractor after sufficient cooling, or drying and cooling operation. This depends on the seed and the processing conditions, which may also require some conditioning prior to expansion.

The main benefits of expansion are:

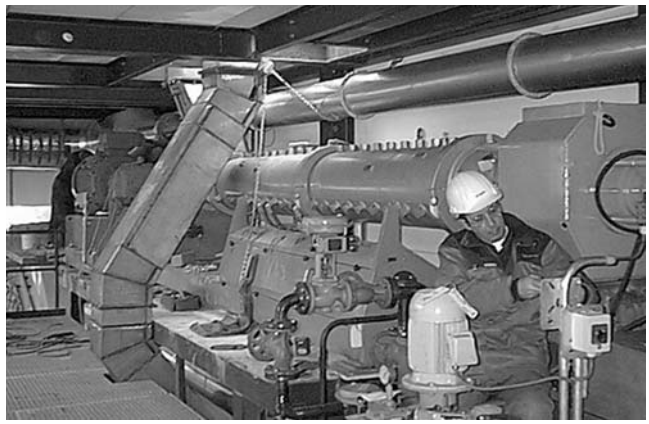
- 50% increase in bulk density, therefore more capacity
- better percolation due to the porosity of the material
- increase of miscella concentration
- less solvent carry-over to the D.T., so less steam used
- less hexane to recover, so less solvent loss
- lower residual oil

The most common and well-known application of expanders is to improve preparation of soybeans for better extraction and to increase the capacity of existing soybean oil plants. The expander, however has also been used successfully over the years to prepare other oilseeds such as cottonseed, rice bran, wet and dry-milled corn germ, rapeseed, and sunflower. Each seed requires a somewhat different approach in equipment selection and arrangement.

Soybean Processing

In this process, the expander is installed right after the flaking mills and before the flakes leave the preparation area.

After the expanders, the material is cooled to about 60°C and dried to a final moisture of about 10%. The expansion process forms a sponge-like structure of the material that promotes good drainage even in deep bed extractors and at the same time because rupture of the oil cells is so complete, solvent leaching of the oil can take place very effectively. Because of the good drainage characteristics, horizontal channeling, a common problem in some extractors, is much less likely to occur. The open cell structure of the expandite prevents the normal extent of solvent holdup in the marc, which in turn translates to lower solvent carry-over to the D.T. with its attendant lower steam requirement.



A Tecnal model EXP-350MLE expander with 300 Kw motor sized to process flakes from 1500 mtpd soybeans.

Soybean processors in North America have use expanders for about 50% of the daily crush rate mixing the expandite with flakes. The severe control of moisture in the incoming beans for high protein meal production can be controlled in the expansion cooling device or cooling equipment. In South America and other countries it is common to run 100% of flakes through expanders. Due to local conditions, mainly the higher moisture of incoming grains, a drier-cooler equipment is required in some cases.

The most important single advantage of expander utilization in soy processing is the significant change in the bulk density of the product. This is normally a change of about 50%, which allows many more tons per day to run through a given extractor volume.

The combination of the benefits from the expander process may allow the enlargement of existing plants up to 30% of the regular processing capacity with no changes in the extraction section. Special cases may require some minor changes.

The same factors also may allow enlargements to 50% or more, and many times up to 100%, if some modifications in the extraction section are done. This depends, of course, on the size of the existing equipment and how much they actually are running above the regular capacity. Only a techni-

cal inspection at the site of the plant and proper analysis can say exactly how much production can be increased. The field has plenty of examples of enlargements much bigger than 50% of the daily crush after correct procedures.

Processors have also discovered all oil produced using expanders in the preparation room has diminished non-dehydratable phosphotides, a factor of considerable value in refining.

Cottonseed Process

Processing cottonseed is another application of the expanders in the preparation of oilseeds. Cleaning, delinting, dehulling, flaking, and conditioning operations are done prior to expander. In many plants expanders replaced the expeller presses with a lot of advantages. The electric power, the frequent replacement or spares and the constant maintenance were drastically reduced. A simple machine, the expander runs 500 million tons per day of cotton meats with only 125 hp. Their helicoids last for one entire season and allow repairs by welding and hand grinding for more working seasons.

Cooling is required by simple units. It is important to say that when direct oil extraction from cottonseed with expanders being used, the free gossypol is extracted together with the oil. Thus, the process of refining at the miscella stage is necessary, which has been done over the years.

Rice Bran Processing: Acidity Stabilization and Preparation for Oil Extraction

The expander process has taken over with considerable advantages over the traditional preparation of rice bran to oil extraction. It has been in use in Thailand since 1979. Some plants in Brazil and Uruguay are also using this process with great success. As the problems of rapid conversion of the oil inside the rice bran to FFA are about the same as dry-milled corn germ, we use about the same process for both oilseeds.

In reality, the expander process accomplishes two jobs:

- prepares the raw material for a straight, efficient extraction
- stabilizes the acidity at the level as processed for a 90-day storage period by inactivation of enzymes

In a rice oil extraction, the material is conditioned by a horizontal conditioner, passes through the expander, is dried to 8%, cooled to 60°C, and is conveyed to the extractor. The expanded material transforms the normally thin powder into a porous, homogeneous, firm, and hard material. Some few fines are formed inside the drier-cooler, but they are easily collected by miscella hydrocyclones. Fine percolation, higher miscella concentration, and other standard features of the soybean expanded meat are also present in the expanded rice bran. Residual oil also can be as low as 0.5%.

The temperature and moisture inside the expander also deactivates the enzyme action, which stabilizes the acidity to the same level as those just before entering the machine. This stabilization allows a storage period as long as 90 days, and the process uses the same conditioner and expander from preparation. Some fines are formed during the conveying stabilization/storehouse/extraction, and they should be removed before the extractor by an air aspiration machine. A miscella hydroclone removes some eventual fines from extraction area.

As with any other expanded materials, some fines are formed inside the drier-cooler due to their friction among themselves. The high temperature inside the equipment and the easy combustion of the fines eventually accumulated require special and accurate construction features of the drier-coolers to avoid the accumulation of fines and consequent risks of fire.

High Oilseeds in the Expander

In recent years expanders have been used to process high-fat oilseeds with the use of a drainage cage mounted just before the discharge end. Feeder-conditioner equipment is also required for this purpose. The hydraulic auto-cone is essential in this process, as it allows control of how much pressure required for a better drainage. The meat, then with a lower oil content, can be more successfully expanded. Sunflower seed has been processed by expanders with the drainage cage that reduces the oil content from 42–44% to 28% before expanding. This "excess of oil" is drained by cage, and decanted to remove some solids formed during the draining process (around 5%) and is sent to the same filtering system used by expellers. This way, a meat with only 28% of oil is really expanded—and the results are approved by customers. The expanded material is porous and homogeneous, improving percolation and drainage within the extractor, and provides a good quality extracted oil. The typical benefits of the expanded meat may be achieved.

The oil drainage cage presents the same quality as the oil from prepresses. As happened to cottonseed, the expanders are replacing expeller machines with the same advantages of reducing power and maintenance.

Sunflower processing requires dehulling, flaking, conditioning, expansion with drainage cage, drying, and cooling. This flow becomes more attractive in plants were soybeans are already running, as it takes the advantage of existing equipment.

Processing sunflower expanders are economically feasible for running dehulled seeds only. The percentage of hulls in the meats to expand should be around 15%. In some countries, however, as the dehulling operation is not allowed by environment laws, it is not possible to use expanders.

Expander Basics

The most consequential element of good expander operation, assuming proper preparation of the oilseed, is the internal pressure developed in the expander barrel. Considerable changes in quality will be manifested in the expanded product as a result of irregular internal pressure.

This internal pressure formed in the barrel is directly affected by a number of variables, but the feed rate of the product and open area of the discharge device are two of the most important.

In most expanders it is common to observe some of the dies that have stopped discharging product indicating a change of internal pressure. This condition can be improved by linking the main shaft motor amps to a feeding device to sustain a constant motor load thereby maintaining some approximation of constant internal pressure.

Probably the worst condition observed in normal operation of die-plate expanders occurs when, as a result of the combination of die and internal part wear, the machine produces only an extrusion of material that is not porous and therefore not as permeable by the solvent process.

Cone Discharge Expander

The annular ring with matching cone is a familiar concept that has been used on screw presses since the very early days of oilseed extraction operations. When coupled with a correctly designed hydraulic system, the cone-ring combination becomes a variable sized orifice that maintains a constant internal pressure at the discharge eliminating many of the problems associated with variables in the feed.

The material is discharged around the full circumference of the ring in the form of cake that breaks into small pieces to fall into the discharge conveyor. The thickness of the expandite is dependent on the rate of feed to the expander and the characteristics of the material being processed. With soybeans, the material ranges from 16 mm to 40 mm thick, depending on conditions.

The internal pressure may be changed easily by dialing in a new gauge pressure setting at the hydraulic control. There is a fixed ratio between the gauge pressure and the internal pressure at the discharge.

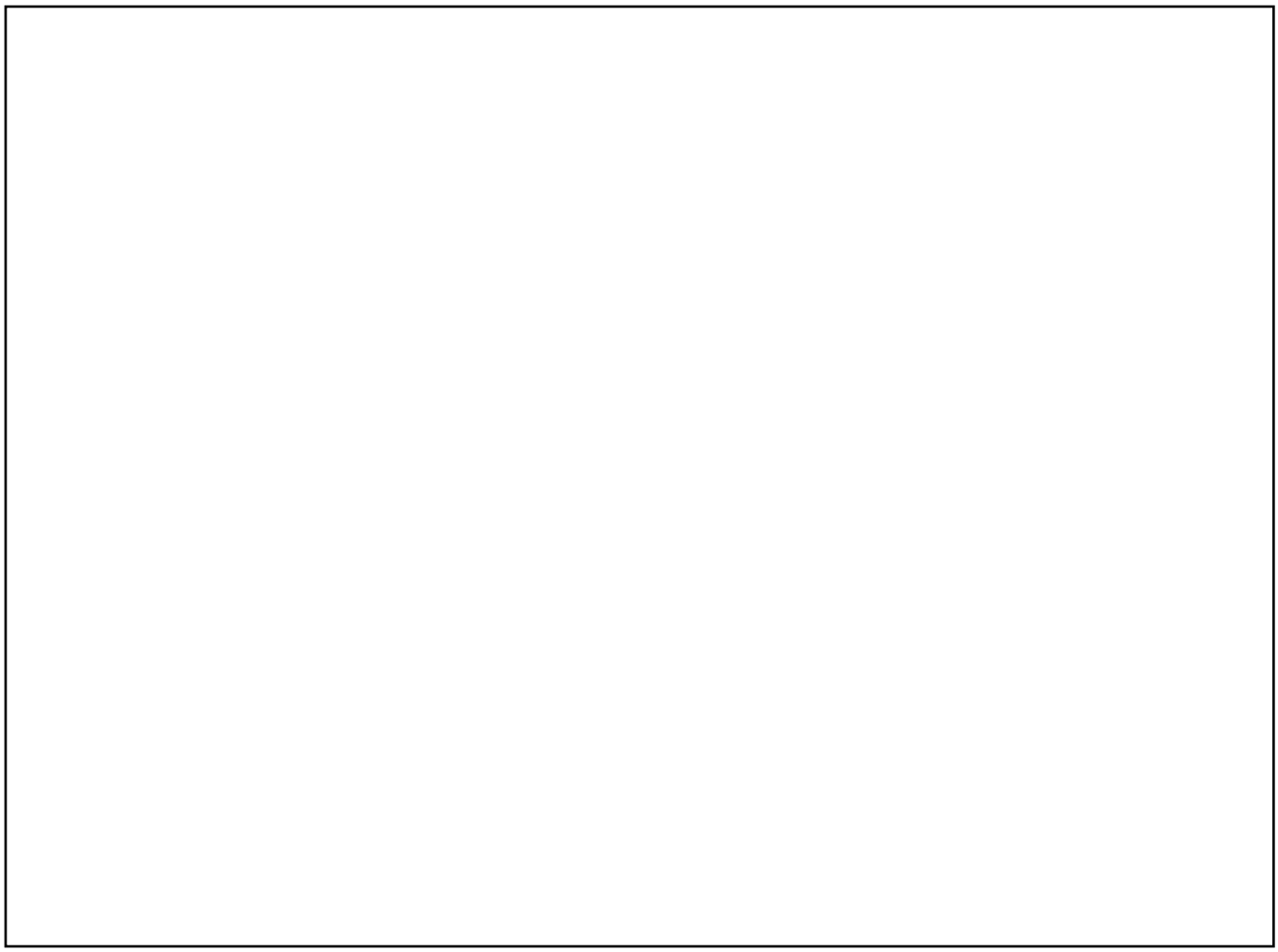
Additional Effects of the Cone Discharge

The cone discharge equipped expander has the ability to facilitate a significant turndown of capacity without negatively effecting the process. This attribute is particularly interesting in plants where expandite is being blended with normal flaked meats at a finite ratio and there is a requirement for reducing the plant capacity.

The cone discharge expander represents a strategic improvement over conventional machines in the area of remote, automatic startup, and shutdown procedure. Removing die plates for die cleaning and cleanout of the barrel is a well known chore that must be done every time the machine is shut down. If the material in the barrel is not removed quickly, it may become necessary to turn out some of the breaker bolts to facilitate complete discharge of material from the barrel which greatly increases the time and effort to restart the equipment.

The hydraulic system may be controlled so that prior to shutdown, the cone is withdrawn at the same time feed to the unit is discontinued. With the wide open end, the machine is then almost 100% self cleaning. After restarting the machine, the feed material may be run through the barrel with the cone withdrawn for any desired length of time until conditions are good for continuing the expanding process. The cone may be engaged and pressure increased slowly so that difficult-to-expand material may be handled without fear of plugging the barrel and stopping production completely. Full-sized test installations profit greatly from the ease of changing the amount of expansion on a particular product.

At least on one occasion it was observed that when switching from a die plate to the cone discharge the meal grinder horsepower was reduced noticeably. While no figures are available,



this represents another reasonable dividend when using the cone discharge.

Other New Expander Features

The first expanders used in commercial oilseed processing in North America were about 200 mm internal diameter. Later, 250 mm units were installed and more recently, the 300 mm expander has been introduced in US. soya operations as well as European softseed processing.

There is an economy of scale in these sizes with the 300 mm machine being about 30% more efficient at 1000 tons/day rate than two 250 mm units at the same capacity.

The physical size of the outside of the 250 mm and 300 mm barrel allows the practical incorporation of steam jackets. This feature will reduce the sparge steam requirement of the expander and under some conditions, allow operation of the system without the need of a separate material drier.

Direct extraction of high fat oilseeds has become efficient by inserting expanders in the process. New plants may design the solvent distillation system for the higher volume of oil while retrofit plants can take advantage of the drainage cage equipped unit which removes some oil before expanding. The cone discharge has added increased value to this latter process by allowing the two separate internal pressure requirements to be varied externally.

Today, it is possible to obtain expanders with full length replaceable liners and flanged barrels to facilitate liner replacement. Screw flights are segmented and are being produced in a variety of materials such as nodular iron, ductile iron and cast steel to meet the specific demands of the industry. The number and quality of third party parts supply companies has grown steadily.

Conclusion

The expander principle offers considerable benefits to most solvent extraction operations. It may be the best way to produce consistent results when processing oilseed material with widely variable parameters.

New developments in expander processing along with novel ways of applying existing technology will continue to be of interest to processors who must maintain their status quo.

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2005 Update

Since this paper was presented in 1996, processors, particularly in the soybean plants, have employed several new developments. First has been the development of the drilled cone discharge, which emulates a fixed die plate type discharge for stronger, more durable collets. The other major development has been the natural evolution of size of the machines. Plants are operating today with a range of expander capacity between 100 tons per day up to 2500 tons per day per machine. These larger expanders produce the same quality material but with a good increase in efficiency of horsepower required. ■