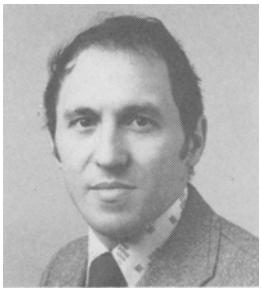
Oilseed Flour for Human Food

F.G. BASTIAENS, Cargill Soja Industrie B.V., Amsterdam, The Netherlands



ABSTRACT

Methods of producing oilseed flours, primarily soybean flours, for human consumption are reviewed. Differences between processing for human food and for animal feed are described.

INTRODUCTION

In this paper I shall discuss the production of oilseed flour for human consumption and outline some of the more important processing and handling differences in relation to the properties required of the finished products.

I will concentrate on soybean processing, since this is one of the most widely known oilseeds.

Defatted soy flour production for human consumption may be divided into four general steps, in each of which are parameters which must be closely controlled, since they affect finished product quality. These stages, which are illustrated in Figure 1, are (I) pretreatment of the beans; (II) oil extraction; (III) flash desolventizing, cooking, and cooling; and (IV) grinding and handling of flour.

PRETREATMENT OF THE BEANS

Bean Handling

When the beans arrive at the storage area, care must be taken during unloading to select the beans most suitable for human food production. Therefore, rapid quality checks and analyses for which adequate equipment and trained operators are required must be performed in the bean receiving area. An additional complication exists for plants not situated in the bean growing countries, since most deliveries are made in large shipments needing high unload capacity conveyors–up to 1,200 tons/hr. At this discharge rate, it is even more difficult to preselect the beans, making a flexible storage system an essential. This need for flexibility is in complete contrast with bean handling areas for animal feed plants.

Bean Drying and Cleaning

The beans should be cleaned completely of all foreign materials (FM), such as seed pods, weedseeds, trash, and soil. To achieve the optimum bean quality, it is necessary to equip the plant with highly efficient scalping and dust-collecting systems ahead of the bean dryer. This gives beans practically free of FM. Before the dehulling operation, the beans are dried, usually to 10.5% moisture, depending on the dehulling system used. It is important to dry the beans uniformly and at low temperature (max. 70 C) to minimize protein denaturation.

Dehulling

The dehulling system is basically the same as that used for high protein animal feed production. More attention must be paid, however, to the air pickups, conveyors, general layout, etc., to prevent microbial and other contamination of the product.

EXTRACTION

The extraction process needs no additional modifications, compared to animal feed production. This must be a well controlled operation. The big difference in processing occurs in the desolventizing operation.

FLASH DESOLVENTIZING, COOKING, AND COOLING

In comparing the normal desolventizing-toasting system (D-T) and the flash desolventizing system (FDS), it can be seen that in the D-T a large amount of heat at 100 C is given to the flakes over a long period of time (15 min) (Fig. 2). This gives a denatured product of uncontrolled protein solubility.

Several methods are available to measure protein solubility. The two analytical procedures accepted by AOCS and used for commercial purposes are the Nitrogen Solubility Index (NSI) (1) and the Protein Dispersibility Index (PDI) (2) (Table I). The PDI value is larger than the NSI value for a given protein solubility. The difference is related to the mixing speed of the two methods. In either case, the value obtained is a ratio of the amount of nitrogen dispersed, in water under a given set of conditions, to the total nitrogen in the material.

Flash desolventizing, followed by stripping (deodorizing) and cooking, is used to obtain a product over a wide range of PDI values.

The degree of protein denaturation is affected by moisture content, temperature, and time.

In the flash desolventizer, a dry dehydrating atmosphere prevails, the temperature of the flakes is no higher than the boiling point of the solvent for most of the time, and the retention time in the system is only a few seconds.

The flash desolventizing processes used today are shown in Figure 3. The extracted flakes with 27-30% solvent are fed into the desolventizing loop by a variable feed conveyor. The flakes are picked up and conveyed by hot vapor which has been superheated in the vapor heater to 165 C. As the flakes travel through the desolventizing loop to the flake separator, the greatest portion of the entrained solvent is evaporated and the flakes heated up to 80 or 90 C. The desolventized flakes, with ± 1.5% residual solvent, are discharged from the flake collector to the flake stripper.

Stripping, Cooking, and Cooling

The flakes discharged from the desolventizing operation contain 1.5% of hexane. The process of removing residual hexane without significant reduction in PDI is known as "flake stripping" or "deodorizing." For producing flakes with a high PDI, the flakes pass through the stripper and cooker with superheated sparge steam added and with low jacket steam.

The final flake PDI is dependent primarily upon the PDI of the feed flakes entering the flash desolventizing. The total drop in PDI through the FDS and the stripping system is ca. 3 points (max. 5). For cooking, or producing flakes with low PDI, water is added to the sparge steam; the pressure in the vessels is increased to 15 psig and the jacket steam pressure to 25 psig. The effect of retention time on PDI of the flakes is shown in Figure 4. Retention times of high and low PDI flakes vary from 5 to 20 min.

The excess vapor (Fig. 5) is continuously discharged through a pressure controlled valve. The blower circulates a large quantity of cooled vapor back through the heater, where it is reheated before it picks up new flakes. The excess hexane vapor flows through a scrubber, where meal

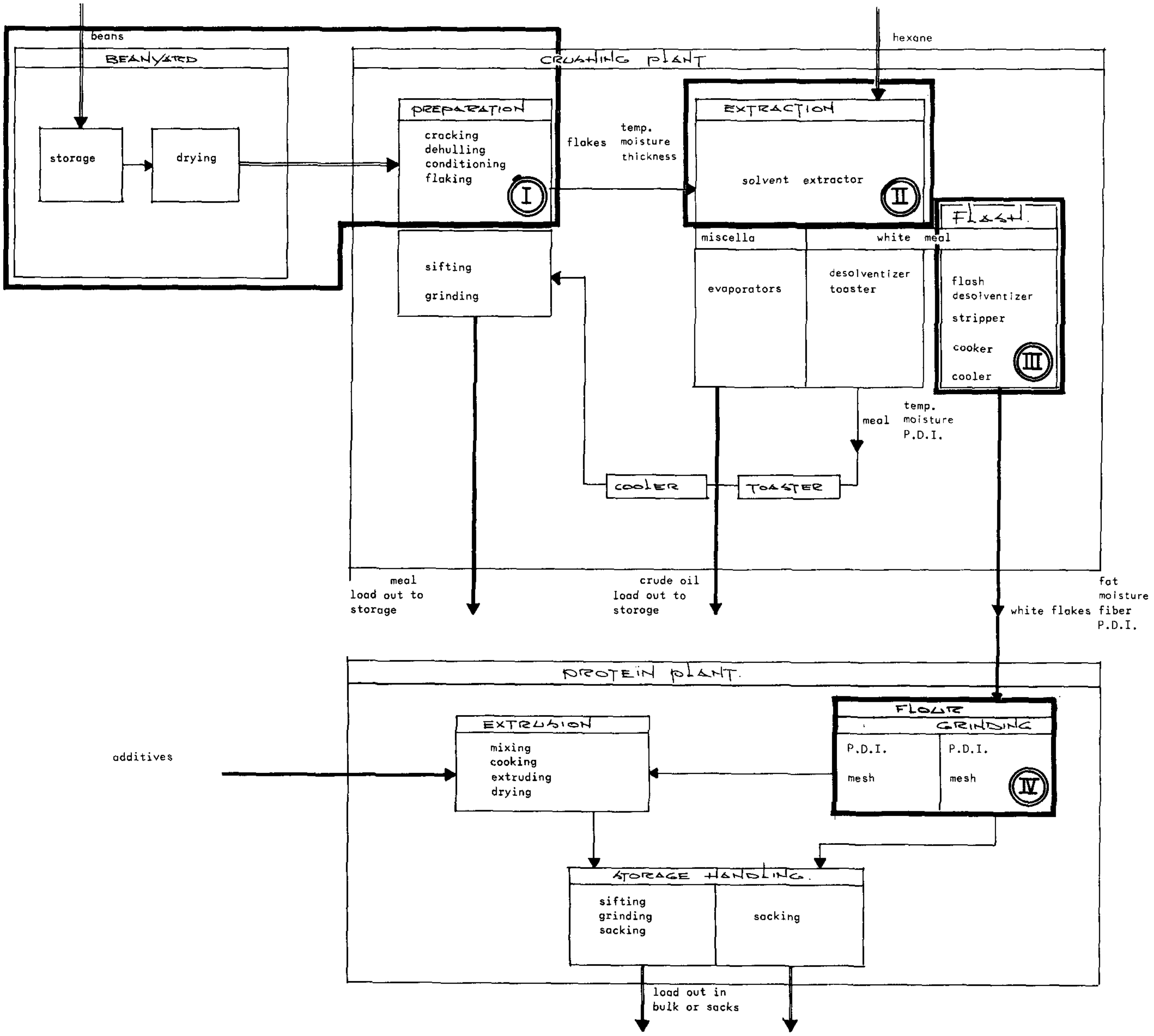


FIG. 1. Preparation step in production of soy flours. PDI = Protein Dispersibility Index.

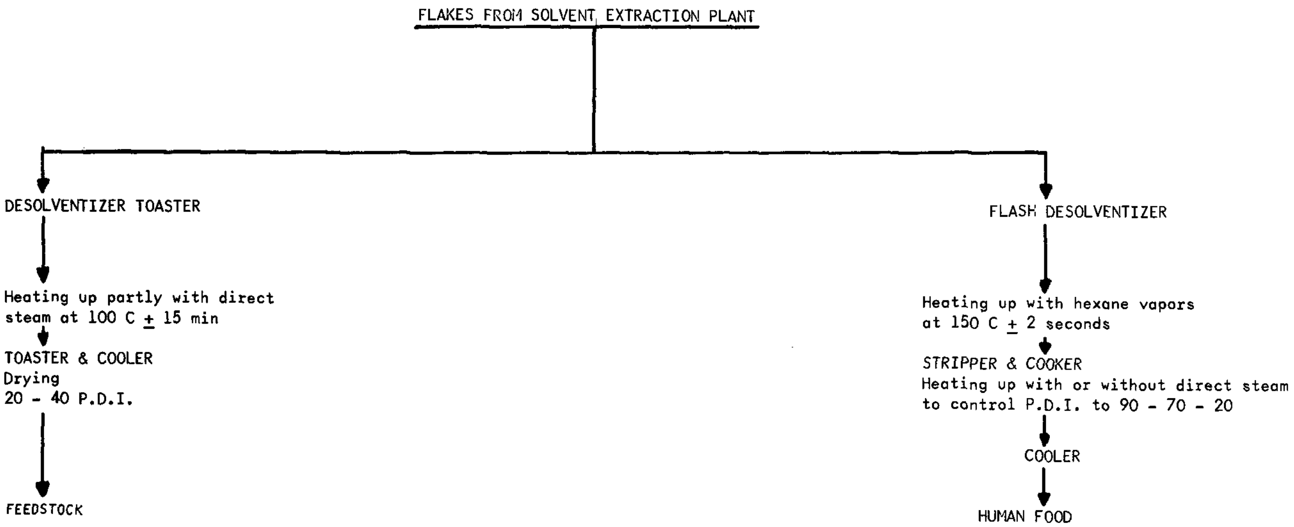


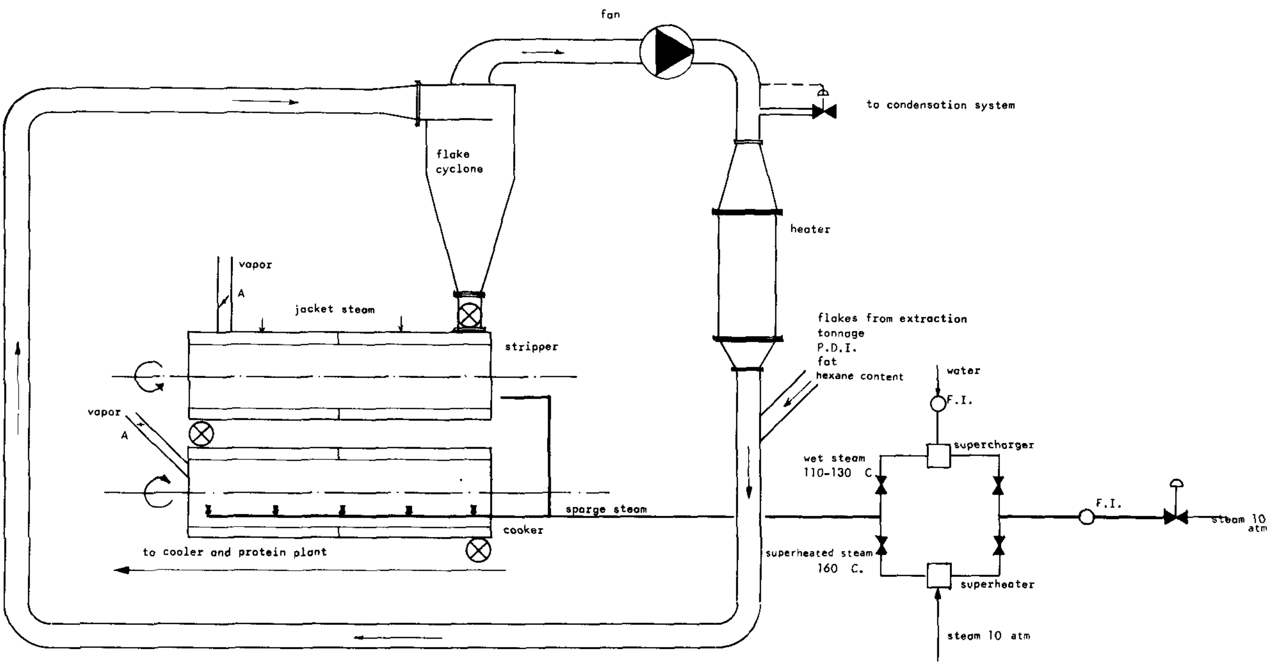
FIG. 2. Different desolventizing steps. PDI = Protein Dispersibility Index.

TABLE I

Standard Methods for Measuring Heat Denaturation of Soy Flour and Grits

Abbreviation	Term	Definition
PDI	Protein Dispersibility[a] Index	Percentage of total protein which is dispersible in water under controlled conditions of extraction.
NSI	Nitrogen Solubility[b] Index	Percentage of total nitrogen which is soluble in water under controlled conditions of extraction.

[a]AOCS method BA 10-65 (2).
[b]AOCS method BA 11-65 (1).



	jacket steam	sparge steam	butterfly valve A
20 P.D.I.	high	wet	closed
70 P.D.I.	medium	dry	open
90 P.D.I.	low	superheated	open

FIG. 3. Flash desolventizing. PDI = Protein Dispersibility Index.

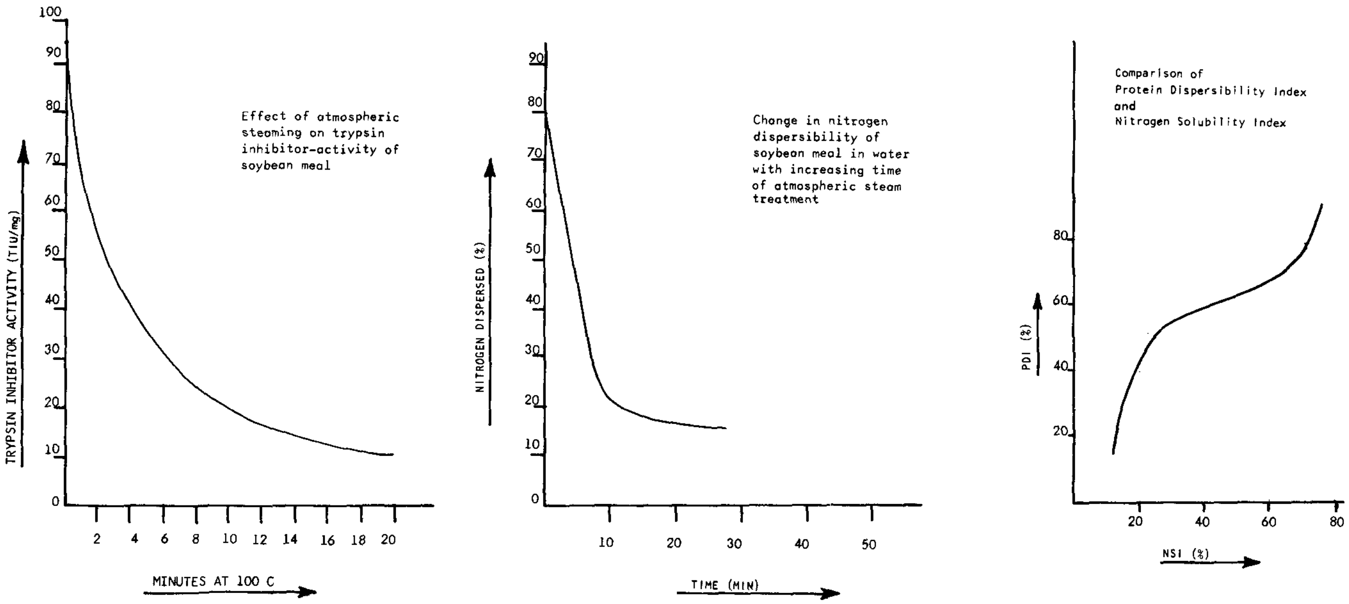


FIG. 4. Effect of retention time on Protein Dispersibility Index of flakes.

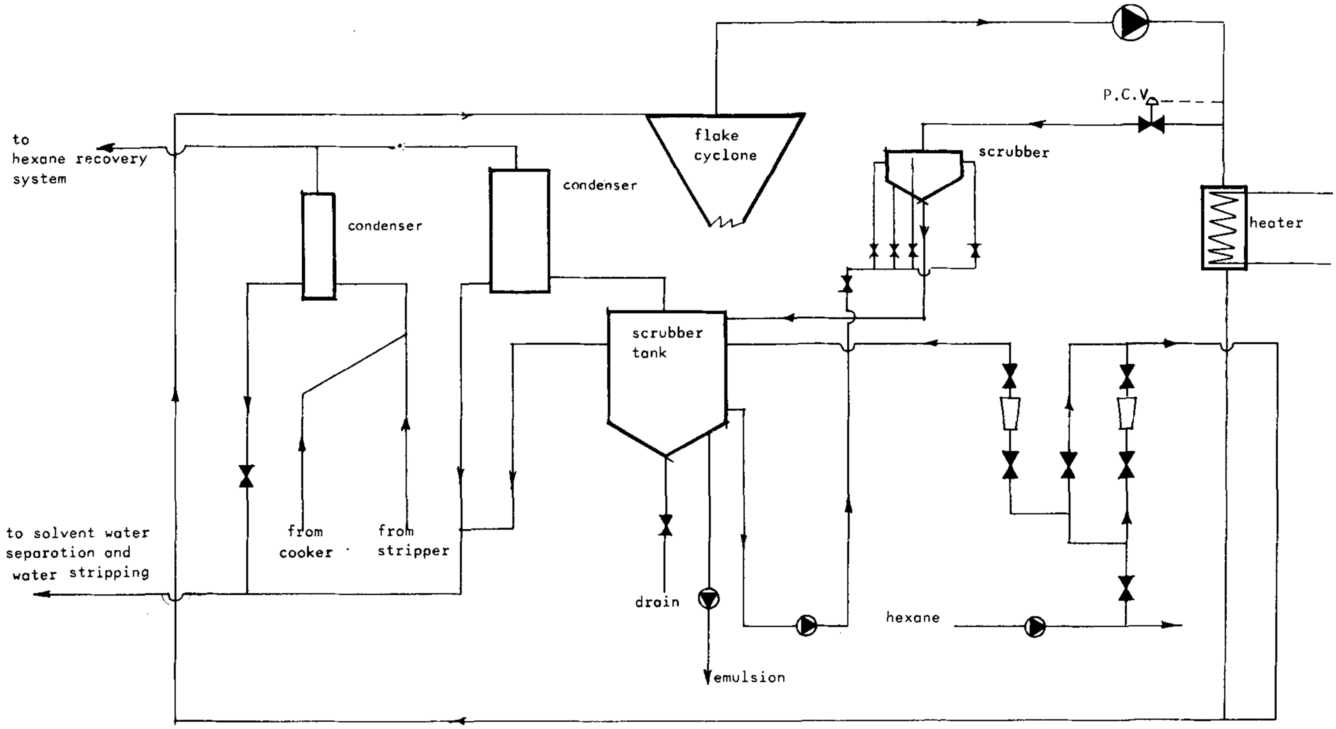


FIG. 5. Vapor flow of a flash desolventizing system. PCV = pressure control valve.

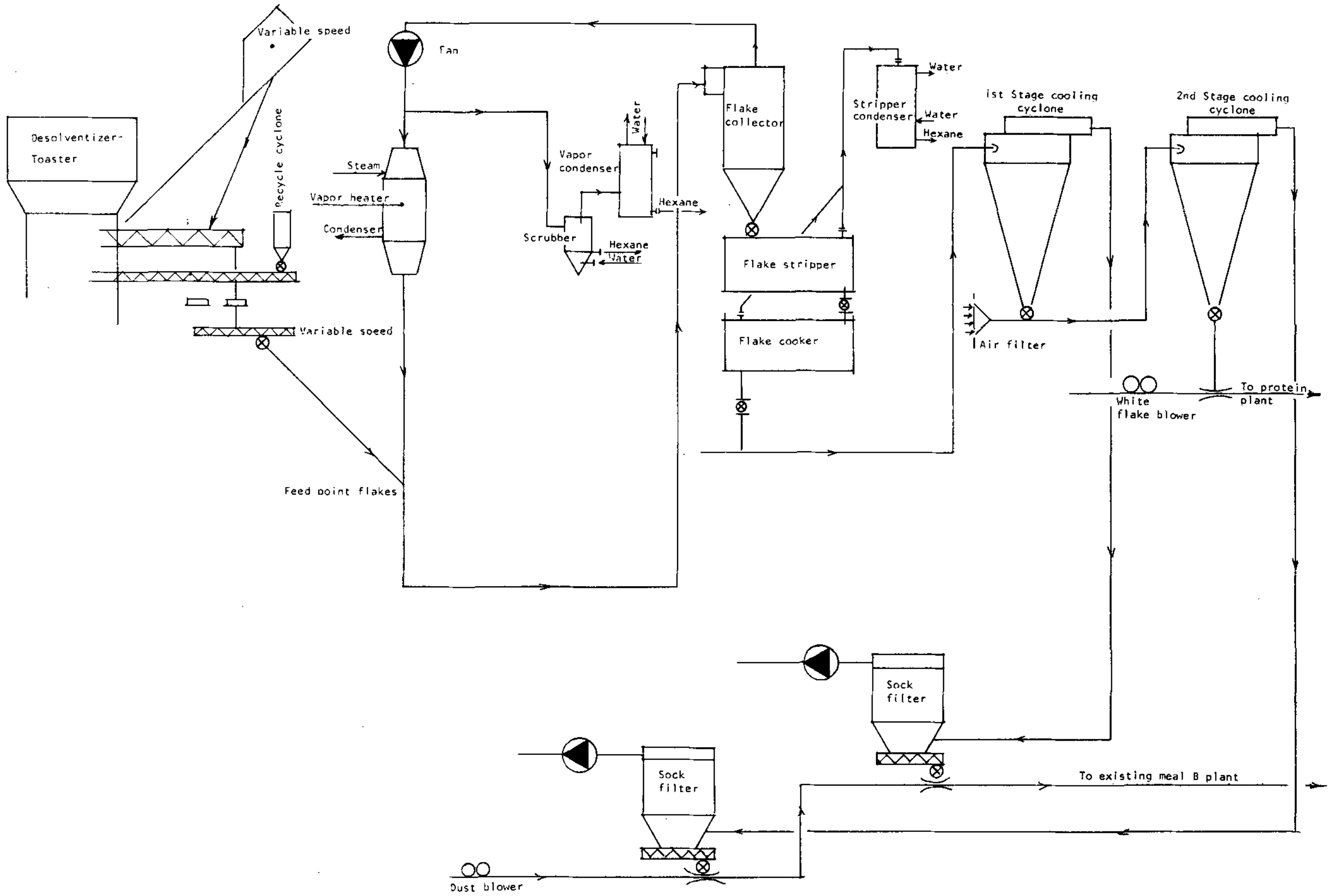


FIG. 6. Complete flow sheet for producing defatted flakes.

particles are washed out. The rest of the hexane vapors are drawn to the vapor condenser. The vapors from the stripper and cooker flow to the stripper condensers. Vapors leaving the condensers go to the hexane recovery system.

Engineering and Construction

To engineer and construct a flash desolventizing system, a great deal of attention must be paid to safety precautions. The system contains hexane vapors under pressure—up to

TABLE II

Commercial Types of Defatted Soy Flakes, Grits, and Flours

Product	Granulation (U.S. standard sieve size)	Heat treatment (PDI)[a] 20-40	60-75	85+
Flakes	+5 mesh	X	X	X
Coarse grits	-5/+20 mesh	X	X	
Medium grits	-20/+40 mesh	X	X	
Fine grits	-40/+80 mesh	X	X	
Standard flour	-100 mesh	X	X	X
Fine flour	-200 mesh	X	X	X

[a]Protein Dispersibility Index.

750 mm water—or vacuum at temperatures up to 165 C, well above its flash point. Precautions are necessary to avoid hazardous leakage of vapor out, or air into the system. The requirements of the pressure tests made before startup are much higher than for the normal desolventizer-toaster. Compared to normal desolventizing, more attention has to be paid to startup and shutdown procedures of the process. All the installations need a CO_2 or N_2 purging system. Figure 6 illustrates the complete process.

Sanitation Remarks

Special design is needed to prevent contamination and to allow efficient cleaning after being down with the system.

Air pickups should be filtered and situated in a dust free, dry area.

Water and steam additions to the process must meet food grade standards.

Other systems, called meal deodorizing, use an inert purge gas such as carbon dioxide or nitrogen instead of superheated steam for producing high PDI flakes.

Leaving the flash desolventizing, flakes enter the cooling system—normally a pneumatic conveying cooling system—which results in finished flakes 5-10 C above ambient temperature.

GRINDING OF FLOUR

To meet the requirements of their many applications, soy flours are produced in many forms with different particle sizes, heat treatments, and fat and protein contents.

1. *Protein content and classification*
   - Soy flour and grits with protein contents between 40 and 50%.
   - Concentrates, protein content of 70%.
   - Isolates with a protein content above 90%.

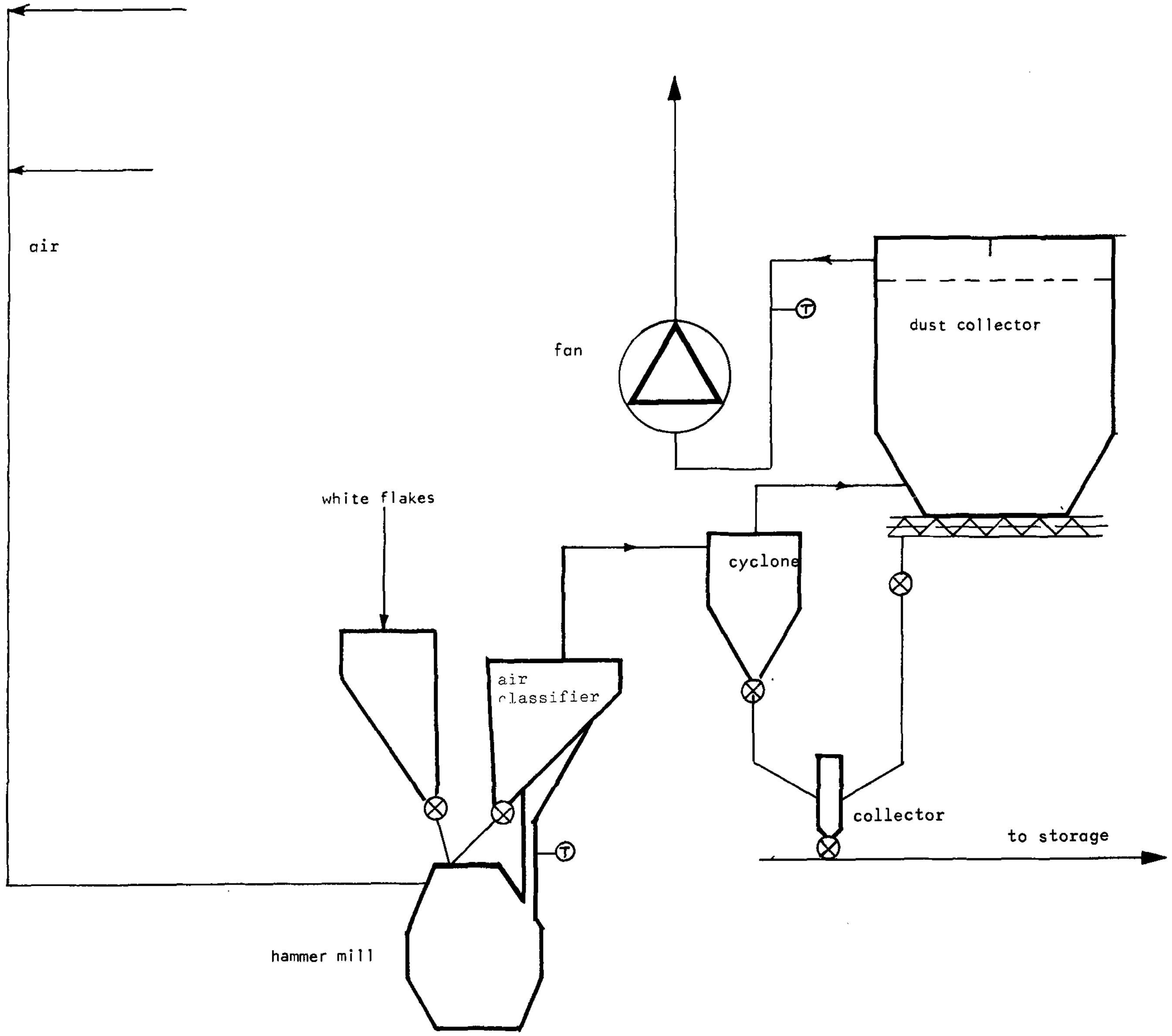


FIG. 7. Flour grinding flow sheet.

2. *Fat content classification*
- Defatted flour with a maximum of 1% fat.
- Full fat flour with a minimum of 18% fat.

(Some refatted flours are available but not common).

3. *Granulation classification*

Most soy flours and grits are produced from the same type of defatted flakes and therefore have the same chemical composition.
- Soy flour is the name normally given to products when 97% passes through a No. 100 mesh standard screen.
- The size classification used for grits varies from 5 to 80 mesh.

4. *Classification by heat treatment*
- Normal heat treated products range from 20 to 85 PDI. Table II illustrates the range of commercial flours and grits which are available.

Process Description

The next section briefly describes one of the more typical processes used to produce flour (Fig. 7).

Flakes are automatically fed into the feed tanks, where they pass through a feedlock and are sucked through the mill. Here the flakes are ground and transported with the same air to the air classifier. The coarser material separates and is returned to the mill. A further, more accurate separation takes place by means of a variable speed rotating disc on which blades are mounted. The rotating blades strike the particles, which are traveling in an upward moving air stream, to force them along the horizontal direction in a circular motion.

Since the larger particles are heavier, they will always drop out of the air stream and be recycled to the grinder.

The smaller particles are carried out of the classifier toward the cyclone, where finished product is collected and sent to storage. If the speed of the rotating blades is increased, more particles will be removed. In general, two grinds are produced (100 and 200 mesh) in the same milling system. For 100 mesh the capacity is twice as large as for 200 mesh at the same energy consumption and the same quantity of air. For example:

100 mesh flour - 4.5 M tons/hr product
- 3,500 Nm^3 air/ton
- 65 KWH/ton

200 mesh flour - 2.2 M tons/hr product
- 7,000 Nm^3 air/ton
- 135 KWH/ton

After storage, the product may be shipped out in bulk or sacks.

Safety

As the grinder is cooled by the transport air, interruption of the air flow will cause overfilling and heating of the mill. To prevent this hazardous situation, the systems need to be provided with temperature and pressure control instruments.

To prevent dust explosions, electrical wiring and equipment shall conform to the NFPA No. 70 Code. Precautions should be taken to prevent ignition by static electrical sparks or metal to metal sparks.

Grit Production

Grits are produced from coarse ground flakes and the separation into various grades achieved by mechanical sifting or a combination of air classification and sifting. The normal cuts produced from one system are in the ranges 20/40 and 40/80 mesh sizes.

Transport, storage, and load out can be achieved in the same way as soy flour.

REFERENCES

1. "Official and Tentative Methods of the American Oil Chemists' Society," Vol. I and II, Third Edition, AOCS, Champaign, IL, 1973 (revised yearly), Method BA 11-65.
2. Ibid., Method BA 10-65.