DENSE-PHASE CONVEYING OF PEANUTS AT H. B. REESE COMPANY, HERSHEY, PA

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Abstract:

This paper will describe the reasons leading to Hershey's decision to use a dense-phase pneumatic conveying system for conveying peanuts in their H. B. Reese factory. Types of system, both mechanical and pneumatic, will be described and their advantages/disadvantages discussed.

The system selected will be described from both conveying regime and operational aspects. Finally, results obtained through two year's operating experience will be compared with forecasted results based upon testing prior to the system being acquired.

Introduction:

The H. B. Reese Company is located in Hershey, Pennsylvania and produces a variety of candies and confections, many of which use peanuts and/or peanut butter as a primary ingredient. The company uses a significant quantity of peanuts per year; and in order to maintain the highest product quality and maximize process efficiency, the most effective methods of material handling are required.

The transport of peanuts has several special considerations that include:

(1) Spillage into open areas must absolutely be avoided. Food processing plants must be kept scrupulously clean.

(2) The breakage of the nuts must be minimized for several reasons:

(a) Quality of roast is the paramount concern. Excessive breakage and abrasion of the nuts can cause oil cells near the surface to rupture. The released oil, during the roasting process, is then oxidized which can adversely affect shelf life.

Naturally, flavor is also directly affected by the quality of roast.

(b) Cleaning and sorting effectiveness is directly affected by the amount of breakage in the nut supply. Higher breakage equates to more particulate removal in the cleaning process and lower rates in the sorting operation.

(c) Dusting from skin fragments is greatly reduced by minimizing nut breakage.

(3) Conveying systems usually require multiple reception points.

(4) All contact surfaces must be of approved food quality materials, e.g. 304 or 316 stainless steel, depending upon the location in the process.

(5) The system must operate automatically in response to level controls and remote control signals. The transport of the peanuts must, therefore, be self-regulating in response to the demand of the process which may fluctuate.

Previous Experience:

Peanuts have traditionally been transported using mechanical conveying systems - primarily vibratory conveyors and bucket elevators. This was the case for many years since mechanical systems were basically the only method of gentle handling available. However, spillage of peanuts at transfer points accounted for product loss and required labor for clean up. Also, mechanical systems were not totally enclosed and were difficult to seal.

Because of the need to distribute to many reception points, mechanical systems carry higher capital costs than say, an equivalent pneumatic system. Maintenance/operating costs are also higher due to the number of moving parts and wearing points normally associated with bucket elevators and mechanical conveyors. Screw conveyors were not usually employed because of product damage.

Mechanical systems have traditionally been used within Hershey Chocolate U.S.A. to handle various types of nuts. The typical predominant reason for selecting a mechanical system was the gentle handling characteristics stated previously. Undoubtedly, mechanical systems will continue to be used, with decisions made on a case-by-case basis. For instance, an existing system that requires expansion or modification may be a case in point where new mechanical equipment would be installed to maintain similarity of operation. Other deciding factors would include the physical properties of the nut meats being handled. For example, nuts which have been oil roasted most likely will continue to be handled mechanically due to ease of access for cleaning the conveyors. Oil build-up in closed pipelines is to be avoided.

Pneumatic systems are used extensively throughout the Hershey Foods Corporation for transport of materials such as sugars, flour, cocoa, and milk powders. The predominant requirement in such systems on powdery materials is containment of fine particles leading to a clean process environment.

Other advantages such as cost of distribution through remotely-operated valving and relatively low operating costs are also important considerations. The fact remains that many of the systems used on powders operate in the dilute-phase regime, and velocities subsequently are very high - in the range of 4,000 - 6,000 ft./minute. These high velocities, when used on peanuts, caused excessive splitting and scuffing of the peanut's surface.

As dense-phase systems were introduced and conveying velocities were reduced, breakage levels were improved. Initially degradation was not yet reduced to the level that would satisfy most peanut processing companies.

In a modern food processing plant such as H. B. Reese, peanut damage through handling is viewed critically and steps are taken to avoid the rupture of the oil cells. Oil presence on the surface of peanuts would not only affect shelf life as previously mentioned, but also would lead to increased cleaning intervals of fouled equipment surfaces and could adversely affect processing rates. Peanut meal build-up, a combination of solids and oil, would further compound potential problems.

Therefore, the choice which faced H. B. Reese was either to continue to use traditional handling methods such as mechanical conveying, or to find a better means of handling the peanuts pneumatically - one which would produce satisfactory results.

Dense-Phase Pneumatic Conveying:

Hershey learned that a dense-phase system called "Denseveyor" had operated previously with other fragile materials such as granular yeast, clay micro-spheres, coffee beans, tea, popped rice and others with good results. In fact, the system had been used for conveying peanuts in a peanut butter processing plant some years before. This particular system had produced breakage levels in the range of 5-6 percent. Hershey's process required that average breakage levels did not exceed 3%, and it was decided to pursue the possibility of obtaining such results by using the Denseveyor.

The Denseveyor operates on a short plug principle within the dense-phase range of pneumatic conveying regimes . The transporter is smaller than is normally associated with traditional pneumatic conveying system pressure vessel types. The pipeline is also larger than normal, and this relationship between small vessel and large pipeline allows the entire contents of the vessel to enter the pipeline while producing a relatively short plug length (Figure 1). This has enabled "difficult" materials such as wet coal, rutile ore, titanium dioxide, ungraded petroleum coke, etc., to be conveyed in a discontinuous plug flow dense-phase conveying regime without any defensive system or conveying line air (boosters) being required.

The previous system had operated in this regime also with one complete vessel full of material being conveyed entirely through the system before the vessel was refilled. As this system had only produced breakage levels of 5 to 6%, clearly a better method was required.

Work by Zenz[1][2] Wen and Simons[3] and Jodlowski[4] had indicated that four basic conveying regimes existed. These were:

1) **Dilute Phase:** Characterized by full suspension flow with conveying taking place above the saltation velocity.

2) **Continuous Dense Phase:** Characterized by a moving bed type flow below the saltation velocity.

3) **Discontinuous Dense Phase:** Characterized by a plug-type flow below the saltation velocity.

4) **"Solid" or "Full Pipe" Dense Phase:** Here the pipe is full of material, and flow is characterized by an "extrusion" type of flow.

Since the average material velocity decreased when moving from 1 to 4 in each case, it was hypothesized that solid dense-phase, by virtue of the fact that velocity should be lower, would produce lower breakage levels than plug flow discontinuous dense phase. It was decided, therefore, to try to obtain as near to full pipe conditions as possible without using boosters, since these would cause local turbulence round the air injection point; and a series of conveying trials was entered into.

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Test Program:

The test was to be of production scale and using a conveying distance that closely approximated the intended system at H. B. Reese. Figure 2 shows a schematic of the test system which consisted of a load-in bin (A); a 4.0 cubic foot pressure vessel equipped with an 8" diameter infeed valve (B); a 4" diameter conveying line which contained four 90° long radius bends and which had a total length of 120 ft. (C); and a receiving box which would be easily accessible for sampling (D).

It was decided to make the receiving box open-topped to allow easy access for sampling and to observe the flow of peanuts out of the end of the pipe. The pipe terminated in a target box (which contained a 90° deflector) and a rubber discharge tube into the box. Later tests incorporated several sections of clear pipe so that the mode of flow through the pipeline could be better observed.

Peanuts were loaded into the pressure vessel via the load-in bin. When the vessel had been filled, compressed air was introduced into the conveying line. The air supply was cut-off as soon as the vessel was empty, causing the peanuts to stop in the conveying line. A cut-off valve on the outlet of the vessel prevented the column of peanuts held in the vertical section of the conveying line from reentering the vessel by gravity.

The vessel was again filled, and the peanuts were evacuated into the line as described above. This process was repeated several times before peanuts began to emerge from the end of the conveying line. Flow into the box was gentle with little dusting. The flow appeared to be similar to that which would be obtained if a bucket of nuts was simply poured by hand into the box.

Hershey personnel consisted of representatives from their Engineering, Production and Quality Control departments, and were present throughout the entire testing program. In this way, everyone with a stake in the results and input into the decision process was present. The Hershey process personnel carried out all the sampling during the test. Representative samples were taken either from the collection box or directly from the product stream as it exited the pipeline. Several control samples were taken from the peanuts before conveying took place for comparison with the conveyed material. Actually, two discreet test programs were run on different dates and with different product. A follow-up test was run to confirm the original test results. This was directly linked to the importance and magnitude of the task at hand.

Each sample was examined by hand on the laboratory bench, and every peanut which was damaged in any way was separated from the main part of the sample. Both parts of the sample were weighed to an accuracy of 0.1 grams, and the damaged peanuts expressed as a percentage.

The percentage of breakages after conveying was then compared against the control samples, and a net breakage value was obtained. The net breakage was in the range of 0.1% to 2.9% with an average of 1.8% - well within the 3% limitation required.

In H. B. Reese's process, it would be necessary to periodically empty the conveying line to change from one batch of nuts to another and for inspection, routine maintenance, etc. It was necessary, therefore, to investigate how much purge air would be required to clear the line. It was found that the air flow used for conveying was sufficient to clear the pipeline by simply overriding the fill cycle control and preventing more peanuts from entering the system. The line was cleared on the first cycle, and no additional air was required.

Table 1 summarizes the results of the tests:

Conveying Distance	125 ft. including four bends
Conveying Rate	11800 lbs./hour
Average Air Consumption	66 scfm
Peak Air Flow	81 scfm
Average Air Velocity	687 ft./minute
Measured Material Velocity	190 ft./minute
Phase Density	40.2
Air-to-Material Ratio	14.8 to 1

Table 1

Installation at H.B. Reese Company:

Based upon the test results, it was decided to go forward with installation of the peanut distribution system at the H. B. Reese Company in Hershey, PA. The system schematically illustrated in Figure 3 was designed to support production requirements and distributes to a total of eighteen reception bins. The bins are mounted on load cells and are discharging to the peanut roasters.

The system is sized to meet Hershey's process requirements, but is capable of delivering 40% above requirements. The maximum conveying distance is 130 ft. to the most distant reception bin. The peanuts are delivered to the system by an existing mechanical conveyor (A) via a surge bin (B), into an 8.0 cu. ft. transporter (C). The transporter discharges into a 5" diameter pipeline (D). Distribution to the reception bins (H) is made through a two-way switch valve (E) and sixteen dump valves (F). Delivery into the final two bins is via terminal boxes (G). The switch valve (Figure 4) and dump valve (Figure 5) are fitted with pneumatic sealing heads to prevent loss of pressure during conveying.

The pipeline at each dump valve and the terminal boxes is isolated by flexible connections to prevent outside interferences to the reception bin load cell weigh system. Conveying air at peak flow was only approximately 125 scfm and relatively dustless. It was decided, therefore, to use a simple vent sock to exhaust the conveying air from the bins.

H. B. Reese employs stringent levels of cleanliness, and all contact surfaces were manufactured in either 304 or 316 stainless steel. Another requirement was for the transporter to be made accessible inside for cleaning. To provide this facility, the vessel top including the infeed valve, was designed to uncouple and swing away.

Peanuts are received at the facility in standard cardboard tote bins. Each shipment, or lot, is recorded, sampled, and given an identifying number. The sample is run through a number of Quality Control tests to determine acceptability.

After cleaning and sorting operations, the peanuts enter the transporter system. A small surge bin collects the product from a mechanical transfer system, and in turn, gravity feeds the pressure vessel.

The Denseveyor system is used to divide the lots of product into sublots. The receiving bins which are load-cell mounted, each hold one sublot. The conveying line is purged between each lot, or every four sublots. This is required to maintain strict control over lot identity.

Sublot weight data, bin status and system status are processed through a central control station. After approval is received from the Quality Assurance Department, the peanuts proceed to the roasting process.

The system was started up December 7, 1987 and has operated 16 hours per day, 5 to 6 days per week, for a total operating time in excess of 11,000 hours. Breakage levels during this time have remained in the 2.0% range and have equaled or bettered the results obtained during the test program.

Since the process required frequent change over of dump valve for delivery of the sublots into different receiving bins, it was originally thought the pipelines would have to be purged every time the bin destination changed. This was to avoid jamming of the valve when the by-pass tube was raised or lowered, and, possible damage to the peanuts. This requirement would have lengthened/slowed down the changeover process. It has been found in practice, however, that the by-pass tube of the dump valves can be raised and lowered with the peanuts still in the line without detriment to either the valve or the peanuts. Purging only takes place between transfer of complete lots.

Mechanically speaking, the system has been exceptional. Only recently has it been necessary to replace the air seal on the switch valve after an estimated 5,000 cycles. The only other incident involved a broken mounting flange on the isolation valve at the pressure vessel outlet. No other maintenance has been required.

The filter socks have performed well, although during start-up the filter area was doubled, mainly to accommodate the purging air velocity and volume on full bins of product. The socks are presently inspected in regular intervals and changed every six months.

Spillage within the pneumatic system is virtually non-existent. The housing around the switch valve was modified to accommodate random stray peanuts which occasionally accumulate on the closed side of the diverter and then fall into the housing when valve position is changed. Spillage does not occur although the housing is cleaned on a routine basis.

Conclusion:

In conclusion, the system installed at H. B. Reese was an important one since the majority of production at the facility depended on the success of the system - all of the peanuts processed in the plant pass through it. The equipment has performed well from both process and mechanical considerations. The decisions made on the basis of the test program have been justified from both a capital expenditure and operating viewpoint. The solid flow method of conveying the peanuts has been shown, both in test and production conditions, to significantly reduce the rate of peanut breakage.

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