Prepressing of Soybeans Prior to Solvent Extraction

JOHN W. DUNNING and R. J. TERSTAGE, V. D. Anderson Company, Cleveland, Ohio

IT has been recognized for some years that the extraction of oil from raw cottonseed meats, copra, peanuts, and other high oil-bearing seeds and nuts is more rapid if these commodities are first prepressed and flaked (2, 3). This difference in extraction rate may be explained by the several theories concerning rates of extraction which are discussed in the literature. Karnofsky (3) concludes that the mechanism of extraction appears to be a combination of diffusion, dialysis, and the solution of slowly soluble extractable materials. In addition to these three factors, the physical nature of the extraction bed itself must be considered. This is necessary since an extraction bed composed solely of fine particles tends to compact and thereby impede the rate of diffusion of the extraction solvent into the bed, thus retarding the over-all rate of extraction. On the other hand, an extraction bed composed of well defined flakes furnishes a porous bed into which the extraction solvent may readily diffuse.

In discussing the relative extraction rates of raw, rolled cottonseed meats as compared to flaked cottonseed press cake, for example, it is stated (1) that the oil in cottonseed meats is contained within a specific cellular structure. Diffusion and dialysis to and across these cellular membranes would therefore have a retarding effect upon the extraction of oil from cottonseed meats. In addition, the flake structure of rolled, raw cottonseed meats tends to disintegrate when the flakes are immersed in petroleum solvents. This condition would similarly tend to retard the rate of extraction. On the other hand, the cellular structure of cottonseed meats is substantially destroyed by prepressing. Diffusion and dialysis across cellular membranes therefore is eliminated from the extraction of oil from flaked prepress cottonseed. In addition, these flakes, when immersed in petroleum solvents, furnish a porous bed through which the extraction solvent may readily diffuse. One would conclude therefore that the rate of extraction of oil from flaked prepressed cottonseed should be more rapid than from rolled, raw cottonseed meats. This is, of course, substantiated by experiment (2, 3).

The above considerations however are not as clear when theorizing on the rate of extraction of oil from flaked soybeans compared to flaked prepressed soybean cake. First, raw soybeans readily lend themselves to the preparation of firm flakes. Therefore no increase in the extraction rate would be anticipated by increasing the porosity of the extraction bed as a result of improving flake formation. Second, it appears that the oil in soybeans is not contained within the specific cellular structure (4), as is the case with raw cottonseed meats. One would anticipate therefore that the rate of extraction of oil from soybeans would not be appreciably increased by the prepressing operation. In order to test the above considerations a series of tests on the prepressing of soybeans and the extraction of oil from the resulting cakes was undertaken.

Soybeans were first prepressed to cakes which contained approximately 7, 10, 12, and 14% oil. Figure 1 shows the prepress cakes which contain 7.1%, 10.2%, and 12.5% oil. It may be seen from Figure 1 that the

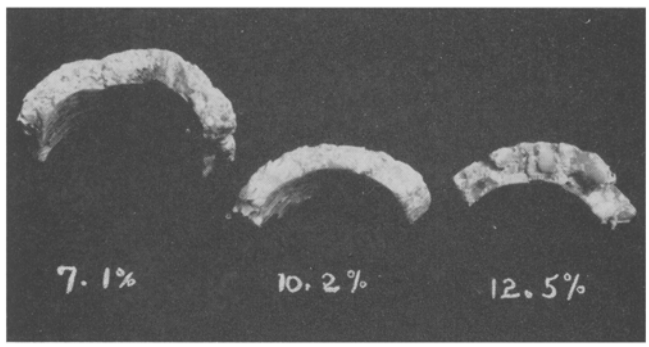

FIG. 1. Soybean prepress cakes containing 7.1, 10.2, and 12.5% residual oil.

12.5% oil cake contains many compressed but intact sections of soybean particles. The compressed soybean particles however are hardly apparent in the 10.2% cake. The 7.1% oil cake contains no sections of non-ruptured soybean particles. Soybeans therefore should be prepressed to less than 10% oil content in order to furnish a cake devoid of the original soybean structure.

These soybean prepress cakes were then conditioned and flaked. It was observed in all cases that the flakes were relatively firm and well defined. Samples of the flakes were suspended in hexane and shaken for a period of five minutes. They were then permitted to settle for two minutes before inspecting the samples for production of fines. Graduates containing flakes of 7.1% oil and 12.5% oil press cakes and original soybean flakes are shown in Figure 2. This photo was taken two minutes after the samples had been

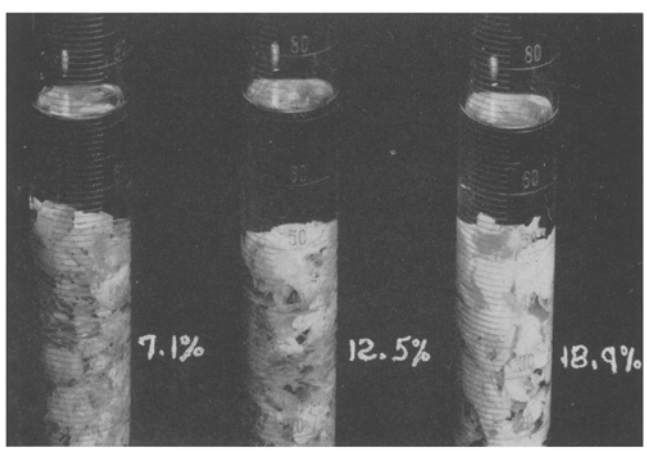

FIG. 2. Soybean flakes of 7.1, 12.5, and 18.9% oil immersed in hexane.

shaken. Since the fines produced from each sample is practically the same, it is apparent that the oil content of the prepress soybean cakes has very little effect upon the firmness of the flakes.

Studies were then undertaken to determine the optimum conditions for prepressing soybeans. This work was directed toward the production of press cakes containing less than 10% oil at the maximum

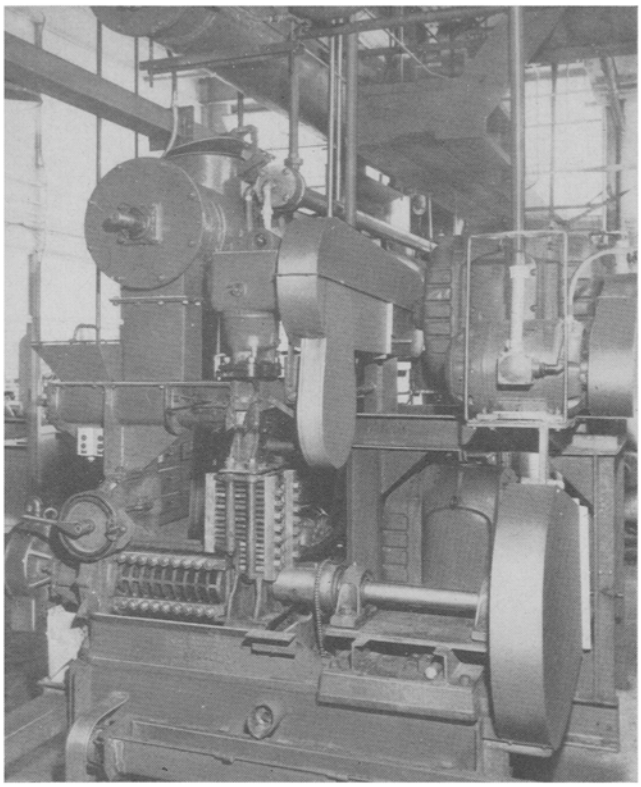

FIG. 3. View of pilot plant Super Duo Expeller.

capacity of the Expeller. This work was conducted in the quarter size Expeller in the V. D. Anderson pilot plant. This unit has one-eighth the capacity of a standard Super Duo Expeller and is shown in Fig. ure 3. Various runs with the pilot plant equipment demonstrated that for highest capacity the soybeans should be first cracked to approximately one-sixth of the original particle size. The cracked beans should next be conditioned at approximately 10% moisture content and at 140 to 160°F. and flaked as is common practice in solvent extraction. The flaked soybeans should then be dried to approximately 4% moisture content prior to prepressing.

The pilot plant Expeller was equipped with the equivalent of the standard YDV-7 prepress shaft. The horizontal shaft was operated at 45 r.p.m. and the vertical shaft at 85 r.p.m. The vertical barrel was spaced .025 in. in the top section; .015 in. in the middle section; and .010 in. in the bottom section. The horizontal barrel was spaced .010 in. in each of the three sections. The soybeans used in the prepressing tests contained 18.9% oil and 7.1% moisture. The beans were cracked and conditioned at 140°F., after the addition of .15 g.p.m. of water to the conditioning unit. Data from three different runs indicate that the pilot plant Expeller could process 600 pounds of beans per hour, furnishing prepress cakes containing 8.5% residual oil. At 650 pounds per hour a cake containing 9.9% oil was produced, and at 750 pounds per hour a cake containing 9.8% residual oil was produced. Based on these pilot plant unit capacities, a Super Duo prepress Expeller would have a capacity of 52.3, 56.7, and 65.4 tons of soybeans per day. A Super Duo prepress Expeller would therefore have a capacity of approximately 60 tons of soybeans per day, furnishing a prepressed soybean cake of less than 10% oil content.

Samples of the soybean prepress cakes which contained 9.3% and 12.8% oil were conditioned and flaked. Total submergence extraction rates were then run on three samples of flakes. The total submergence extraction rate test used consists of gently shaking a 10-g. sample of the flakes with different 50-ml. portions of hexane for the periods of time indicated in Figure 4. After the lapse of each period of time

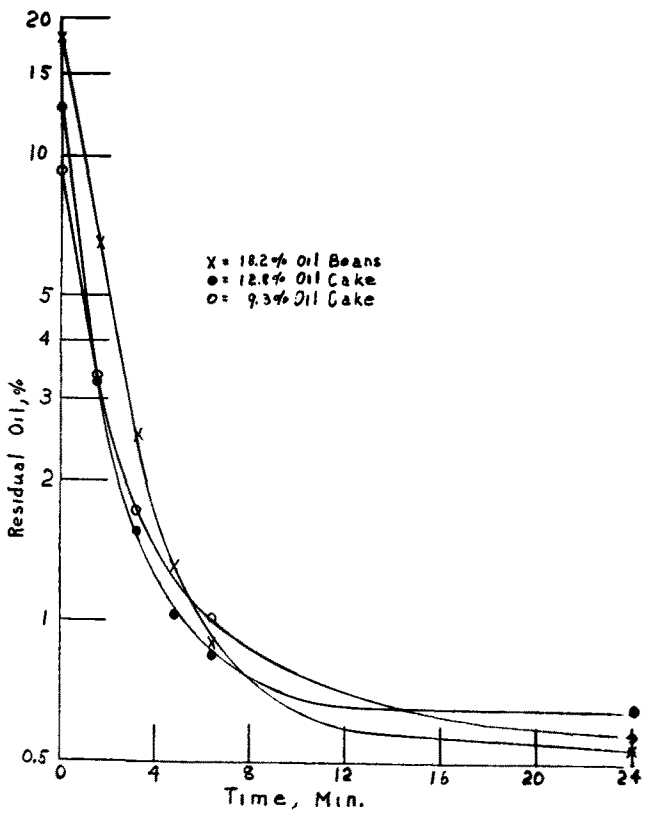

FIG. 4. Effect of residual oil in soybean prepress flakes on rate of extraction of oil from those flakes.

the miscella is filtered from the flakes, the sample is dried to constant weight so that the amount of oil extracted in that period of time is determined. The test was standardized to duplicate the extraction results that are obtained in commercial submergence column type extractors. The data from these tests are plotted in Figure 4. It is apparent from Figure 4 that the extraction rates of oil from soybean press cakes containing 9.3% oil and 12.8% oil are about the same as the rate of extraction of oil from soybean flakes themselves.

It may be concluded therefore that soybeans readily lend themselves to the prepressing operation. Approximately 60 tons per day of soybeans may be prepressed in a Super Duo Expeller yielding prepress cakes containing less than 10% oil content. The prepressed, conditioned, and flaked soybean cakes however even at less than 10% oil content do not show a higher rate of extraction over standard soybean flakes.

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