System for Production of High and Low Protein Dispersibility Index Edible Extracted Soybean Flakes[1]

E.D. MILLIGAN and **J.F. SURIANO,** EMI Corporation,
Des Plaines, Illinois 60018

ABSTRACT

A standard flash desolventizing system has been combined with horizontal agitated meal stripping and cooking vessels operating at atmospheric pressure to provide an integrated system for the production of high, intermediate, or low protein dispersability index edible soybean flakes from extracted solvent-wet flakes. Flash desolventizing removes most of the hexane in the wet flakes by evaporation at low temperature in a turbulent stream of superheated hexane vapor. The small remaining hexane quantity is removed in a stripping process capable of producing the full range of protein dispersability index values in the flakes by treating the flash desolventized flakes with either dry superheated steam or wet saturated steam under carefully controlled conditions of steam temperature, pressure, flow rate, and moisture content. The products are light colored, with little production of fine particles.

INTRODUCTION

During recent years, there has been a dramatic growth in the production of specialty protein products from soybeans for both industrial and edible uses. This growth has been accompanied by increased demand for a wide range of products with various values of protein dispersability index (PDI) and for light color. To meet this demand, it has become necessary to change equipment and operating conditions from those customarily used in solvent extraction plants producing meal for animal feed. The desolventizing step is the one most critical for production of high quality flakes for subsequent protein products production. In most plants, desolventizing is accomplished in the desolventizer-toaster, or D-T, in trays operating with high temperature, long retention time, and high moisture content. These severe heat treatment conditions are used to produce the golden toasted color desired for animal feed and provide for the inactivation of antidigestive factors present.

However, production of protein products with a full range of functional properties requires desolventizing under more gentle heat conditions with minimum retention time, at low temperature and at low moisture, to minimize protein denaturation and produce the lightest possible color flakes. These flakes then are heat treated under carefully controlled conditions to strip residual solvent and produce high, medium, or low PDI flakes as required, still with a light color.

FLASH DESOLVENTIZING SYSTEM

The flash desolventizing system is designed to obtain these conditions and to produce desolventized flakes with maximum soluble protein content. The PDI of the flakes leaving the flash desolventizing system is within 1-2 points of the PDI of the feed to the system.

A simplified flowchart of the flash desolventizing system is shown in Figure 1. The main elements of the system are the desolventizing tube, the flake separator, the circulating blower, and the vapor heater. These are arranged as shown in a closed loop system in which superheated solvent vapor is circulated continuously. Solvent wet flakes are fed continuously into the system through a variable speed feed conveyor. The flakes are entrained in and conveyed by the high velocity circulating vapor stream. Turbulent contact with superheated vapor results in the evaporation of most of the solvent from the flakes, which then are separated and leave the system through a rotary valve into the flake stripper. The evaporated vapor leaves the system through a control valve, is scrubbed and then condensed in the solvent condenser.

The flakes from the flash desolventizing system contain a residual quantity of up to 1.0%, by wt, of hexane which is removed by retention in a heated vessel for a sufficiently long period to allow for evaporation and diffusion of the hexane from the flakes, an operation known as stripping. A carrier vapor is sparged into the vessel to remove the diffused hexane vapor from the void spaces in the flakes. The use of moist heat and high temperature is avoided in this process to avoid denaturation of the soybean protein if high PDI flakes are desired. Values from 85-90 PDI are possible depending upon the PDI of the entering flakes.

If, on the other hand, low PDI flakes are desired, the flash desolventized flakes are cooked at relatively higher temperature and moisture, and for a longer time. Experimental work on the flash desolventizing system by the Northern Regional Research Center, Peoria, Ill., was described in 1959 (1).

The first commercial flash desolventizing system was installed in a soybean extraction plant in 1960, followed by several more in the early 1960's. Now 13 units have been supplied or are in process in the U.S. and abroad. The early units made use of existing surplus equipment to perform the stripping and cooking operations, usually schneckens left over from previous extraction plants.

The methods used in the early stripping systems to prevent protein denaturation utilized either circulating inert gas or a low rate of live steam sparging. With inert gas sparging, the maximum PDI values of 85-90 were obtainable, while with low rate steam sparging the maximum PDI values obtained were 75-80. The inert gas system required recovery of hexane in a mineral oil absorption system and recirculation of the lean gas. Fines in the inert gas frequently plugged the mineral oil system and resulted in excessive downtime for cleaning, during which time the solvent loss was excessive. In the case of live steam sparging, the very low steam quantity necessary to avoid denaturation frequently was insufficient for removal of residual hexane; and the loss of solvent with the flakes increased.

If the flakes required controlled cooking, the early systems employing schneckens were found to be primitive, cumbersome, and difficult to control.

NEW SYSTEM

A new system with positive solvent recovery and minimum operating cost was needed to eliminate these operating problems and to provide an easily controlled process. This system should be flexible enough to permit production of flakes with high, medium, or low PDI values simply by changing operating conditions from 85-90 PDI down to 20-25 PDI.

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[1]One of seven papers presented at the symposium, "Processing Methods for Oilseeds," AOCS Spring Meeting, April 1973.

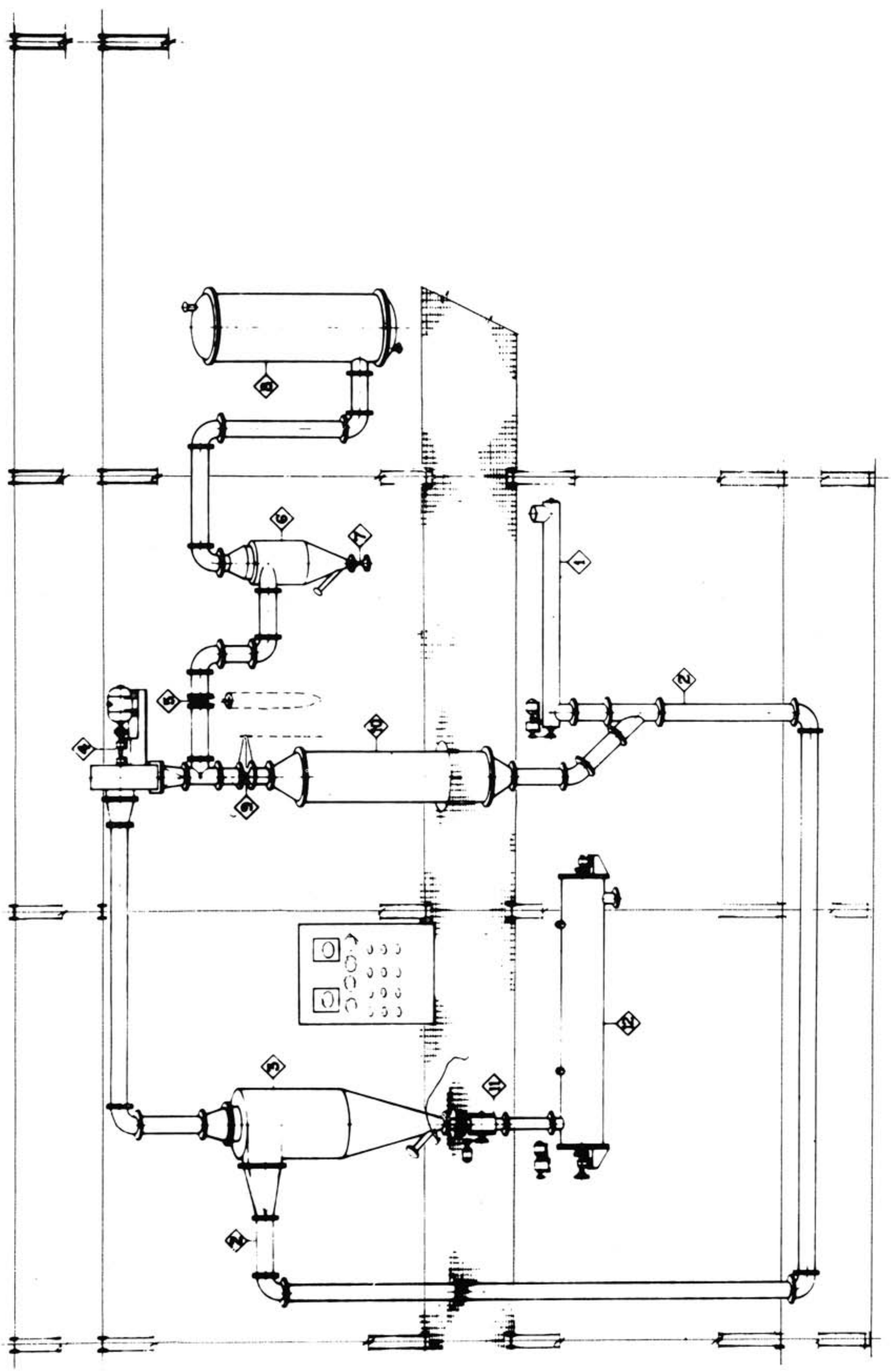

FIG. 1. Flash desolventizing system flow chart: 1 = feed conveyor, 2 = desolventizing tube, 3 = flake separator, 4 = circulating blower, 5 = system pressure control valve, 6 = vapor scrubber, 7 = scrubber discharge lock, 8 = solvent condenser, 9 = recirculating control valve, 10 = vapor superheater, 11 = separator discharge lock, and 12 = flake stripper.

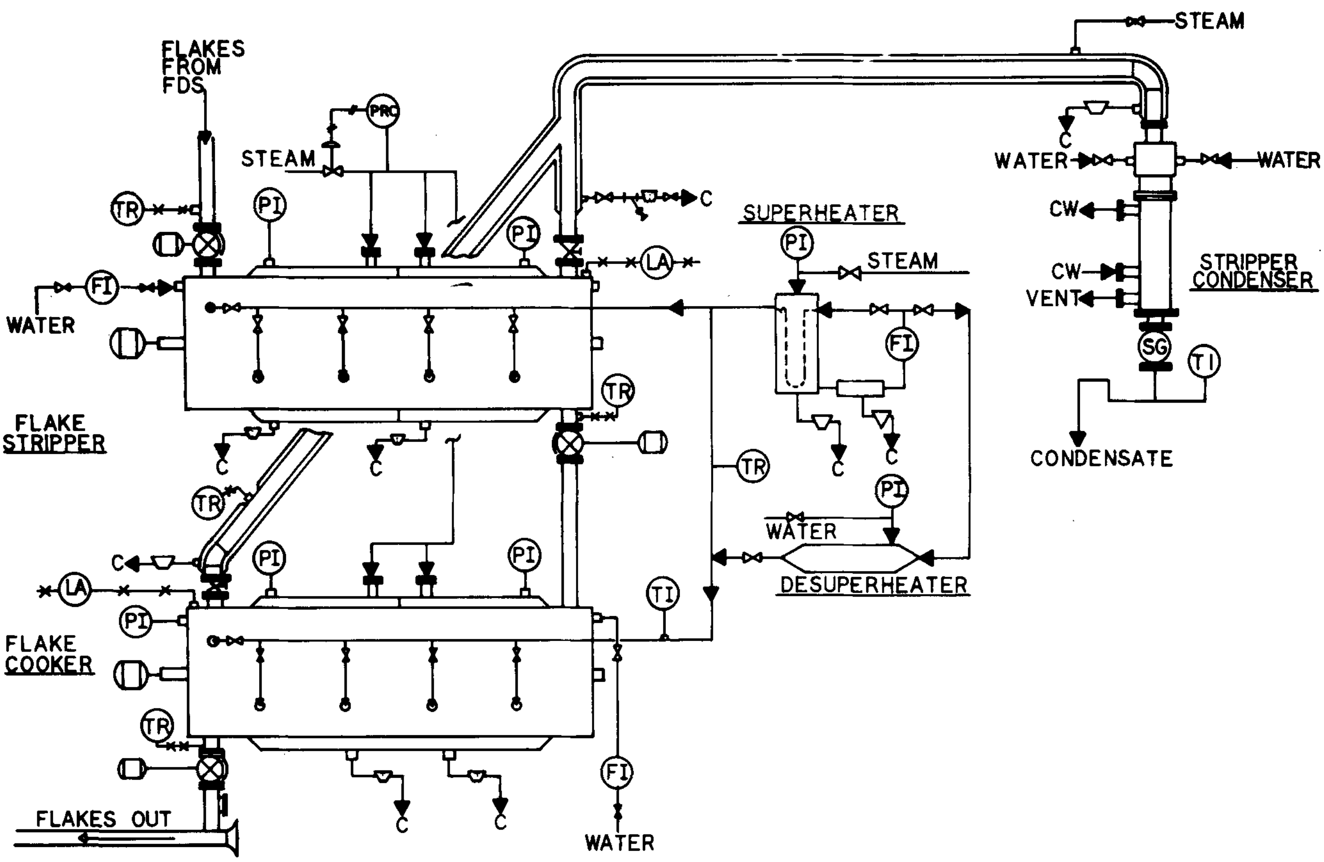

FIG. 2. Flake stripper and cooking system flow chart.

The system now being supplied for this purpose includes a standard flash desolventizing system combined with a new design for the flake stripping and cooking system. This system is designed to produce flakes at any desired PDI value within the full range of PDI desired for edible and industrial protein uses, under precisely controlled conditions, and to minimize the operating problems and solvent losses encountered with the earlier systems.

Figure 2 illustrates the new flake stripping and cooking system developed to meet the above requirements.

The high PDI flakes leave the flash desolventizing system through a rotary valve under the flake collector and enter two vessels in series, mounted one above the other. These vessels are horizontal steam jacketed tanks each with a motor driven shaft equipped with conveying and mixing paddles. Live steam can be admitted into the flakes through tangential inlets along the length of the vessel. Vapor is removed through steam jacketed pipes and is scrubbed and condensed in a combination scrubber-condenser. Flakes are conveyed through the top vessel, dropped through a rotary valve into the bottom vessel, and are finally discharged to a pneumatic cooling system through a rotary valve. Water can be added at the feed end of each vessel through a spray nozzle. The jacket is equipped with a steam pressure recorder-controller, and key temperatures are recorded.

The live steam to either vessel is controlled through a flow meter and then can pass alternatively through either a superheater or a desuperheater. In the superheater the low pressure steam from the flow meter is heated by indirect contact with the high pressure supply steam. In the desuperheater, water is sprayed into the low pressure steam to produce a saturated steam. Thus, wet steam, saturated steam, or superheated steam can be admitted into either vessel under controlled conditions as required.

The operating variables of moisture level, jacket temperature, steam temperature and quality, and steaming rate are all independently controllable. In addition, retention time in the vessels may be changed by changing the speed of the shaft rotation.

In operating the system for stripping only to produce high PDI flakes, an essential feature of the process is the prevention of condensation of live steam on the flakes. Such condensation and heating would result in excessive denaturation of the soybean protein. This is now accomplished by using superheated steam at atmospheric pressure as the carrier vapor in place of the circulating inert gas or air-steam mixtures formerly used. The superheated steam temperature and rate are carefully controlled to provide sufficient sensible heat for heating the flakes to 212 F without condensing any of the superheated steam. Because the quantity of steam used would result in an abnormally high vapor velocity in the usual schneckens type of vessel previously used, it is necessary to use a vessel of larger diameter to reduce the velocity to a reasonable figure. The jacet steam pressure also is controlled at a low level to prevent denaturation of the protein. By use of this system, provided that the solvent-wet flakes are supplied at a PDI of 90, the stripped flakes are regularly produced at a PDI of 85, a total drop of only 5 points. The steam and hexane vapor from the vessels are condensed in the specially designed scrubber-condenser, and the solvent is recovered easily.

The flakes can, alternatively, be cooked to a PDI of 20-25 by adding moisture, admitting desuperheated or saturated steam, increasing the jacket temperature to maximum, and increasing the retention time by slowing the vessel rotation speed.

Flakes with intermediate PDI values can be produced by suitable modifications to the above conditions.

In a system placed in operation last year, flakes with PDI values ranging from ca. 15 up to ca. 85 have been produced by adjustment of the above controllable variables. The system is designed for ease of cleaning for sanitation purposes. The mechanical design is simple requiring a minimum of maintenance. The products produced are light colored and contain a minimum of fines, and the solvent loss is negligible because of the absence of noncondensible gas in the vapor both from the flash desolventizing system and the stripping system.

REFERENCES

1. Brekke, O.L., G.C. Mustakas, M.C. Raether, and E.L. Griffin, JAOCS 36:256 (1959).

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