Current Trends in Meal Desolventizing

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ABSTRACT

Several types of current desolventizing systems are illustrated and their important features are discussed. All of the leading desolventizer suppliers are continuing to make mechanical and process improvements to their systems. The current trend is to design systems which have less downtime, lower steam and electrical requirements, better solvent recovery, and less space requirement for installation. While desolventizer-toaster systems are making improvements in the reduction of steam and electrical consumption, their energy requirements are still higher than those of the vapor desolventizer-deodorizer or the flash desolventizer system. The type of system selected depends mainly upon the product to be produced—animal meal or human edible soy flour.

INTRODUCTION

Meal desolventizing systems must be designed to accomplish a number of functions simultaneously. Solvent must be removed thoroughly from the meal and must then be recycled back to the process safely and efficiently. To avoid explosions and/or fires caused by residual hexane in meal, the meal produced must be suitable for safe storage for prolonged periods under confined conditions. If the desolventizing time is inadequate, hexane will continue to diffuse from the meal while it is in storage. For example, corn germ meal, and in some instances soybean meal, can release hexane in confined storage until the hexane-in-air surrounding the meal builds up to within the explosive limit. The desolventizer design should prohibit loss of solvent to the adjacent areas under any conditions: start-up, normal and emergency shutdown, and good or poor extractor drainage. Energy consumption in the desolventizing process is quite high both in steam and in electrical usage. The processor must minimize this energy consumption in order to stay in business. Meal should be cooked under controlled conditions so the desired functional properties are obtained. For ruminant feed, soybean meal must be toasted thoroughly to inactivate urease and certain enzymes and to denature the protein. However, soy flours for human use, depending upon their ultimate application, are produced under controlled conditions from thoroughly toasted to untoasted meal.

All soybean desolventizing systems must be designed to receive defatted soybean flakes containing ca. 30 wt % hexane and remove the hexane from the meal down to commercially acceptable levels. To produce a soybean product having both the required protein dispersible index (PDI) and relative protein efficiency, control of processing variables during desolventizing is essential. During desolventizing, the three pertinent variables (time, temperature, and moisture) are near or above their threshold values. Consequently, by carefully controlling these variables, a preselected type of meal product can be produced.

DESOLVENTIZING SYSTEMS FOR ANIMAL MEAL

There are so many European and American designers and fabricators of desolventizing equipment that it is not possible to describe them all in this paper. However, since there are many technology exchange relationships between European and American suppliers, it is believed that the current state of the art for these systems can be illustrated by the material supplied by three leading American suppliers.

It must be remembered that the complete desolventizing process also involves meal drying and cooling steps as well as desolventizing and toasting.

Currently, various improvements are being introduced by equipment suppliers which in general reduce electrical and steam requirements, improve solvent recovery, provide for longer trouble-free operation due to mechanical improvements, and reduce overall equipment costs.

Methods for treating meal in the various desolventizing toasting systems are similar (1). The desolventizer-toaster (DT) unit is a vertical shell containing steam-heated trays, sparging steam sections, sweep arms and a drive system, and a means for discharging the vapor at the top and the meal at the bottom. Hexane-wet flakes enter the top section and are sparged with steam on one of the upper trays. Steam condenses in the flakes vaporizing the hexane so the moisture content is raised to ca. 20%. In the lower trays, the moisture content is reduced as the flakes are heated to 107 C (225 F). The meal is then dried to 14-15% moisture before it is cooled and the moisture content is then reduced by evaporation to 11-13%. Traces of solvent can either be sent to the effluent air or can be recovered during the drying and cooling operations. DT units are commonly used to produce meal for ruminants and poultry. Typical products from DT units range from 10 to 30 PDI.

French Oil Mill Systems

Figure 1 shows a typical flow chart for a large soybean operation. The extractor, desolventizer-toaster, dryer, and cooler plus accessory equipment is illustrated. Figure 2 shows a French soybean DT unit. Figure 3 shows a French DC (dryer cooler) system for a 1600 ton/day soybean plant. The unit is 180 in. in diameter and consists of 4 sections. Some of the improved features include: better solvent recovery from the DT section due to the use of external vents and more drying, less steam requirements, stationary rather than rotating internal vents, self-cleaning external vents in the lower portion of the DT, thus allowing more efficient drying, improved safety due to holding the meal on top tray during start-up, and elimination of the vapor scrubbers through the use of a tangential swirling/scrubbing system from the top deck of the DT (W.M. Barger, French Oil Mill Machinery Co., private communication, 1982).

Crown Iron Works Systems

Figure 4 illustrates a DTDC (desolventizer-toaster-dryer-cooler) system. As compared with the conventional method in which a desolventizer-toaster, a dryer, and a cooler are used in sequence, the DTDC unit is one machine containing all of the functions which saves steam and electrical energy, costs considerably less than a conventional system, produces meal with less residual hexane, and is simpler to operate.

Heinz Schumacher, the inventor of the DTDC system reported that the following improvements have recently been made (H. Schumacher, private communication, 1982). (a) Instead of only one chamber at the top section, three or four trays have been inserted in the desolventizing-toasting section. This reduces electrical consumption by ca. 30%. (b) Perforated trays are used throughout the

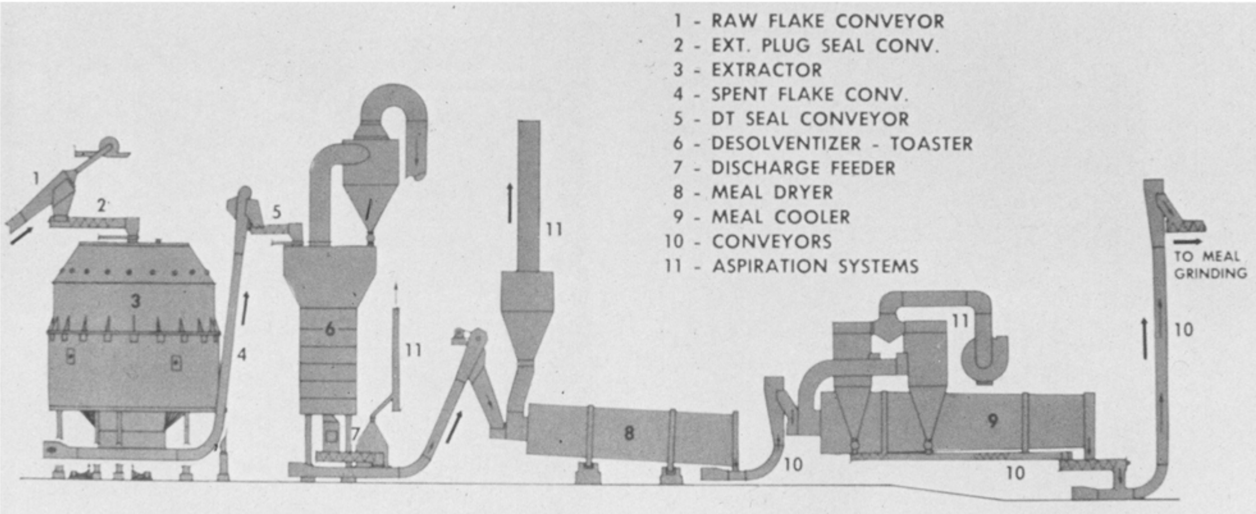

FIG. 1. Flowchart: extraction solids flow typical for large capacity soybean extraction plant. (1) Raw flake conveyor; (2) external plug seal conveyor; (3) extractor; (4) spent flake conveyor; (5) DT seal conveyor; (6) desolventizer-toaster; (7) discharge feeder; (8) meal dryer; (9) meal cooler; (10) conveyors; (11) aspiration systems.

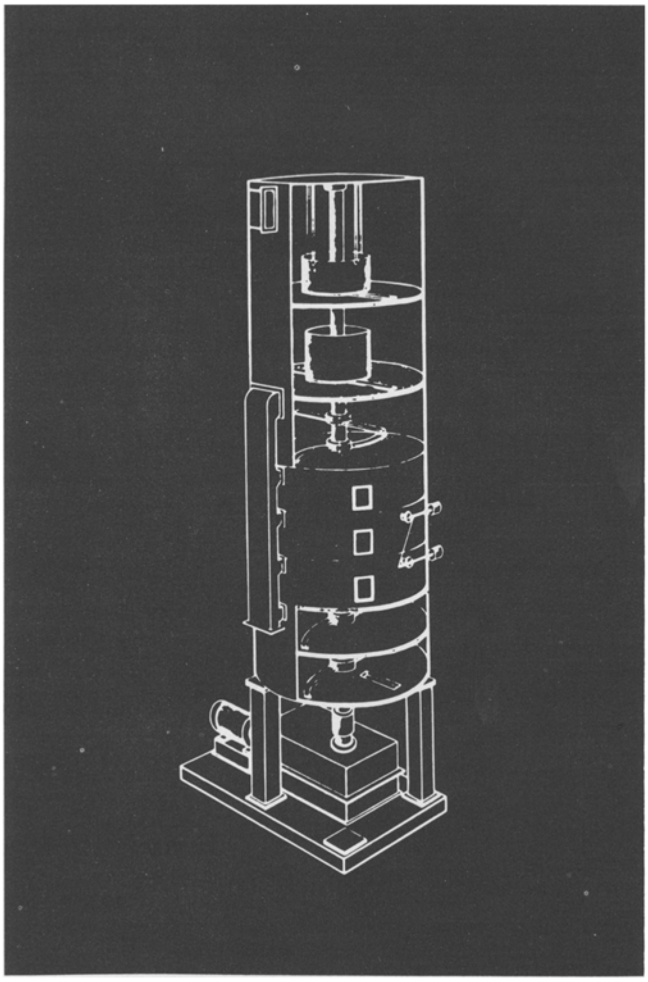

FIG. 2. French desolventizer-toaster for soybeans.

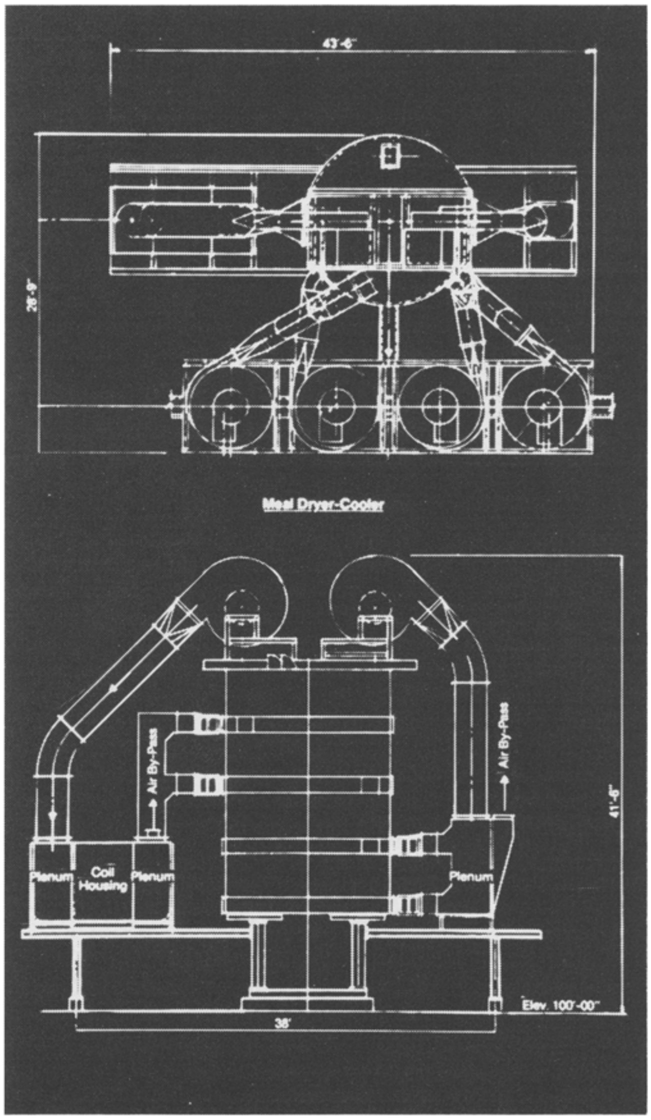

FIG. 3. French dryer-cooler for 1600 ton/day soybean plant.

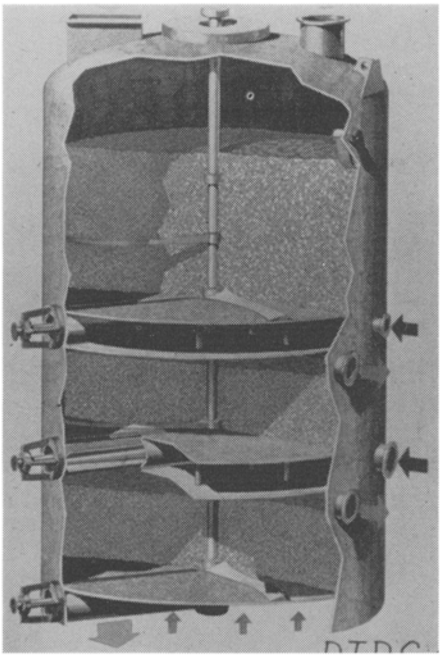

FIG. 4. Crown desolventizer-toaster-dryer-cooler.

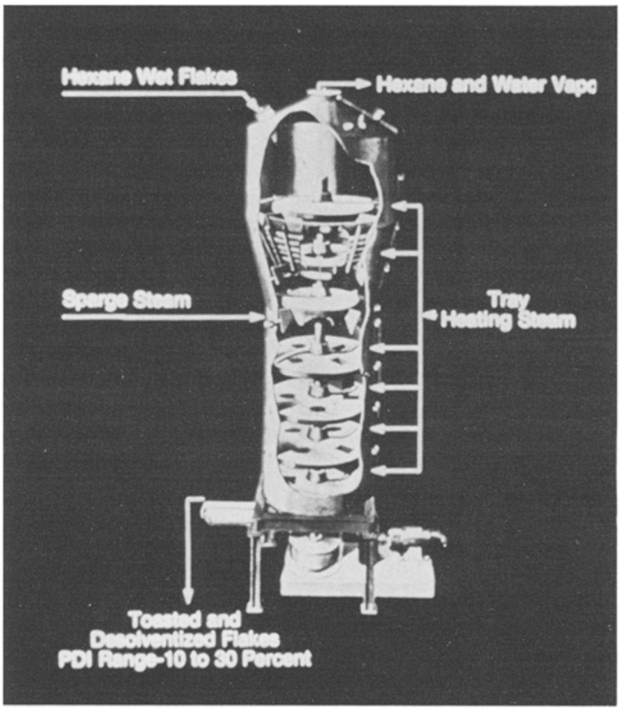

FIG. 5. Dravo desolventizer-toaster.

desolventizer-toaster section and steam is applied at the lowest possible point in the system. This results in considerable steam savings. (c) The foregoing improvements also resulted in lower residual hexane in the meal than with previous DTDC systems.

As mentioned previously, the top section of the DTDC is a desolventizer-toaster (G.D. Brueske, Crown Iron Works Co., private communication, 1982). The next section is a dryer. The meal from the DT section flows through a rotary valve and is dried by hot air introduced through the perforated tray. Some evaporative cooling takes place during drying, thereby reducing both steam and cooling requirements. The dry meal is then passed through another rotary valve to the cooler section. Ambient air is passed through the perforated tray of this section in a manner similar to that employed for steam or hot air for the two previous sections. The meal leaves the DTDC unit at nearly ambient temperature.

Dravo Systems

Figure 5 shows a conventional Dravo desolventizer-toaster. This type of DT unit uses chutes rather than gates to control the level on the trays. Dravo has a new concept in energy conservation and hexane recovery (2). Basically, this new concept involves the coupling of the DT unit and the conventional, horizontal, steam tube meal dryer. The connecting conveyors between the DT and dryer must be vapor-tight to eliminate the loss of vapors to the atmosphere. A meal seal is provided for the dryer outlet. Drying is accomplished in the absence of air, and the atmospheric steam evolved during the drying is removed from the dryer by a steam eductor. The motivating steam plus the steam and solvent evolved from the dryer is sparged into the DT unit trays in the normal manner. With this process, the meal is dried to 14-15% moisture. However, this concept can be expanded to include the meal cooling step. Then, a rotary meal cooler equipped with tubes for water cooling is used and the passage of air effluent through the meal is eliminated during cooling. It is necessary, when cooling with water, to dry the meal prior to cooling down to 11-13% moisture. This additional drying evolves more steam in the dryer and lowers the residual hexane content in the meal by removing it along with the moisture being evolved, thereby assuring some additional hexane recovery.

Desolventizer Systems for Human Edible Soy Flours

Soy flours are produced with varying degrees of protein denaturization as measured by protein dispersible index value. For example, Table I shows typical PDI values common for soy flours.

TABLE I

Typical PDI Values for Soy Flours

PDI	Product
90-95	Bleaching agent in white bread
70-80	Bakery mix
	Doughnut mix
35-45	Beverages
	Meat processing
8-20	Baby cereals
	Pet foods

Vapor Desolventizer-Deodorizer System (1,3)

Figure 6 illustrates the Dravo desolventizer-deodorizer system which is designed to provide a broad range of PDI products. This system is designed to allow time, temperature, and moisture to be adjusted during operation. All but 1% of the solvent is removed from the meal by the super-

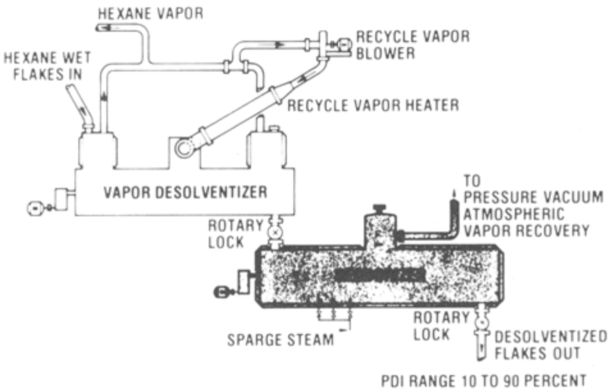

FIG. 6. Dravo desolventizer-deodorizer system.

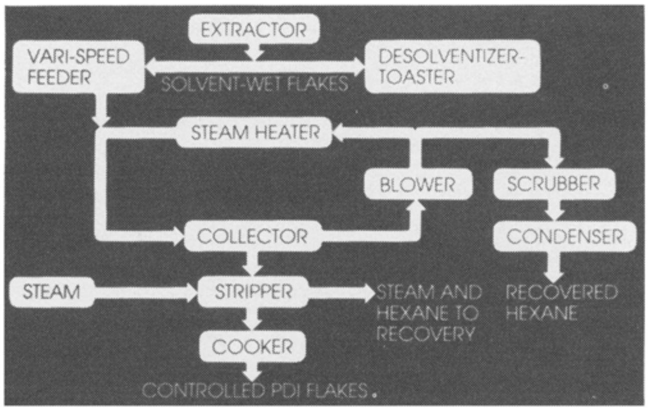

FIG. 7. EMI flash desolventizer system.

heated vapor in the desolventizer. The meal then passes through a lock to the deodorizer. The steam pressure within the deodorizer can be regulated between ½ and 2 atmospheres. By adjusting this steam pressure and by minor adjustments to the height of the discharge dam, the PDI of the meal can be adjusted over a range of 10-90 with the upper limit approaching 1 or 2% below the PDI of the extracted flakes.

Flash Desolventizer System (4,5)

Figure 7 illustrates an EMI flash desolventizer system.

A flash desolventizer consists of a pneumatic-conveying desolventizing tube, a cyclone flake separator, a hexane blower, and a hexane vapor heater arranged in a closed-loop system in which superheated vapor is constantly circulated. Solvent-wet flakes are fed continuously into the system through a variable speed conveyor to the circulating vapor stream where the solvent is removed down to ca. 1%. The desolventized flakes are then discharged into a cooking system wherein the variables of time, temperature and moisture can be adjusted to produce meal in a closely controlled range as required.

The control of protein solubility is achieved in the cooking system. Earlier cooking systems used either inert gas or a small amount of sparge steam to remove the final amount of hexane and prevent protein denaturation. Fines from the inert gas system often plugged the mineral oil system, resulting in additional downtime and solvent loss. For live steam sparging, the low steam rate was sometimes inadequate to remove residual hexane, thereby causing excessive hexane loss. The solubility control cooking system consists of two vessels in series—a stripping vessel and a cooking vessel, mounted one above the other. These are horizontal, steam-jacketed vessels, equipped with conveying and mixing devices. Sparge steam is admitted into tangential inlets along the length of the vessels. The vapor is scrubbed and condensed in a combination scrubber-condenser. The flakes are conveyed from the stripping vessel to the cooking vessel through a rotary valve and are eventually discharged through another rotary valve.

The operating variables of moisture level, jacket temperature, steam temperature and quality are all controlled independently. Also the retention time in the vessels can be controlled by changing the speed of the shaft rotation.

The products with PDI values ranging from 10 to 85, are light colored, and contain a minimum of fines. Due to the absence of noncondensible gas in the system, the solvent loss is negligible.

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