Solvent Extraction Techniques for Soybeans and Other Seeds: Desolventizing and Toasting

C. L. KINGSBAKER, Blaw-Knox Chemical Plants, Inc., Pittsburgh, Pennsylvania 15222

Introduction

If a chemical engineer were given the problem of designing a piece of equipment to remove hexane solvent continuously from several thousand tons a day of soybean flakes using direct and indirect steam and toast them to a golden brown color, he would probably throw up his hands and say it could not be done. It is no wonder that after first using Schneckens, then vapor desolventizers, soybean processors have ended up with the "DT's." There is no doubt that desolventizing and toasting are the most difficult processes in the solvent extraction field to carry out both from the standpoint of equipment design and day-to-day operation. The various systems described in this paper provide the processor with the necessary equipment to produce a variety of products. The proper selection of the desolventizing and toasting systems can only be made when the specific products to be sold have been determined.

Schnecken System

The earliest continuous desolventizing toasting system was the Schnecken, which is illustrated in Figure 1. A Schnecken system consists of a series of horizontal steam jacketed tubes stacked one above the other. They are provided with ribbon conveyor flights to transport the meal and allow vapor to escape. Sparge steam is added at the outlet of the bottom tube, which is generally larger in diameter than the others and it flows countercurrent to the meal. As meal is conveyed from tube to tube, live steam and radiant heat remove the hexane. Experience with the Schnecken indicates they are difficult and hazardous to clean, expensive to maintain and generally do not remove solvent as thoroughly as other types of desolventizing systems. The maximum protein dispersible index (PDI) for the meal from the Schnecken is in the range of 65% to 75% with normal PDI values in the range of 40% to 50%.

Vapor Desolventizer

The next equipment that appeared in the industry was the vapor desolventizer deodorizer pressure toaster system. Figure 2 illustrates a modification of this system in which the deodorizer can also function as a toaster (1). This system produces the widest variety of products as measured by PDI values, and is in use in plants today to produce meals for soybean concentrates and isolates. All three pertinent variables, time, temperature, and moisture, can be adjusted at will during operation.

About 99% of the solvent is removed in the horizontal vapor desolventizer by a special cage which conveys and showers the flakes through superheated solvent vapor. Residence time is only 3 or 4 min, temperature of the flakes is kept under 185 F, and no moisture is added. In fact, there is a slight moisture reduction while passing through the recycle vapor desolventizer. PDI value of meal from the recycle vapor desolventizer is essentially that of solvent flake feed. Should maximum protein denaturation be required in the product meal (low PDI values) water is added to the vapor desolventizer product meal in the mixer conveyor ahead of the deodorizer.

The deodorizer is a horizontal vessel containing a conveying and lifting device, designed to provide intimate contact between flakes and stripping gas (steam). The vessel is provided with a discharge dam arranged so that retention time can be adjusted during operation by regulating meal level. Pressure within the vessel can be regulated as required between ½ atm. and 2 atm. Under vacuum (½ atm.), steam does not condense in the meal and acts as a solvent stripping medium. At atmospheric pressure some steam condenses in the meal while vaporizing hexane but the balance of steam acts as stripping medium. As pressure increases, more of the steam condenses while vaporizing hexane and now the moisture is high enough for a thorough cooking operation. It will be found that primary control of PDI value of product meal is attained in the deodorizer and mixer by controlling: (a) Residence time, meal level in the unit controlled by the movable dam; (b) Temperature, set by vacuum, atmospheric or pressure operation; (c) Moisture, set by stripping steam flow and pressure control in the deodorizer to control quantity of condensed steam in the meal. Further moisture addition, if required, is accomplished in the mixing conveyor.

The advantages of the vapor desolventizer deodorizer system are: (a) Low steam consumption; (b) Controls time, temperature, moisture as required to produce desired PDI products; (c) Trouble free operation and low maintenance; (d) High recovery of solvent; and (e) Minimum flake breakage for Japanese protein products.

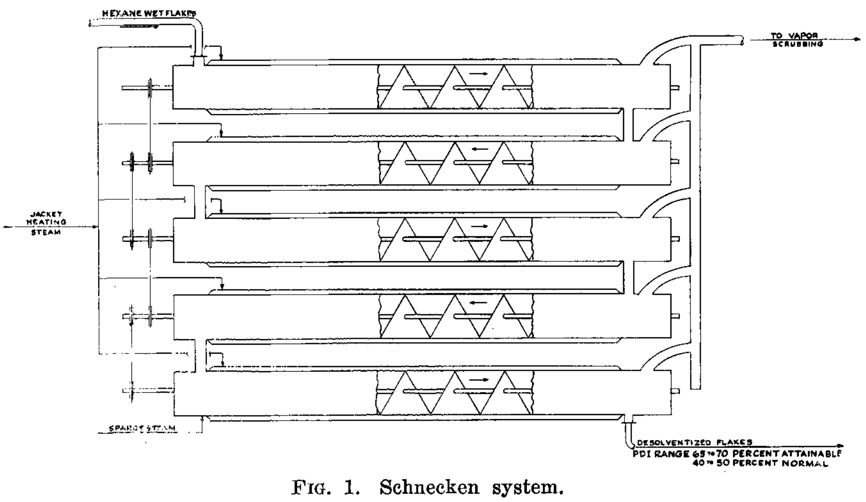

FIG. 1. Schnecken system.

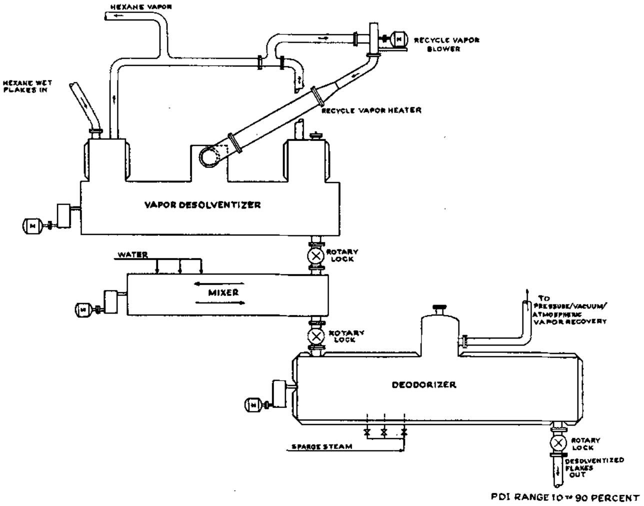

FIG. 2. Vapor desolventizer deodorizer system.

Product meal PDI values can be controlled throughout the range of 10% to 90% with the upper limit approaching 1% or 2% below the PDI of the extracted soy flakes.

Figure 3 illustrates a flash desolventizer system which includes both desolventizing and meal deodorizing sections (2). The desolventizer section consists essentially of a pneumatic (hexane vapor) conveying tube into which solvent extracted flakes are fed, and through which superheated solvent vapors simultaneously desolventize and convey the flakes to a cyclone separator. The vapors and flakes are separated in the cyclone. Solvent vapor removed from the meal enters a condenser, and the balance of the hexane vapor is recirculated through the superheater. Desolventized flakes with most of the solvent removed are discharged through a rotary lock to the meal deodorizer.

In the meal deodorizer, the balance of the solvent is stripped from the flakes by an inert purge gas which flows counter to the meal. The purge gas can be recycled through a filter and a hexane condenser, and reused again. The attainable PDI on meal product is in the 70% to 90% range with the upper limit about equal to the vapor desolventizer deodorizer described above, when operating the deodorizer unit under vacuum.

The flash desolventizing system is used primarily as follows: (a) Where the throughput rate is relatively low; and (b) Where material being processed is very fine. Its main disadvantage is the relatively high power requirement per unit of throughput. Its advantages are lower installed costs at the lower processing rates and it can handle fine materials. Since this system operates at relatively low temperatures, no cooking of the meal occurs and, therefore, cannot be used in the animal feed industry.

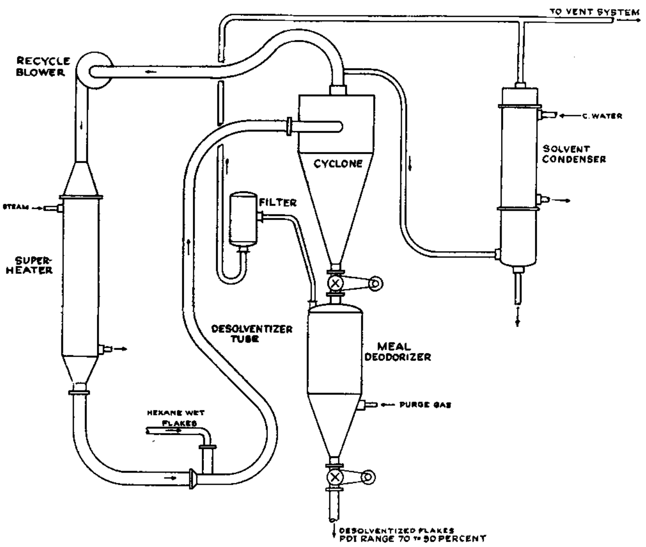

FIG. 3. Flash desolventizer system.

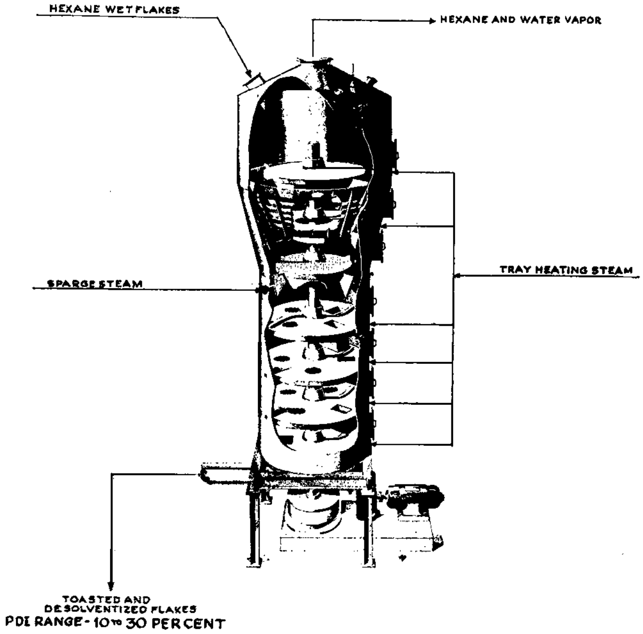

FIG. 4. Desolventizer toaster system.

Desolventizer Toaster

The desolventizer toaster, which is illustrated in Figure 4, is a unit that is widely used in processing soybeans in the United States (3). Its capacity ranges from 100 tons/day to one that is operating far in excess of its design rating of 2400 tons/day. The D-T, as it is commonly known, is patented by Kruse (4) and is a vertical vessel with steam heated tray sections. Hexane wet flakes, which enter the top or desolventizing section, are sparged with steam on one or more of the upper trays. Steam condenses in the flakes, vaporizing the hexane so that the moisture content of the flakes is raised to about 20%. In the lower trays, the flakes are heated to about 225 F where they are toasted and the moisture content is reduced several per cent. The desolventizer toaster produces a golden brown meal used in making cattle, hog and poultry feeds. Urease and other enzymes harmful to animals are easily destroyed. However, the unit has a high steam consumption, and produces meals with a PDI of 10% to 30%. It cannot be used for production of soybean isolate and concentrate meals.

Soybean desolventizer toaster units (3) are designed with the sparge steam addition through small holes on Tray 3 rather than through steam pipes attached to the sweep arms on the top trays. This provides a high steam efficiency, about 8½ to 9 lb./hr for each ton per day of soybeans processed rather than the normal 10 to 11 lb./hr when using sweep steam. It also provides better steam distribution resulting in more uniform cooking to give the golden brown colored meal so desired by the feed industry.

REFERENCES

1. Kingsbaker, C. L., Jr., R. D. Good and K. W. Becker, U.S. Patent No. 3,392,455 (1968).
2. Good, R. D., U.S. Patent No. 3,367,034 (1968).
3. Kruse, N. F., and N. H. Witte, U.S. Patent No. 3,018,564 (1962).
4. Kruse, N. F., U.S. Patent No. 2,585,793 (1952).

[Received January 2, 1970]