great promise, particularly from the standpoint of water conservation. The popular concept of this process seems to be the production of potable water from sea water. That is hoping for too much for the present—at least, at anything that would be a reasonable cost. However there are certainly numerous practical and economically feasible applicaitons for this means of water improvement when it is developed.

In this brief discussion an effort has been made to present some of the practices and recent developments in the field of industrial water conditioning. It can readily be seen that there are numerous and varied means of attacking the problems as they arise, and in most cases they can be successfully overcome. Let it be understood however that all the difficulties have not been eliminated, and further research and development must continue. However it is fully realized that the modern high pressure, extreme rating boilers, and complex cooling systems could not be operated without scientific practices in water conditioning.

Materials-Handling at Oil Mills

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MATERIALS handling in one form or another has presented its problems to man since the beginning of time. To Archimedes, about the year 300 B.C., goes the credit for conceiving the principle of the Archimedes screw, developed originally to lift water for irrigation purposes in ancient Greece.

C. S. Vercoe

To Joseph, about the year 1900 B.C., goes the credit for outstanding performance on a huge grain-handling job. Pharoah had him store a supply of corn in the granaries of ancient Egypt during the seven years of plenty so that millions of people would have food during the seven years of drouth which was to follow.

But to Hercules goes the credit for the biggest materials-handling job performed single-handedly. In Greek mythology we read that King Augeas sheltered 3,000 oxen in a stable, which had not been cleaned for 30 years. The local sanitary commission finally put the heat on the king to clean up his stables and to do it in a hurry. King Augeas commissioned Hercules, the local materials-handling engineer, to do the job in a single day. Hercules had the know how and the brawn. He changed the courses of the rivers Alpheus and Peneus, ran them through the stables, and cleaned out the 30 years' accumulation within a single night.

So to Hercules goes the credit for solving one of the world's first big materials-handling jobs. And to King Augeas goes the doubtful honor of being a filthy housekeeper and the first man on record to put off the installation of materials-handling equipment for 30 long years. It is to be regretted that in our time many men are following the lead of King Augeas and putting off from day to day the installation of modern materials-handling systems which would speed production, reduce costs, save manpower, or clean up a filthy plant area.

In our modern oil extraction plants we cannot rely on the brawn of a modern Hercules to meet the capacities of exacting requirements which govern all of our operations of today. We therefore must secure the services of a good materials-handling engineer and a reliable manufacturer of equipment in order that the proper equipment be specified for the job. In so doing, needless delays in the production line and excessive maintenance costs will be eliminated.

Let's consider basic information required for nearly every job, keeping in mind that the more detailed and correct the data submitted, the better the installation should prove to be.

1. Material characteristics.
   a. What material is to be handled?
   b. Weight in pounds per cubic foot—not packed.
   c. Moisture content.
   d. Temperature.
   e. If lumpy, what are the sizes of lumps and the percentages of each?
   f. Is it corrosive?
   g. Is it abrasive?
   h. It is free-flowing?
   i. Does it flow in a sluggish manner?
2. Required capacity.
   a. Per minute, hour, and day.
   b. Total days per year.
   c. Will material be fed uniformly?
   d. Will there be surge loads—state maximum?
3. Distance material is to be moved.
4. Location of feed inlets and discharge openings.
5. Is equipment to be used only temporarily, or is the installation to be designed for long life?
6. Will the installation be made primarily for one or more of the following reasons:
   a. Reduce costs.
   b. Save manpower.
   c. Control or improve quality.
   d. Increase production.
   e. Improve working conditions.

Some of these factors naturally are of more vital consequence than others to the selection of conveying equipment for a given job. For instance, the varying physical characteristics of many materials to be handled form a major item in the proper selection of an elevating or conveying medium.

Take soybeans for an example. Are we to consider whole soybeans, cracked soybeans (with or without hulls), soybean flakes (raw or extracted), soybean cake, or soybean meal? The temperature and moisture content of the material while being handled also figure prominently in the proper selection of conveying equipment.

Or perhaps we should consider cottonseed (raw or delinted), cottonseed meats (raw or cooked), cottonseed cake (hydraulic press or screw press type), cottonseed flakes (raw, cooked, or extracted), or cottonseed meal. Here also the temperature and moisture content of the cottonseed are equally important factors, if not more important than for soybeans.

Speaking in general terms, dry materials will usually handle more readily than those having large percentages of oil or moisture. Many fine dry materials however tend to aerate readily and are difficult to handle in some types of elevating and conveying equipment. The same is also true for the "soupy" mixtures in which solid contents are small, percentagewise, compared to the amount of liquid present.

ANOTHER item to be considered, one which is frequently a source of confusion, is the manner in which the required capacity of an elevator or conveyor system is specified. It may be stated that the capacity of a cottonseed oil mill is 300 tons per day, but one cannot tell if this figure is the rated capacity of the extraction equipment, the capacity of raw cottonseed, the cottonseed meats coming into the mill; or if the 300 tons includes surge capacity, plus a reasonable amount for a stepped-up capacity to be acquired at a future date as the operators become more proficient in handling their plant.

Speaking in general terms, we may say that from 300 tons of raw cottonseed we obtain only about 200 tons of cottonseed meats when the lint and hulls have been removed and that this amount is further reduced to about 165 tons of cake or flakes after the oil has been partially removed.

Three hundred tons of raw cottonseed will therefore net only about 150 tons of meal. Such being the case, it is quite obvious that care should be taken to be very explicit in stating the capacity as well as the type of material to be handled as the size and speed of conveyors and required horsepowers should generally be based on the maximum rated capacity of the conveyor at full surge loading.

In designing a new plant, careful thought should also be given to the possibilities of future plant expansion and increased capacity in order that there may be required but a minimum of changes in the conveying equipment when that time arrives.

I think we can get a good perspective of a plant layout, for both the type of equipment and size of the various elevating and conveying elements if we follow the flow of material through an existing modern solvent extraction plant.

In order to provide for maximum flexibility in the over-all plant operation, the engineers designing this plant thought it best to employ two parallel lines of elevating and conveying equipment and to locate duplicate items of processing equipment in each line to handle the solid materials through the various stages of processing. These parallel lines begin with the handling of raw beans from the concrete silos and extend all the way through the processing lines up to the handling of the finished meal into storage. Each line has a nominal rated capacity of 275 tons per day with provisions being made for a reasonable future increase in plant capacity.

The design capacity is based on handling about 1,600 cubic feet or 74,000 pounds per hour of whole soybeans weighing about 46 pounds per cubic foot. These figures include a reasonable amount for stepping up the plant capacity at a future date. On some of the conveyors in the system which are subject to surge loading, the design capacity is stated to include a reasonable percentage for surges in addition to the percentage allowed for a future increase in the capacity of the plant.

In planning the layout and in sizing the conveying equipment, considerable attention was given to using wherever possible only those conveyor parts which are made to manufacturers standards, thus avoiding as many special features as possible. Such careful planning saves many hours of down-time during emergency repairs and speeds up maintenance and repairs during regular shut-down periods.

It will be noted that 12-in. diameter screw conveyors are used throughout most of the following system even though in some instances the next smaller diameter screw operating at an increased speed would have provided the required capacity. Although somewhat more expensive than smaller diameter screws, this eliminates the necessity of carrying in plant stock a complete line of parts for two or more different diameters of screw conveyors, resulting in lower inventory costs and a simplified repair parts program.

Similar planning is used on the chain conveyors in that one standard chain of heavy design which is suitable for the heaviest loading on conveyors of a given size is employed on several shorter conveyors of the same sectional area in which the chain loads are relatively light. Here again one spare chain for several conveyors is all that is required for servicing during an emergency.

The same careful planning is applied to the gearmotors used for driving the elevators and conveyors. Only one manufacturer's gearmotors are used, and one complete gearmotor and a set of spare parts for each gearmotor are on hand for each drive used in the plant. Gearmotors of only three or four ratios for a given horsepower are used even though most manufacturers make and stock about 20 different ratios. Further speed changing is accomplished in the roller chain drive employed between the reducer output shaft and the conveyor driveshaft. Emergency repairs are accomplished by taking a gearmotor, which has failed or is subject to failure, out of service and replacing it with the new spare unit carried in stock. The unit taken out of service is then reconditioned with the set of spare parts carried in stock for that purpose. With this practice down-time and high maintenance costs are minimized.

Now let us follow the materials-handling equipment used in this elevating and conveying system for handling a rated capacity of 550 tons per day.

Soybean Oil Mill

A grain car unloader empties the soybeans from box cars having a capacity of 2,000 to 2,500 bushels each, at a rate of 10 to 12 cars per hour into a hopper beneath. The unloader tips the cars sidewise as well as endwise, and the complete unloading cycle is accomplished within about 4½ minutes.

A belt feeder, 48-in. wide, takes the beans from the unloading hopper and conveys the material to a bucket elevator.

A high speed bucket elevator with a double row of 20 in. by 7 in. high speed elevator cups, mounted on a belt operating at a speed of about 750 feet per minute, delivers the material to the top of the headhouse.

A belt conveyor, 36 in. wide, equipped with a motor-propelled tripper, takes the beans from the elevator and distributes the material throughout the long rows of concrete silos extending beyond the head house.

From storage the whole soybeans are reclaimed and routed to the bean cleaners on two parallel lines of 18-in. belt conveyors. Average capacity is based on handling 23,000 pounds per hour or 500 cubic feet per hour. Design capacity is based on handling 37,000 pounds per hour or 800 cubic feet per hour. Beans weigh 46 pounds per cubic foot.

In handling whole soybeans, it will be noted that due to the very abrasive nature of the whole beans, the equipment selected, *viz.*, belt conveyors and bucket elevators, is such as to provide relatively long life under adverse operating conditions. In other words, the beans are carried instead of sliding or being pushed along.

After the beans have been cracked, they do not have the extreme abrasive qualities of the whole beans and therefore are suitable for handling in other types of equipment.

Collecting screw conveyors, 12-in. diameter, and centrifugal discharge bucket elevators with 8 in. by 5 in. buckets, carry the cracked beans to the bean heaters, and distributing screw conveyors, 12-in. diameter, feed the cracked beans to the flaking rolls. Design capacity is 28,800 pounds per hour or about 640 cubic feet per hour.

In handling the cracked soybeans, abrasion does not present a serious problem, and this is especially true after the hulls have been removed. Care must be exercised to avoid creating excessive fines as a high percentage of fines may cause unnecessary trouble in removing them after extraction.

Such being the case, it is well to carry the cracked beans well below the hangers in the screw conveyor and operate the screw at a relatively slow speed. We also prefer to use a bucket elevator or En Masse type of elevator at this stage of processing, rather than a vertical screw lift, in order to avoid creating an excessive amount of fines.

Collecting screw conveyors, 14-in. diameter, receive the flaked soybeans from the lines of flaking rolls and discharge the material into En Masse type elevators having a sectional area 7 in. by 12 in. (Bulk-Flos), which in turn discharge into long 7 in. by 12 in. horizontal Bulk-Flos, which carry the fully prepared raw flakes from the preparation building into a separate extraction building about 200 feet away. Design capacity is 34,000 pounds per hour or 1,360 cubic feet per hour.

En Masse conveyors, such as the Bulk-Flo, have generally been accepted as a preferred elevating and conveying medium at this stage of processing for several reasons.

These reasons are: 1. they handle the thin, fragile flakes gently so as to avoid degradation; 2. the material is elevated and conveyed in a steady stream, whether partially loaded or fully loaded; 3. the horizontal run provides a means of recirculating a small percentage of flakes in order to be sure that an exact amount of flakes is fed into each basket of the extractor; 4. the conveyor can be insulated readily to retain the heat in the material being conveyed; and 5. the full flights keep both runs of the conveyor clear of an accumulation of material which might become rancid.

Although belt conveyors would handle the material gently, they have the disadvantage of not being suitable for handling a recirculating load, and it is somewhat difficult to keep the fines from building up on the idlers and the deck plate. They also are more difficult to insulate if such is thought necessary.

Long horizontal screw conveyors, with a number of hangers, would be the cause of a much larger percentage of fines, and a second line of conveyor would also be required to handle the recirculating load.

Screw conveyors, 14-in. diameter, take the spent flakes from the extractor and discharge into a bank of dryers, which in turn discharge into 7 in. by 12 in. vertical Bulk-Flos. These units discharge into long horizonal 7 in. by 12 in. Bulk-Flos to carry the material from the extraction building back to the preparation building. Design capacity is 23,000 pounds per hour or about 960 cubic feet per hour.

In handling the spent flakes at this stage of processing, we find that corrosion becomes a major item with which to contend. Therefore heavy casing sections and heavy chains are necessary to secure long life and keep maintenance costs down. In some cases head and take-up sections are made of stainless steel. Care should always be taken to see that excess moisture is vented from the terminals or intermediate runs.

The spent flakes are now ready to be discharged into the first toaster. A 7-in. by 12-in. Bulk-Flo takes the discharge from the first toaster and discharges into the second toaster. Design capacity is 32,500 pounds per hour or about 1,200 cubic feet per hour.

On some more recently designed solvent extraction plants the spent flakes from the extractor are fed directly into a single desolventizer toaster unit by means of a 7 in. by 12 in. Bulk-Flo, thus eliminating a number of elevating and conveying units as well as several processing units.

A 9 in. by 15 in. Bulk-Flo now takes the discharge from the toasting equipment, and the hot toasted meal is fed into a multi-louvre cooler to reduce excess heat and moisture, preparatory to grinding. Design capacity is 70,000 pounds per hour or about 2,330 cubic feet per hour.

A screw conveyor, 14-in. diameter, collects the toasted flakes from the cooler and discharges into the first set of screens, from which they are spouted into the first grinders. Design capacity is 23,000 pounds per hour or about 960 cubic feet per hour.

A 7 in. by 12 in. Bulk-Flo takes the oversize from the first grinders and delivers to the second screens, from which they are spouted into the second grinders. Design capacity is 50,000 pounds per hour or about 1,430 cubic feet per hour.

Another 7 in. by 12 in. Bulk-Flo takes the discharge from the second grinders and carries the meal to the storage bins, where the material is held for the final processing by the day shift, preparatory to sacking. Design capacity is 50,000 pounds per hour or about 1,430 cubic feet per hour.

A twin paddle mixer, 20-in. diameter, takes the meal from the bins, and here the moisture content is adjusted to suit shipping and storage standards. The mixer discharges into a 12-in. diameter screw conveyor and from there to a 9 in. by 15 in. Bulk-Flo, which delivers the meal to the granulators for final processing. Design capacity is 84,000 pounds per hour or about 2,400 cubic feet per hour.

Slider belt conveyors, 12 in. wide, are mounted directly beneath the bag sewing machines for carrying the bags away after the tops have been sewed, and these in turn discharge the finished bagged meal onto a 36-in. wide slider belt conveyor, which conveys the loaded bags to the shipping platform.

Cottonseed Oil Mill

Cottonseed unloading and storage equipment differs considerably from the materials-handling equipment required for soybeans. In a recently erected hydraulic press cottonseed oil mill the seed is unloaded from trucks or rail cars by air at a point about midway between two seedhouses. The seed is transferred from the collecting hopper to a 16-in. diameter, reversible screw conveyor which carries the seed to either house. Here the seed is discharged into a 24-in. wide, inclined drag flight conveyor. The drag flight conveyor then discharges to a 24-in. wide, flat belt conveyor equipped with a movable plow for distributing the seed throughout the length of the seedhouse. The seed storing capacity is about 50 tons per hour.

A 12-in. wide, slider belt conveyor operates in the tunnel of each seedhouse. These belts serve the mill building when operating in one direction or can recirculate the seed back through the drag flight conveyor when operating in the other direction. This feature can prove very advantageous if hot seed should be located at any point in the seedhouse.

The normal rating of the reclaim capacity of the mill is about 12½ tons per hour, and the layout of the conveying equipment would be suitable for feeding a mill equipped with hydraulic presses, screw presses, or a solvent extraction system up to the capacity stated.

In hydraulic press mills or screw press mills the handling of the cottonseed meats in the elevating and conveying equipment is not so critical as when handling them for a solvent extraction system where excessive fines usually cause trouble.

Most mills using mechanical presses for extraction can therefore use screw conveyors for nearly all horizontal conveying, and bucket elevators or vertical screw lifts for the vertical runs.

For a solvent extraction plant conveying system we would normally recommend using similar types of elevating and conveying equipment for the various stages of processing as discussed for soybeans, except that we would substitute screw conveyors for handling raw cottonseed instead of belt conveyors as generally used for whole soybeans.

The use of belt conveyors for handling hot cooked cottonseed meats in several plants has not proved very satisfactory as the high oil content and high temperature have caused excessive maintenance expense on the belts. Furthermore the buildup of fines on the idlers and deck plates has necessitated a major cleaning job every month or so.

The handling of hot, steamy spent cottonseed meal from the driers to storage has at times caused excessive corrosion in conveyor chains. Whether this can be attributed to an acid condition or to high moisture at elevated temperatures, we are not in a position to state definitely at this time. The same condition has been noticed on conveyors handling hot spent flaxseed meal, and to date it has not been possible to pin-point the source of trouble.

Experimental work, tackling the problem from several different angles, is now being done, and we are hopeful it will show resulting benefits in the near future.

Summary

From what has already been stated and from many other sources as well, it is quite apparent that as the vegetable oil extraction industry continues to advance and introduces new processes and products, this also brings with it new problems in material handling.

Maybe you will, at this time, permit me to say a word about my company's Materials Handling and Processing Research Laboratory in Chicago because of the benefit it can be to the industry in solving these new problems.

This laboratory is operated as a service organization to all Link-Belt Company engineering plants where materials-handling equipment is manufactured. It has facilities for finding out the handling characteristics of almost any material and nearly every type of conveyor made by the company.

The experimental equipment used is of commercial size, which gives data more in the range of actual field conditions than is usually associated with experimental laboratories.

The laboratory is staffed with engineering and mechanical personnel who are constantly engaged in making specialized equipment setups which would duplicate field conditions. Some of the ensuing results are not always favorable, but if enough latitude can be obtained, a working combination can usually be found for a given problem.

The use of these facilities is arranged for through the Link-Belt plant that manufactures the products involved, and any of you gentlemen desiring to avail yourselves of these services should make your contacts through the usual channels. Costs for such experimental work are usually predicated on the sales potential involved.

In making this presentation, I have outlined the type and size of materials-handling equipment that might normally be employed in a modern, efficiently equipped mill for the extraction of oil from soybeans or cottonseed.

Each mill however presents its individual problems. These should in each case be studied and analyzed by men who have had a wide experience in solving the materials-handling problems of mills engaged in the processing of similar or related materials. A better plant layout and one which will have low operating expense should be the net result.