Solvent Extraction of the Soya Bean

Discussion of Extraction Methods with Detailed Description of One System

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SOLVENT extraction of the soya bean has many attractive features, most important of which is the high oil yield obtainable by use of this method of extraction.

Assuming a soya bean of 20% fat and 7% moisture content, the press method gives a cake with 6% fat while the solvent method yields a meal of 0.5% fat content. If cake and meal moisture content were the same at 7% the fat yields per ton of clean bean would be 300 pounds for the press and 392 pounds for the solvent extraction, or 75% and 98% extraction respectively. Based on 11½c oil and $39.00 meal the solvent extraction shows an increased financial return of $8.90 per ton of beans worked. In reality the solvent method shows a greater advantage than indicated because the average soya bean has a lower oil content than 20%—usually around 17%.

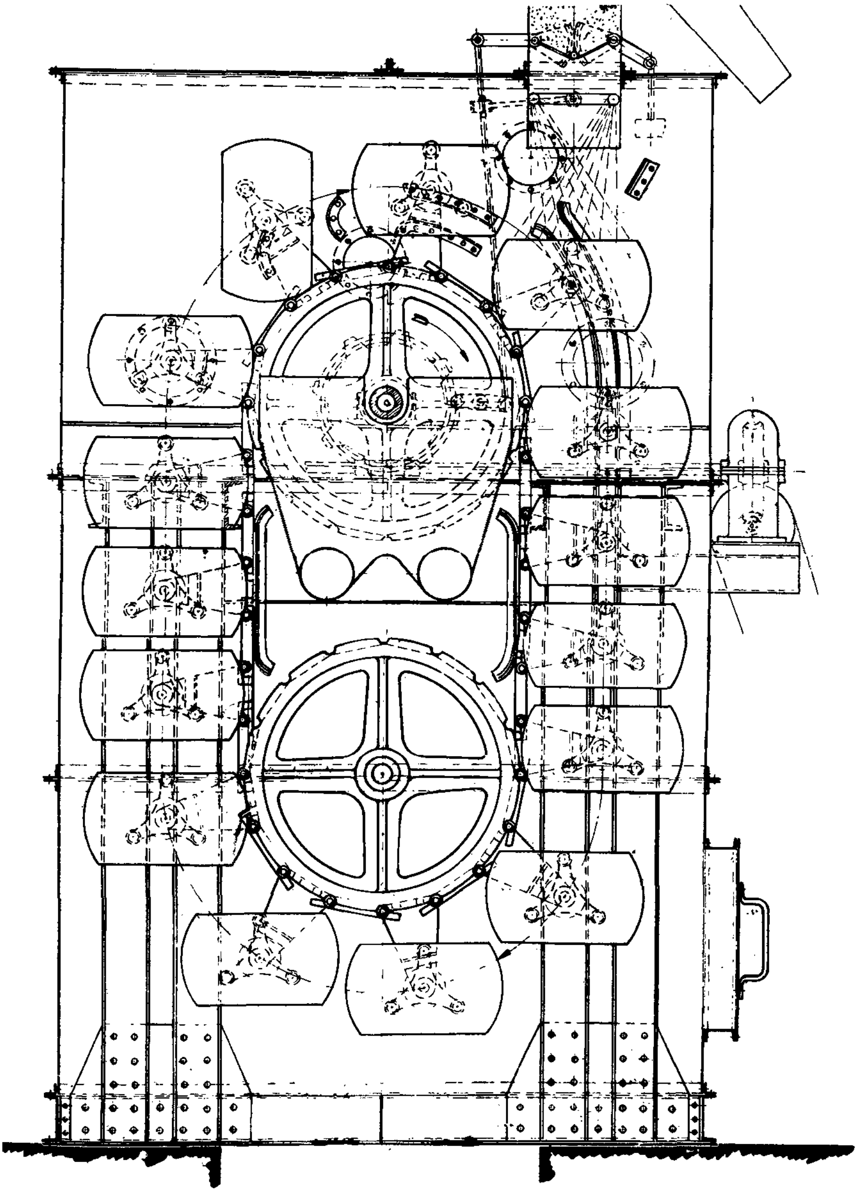
The texture of the soya bean makes it particularly adaptable to solvent extraction. The bean on being crushed gives a somewhat fibrous material, which even with rough handling retains its original crushed shape and size. With proper rolls it may be crushed very fine without the production of any appreciable amount of fines. The crushed material shows no balling or caking action either upon application of slight pressure or when moistened with solvent. Its volumetric shrinkage on extraction is small. In short the soya bean has those properties desired in a material to be extracted by percolation.

The soya bean is unusually rich in vegetable phosphatides and serves as a raw material from which these substances may be recovered.

Particular Method Described

The process described here was patented and developed in Germany, and has been in successful commercial operation there for a period of about ten years. It is based on the principle of continuous operation and counter-current flow and is logically divided into three semi-independent units: Extraction proper, dryer or solvent recovery from extracted meal and oil recovery or distillation unit. One plant is at present extracting soya beans, being operated side by side with Anderson Expellers, the cake of the latter being worked through the extraction process, forming a part of its raw material. Because of this, this particular plant offers a partial comparison of the pressing as against extraction methods.

As shown by the sketch the extractor is essentially a large bucket elevator. The individual buckets, equipped with false bottoms, are filled from a hopper above the extractor, while at the highest point of their flight. They descend on the right side, being simultaneously treated with oil-solvent effluent obtained from the left side of the extractor. On the left and ascending side the material is treated in counter-current with fresh solvent. The bucket, ascending past the



Continuous elevator type extractor

zone of solvent application, goes through a draining period and upon again reaching its highest point is dumped in a hopper below, from where it is delivered to the drying apparatus. The whole is enclosed in an iron casing.

The drying apparatus consists of

a series of specially designed, jacketed tubes, within which the meal is heated and steamed. After traveling the full length of these tubes the meal is delivered through a lock as finished extracted meal.

Evaporators, fractionating columns, heat exchangers, water separator, surface condensers, oil scrubbing tower for solvent recovery from vented air, etc., constitute the recovery unit. The whole is combined as one closed system.

As a solvent a mixture of benzol and alcohol is used. The alcohol enables the recovery of a third and valuable product, "Vegetable Phosphatides."

Operating Requirements and Yields

The following table of six months' operation, representing a run of approximately 8,000 tons, illustrates the quantitative operation of this factory:

No.	Material Worked KG	Loss on Cleaning Beans KG	%	Pressed Oil KG	%	Extracted Oil KG	%
1	1,008,000	7,740	0.8	45,050	4.5	118,960	11.8
2	1,233,500	9,410	0.8	48,190	3.9	150,400	12.2
3	1,330,100	10,360	0.8	47,340	3.6	165,450	12.4
4	1,307,200	11,490	0.9	45,090	3.5	162,170	12.4
5	1,654,900	14,780	0.9	54,580	3.3	211,600	12.8
6	1,380,600	11,330	0.8	42,935	3.1	178,320	12.9
Total	7,914,300	65,110		283,185		986,900	
Average	1,319,050	10,851	0.82	47,197	3.58	164,483	12.38

No.	Phosphatide Oil Emulsion KG	%	Extracted Material Meal KG	%	Finely Ground Extracted Meal KG	%	Total Yield KG	%
1	7,800	0.8	832,575	82.6	200	0.02	1,004,585	99.7
2	8,500	0.7	950,945	77.1	56,550	4.3	1,213,585	98.2
3	9,300	0.7	1,076,520	80.9			1,298,610	97.6
4	14,130	1.1	1,055,725	80.8			1,277,115	97.7
5	18,300	1.1	1,317,800	79.6	10,500	0.6	1,602,280	96.8
6	15,000	1.1	1,076,875	78.1	17,900	1.2	1,331,030	96.4
Total	74,030		6,310,440		85,150		7,727,205	
Average	12,338	0.94	1,051,740	80.0	14,191	1.08	1,287,867	97.5

No.	Required Steam at 8 Atmos. KG	Total Required Power Kw.	Solvent Requirements Benzol KG	%	Solvent Requirements Alcohol KG	%
1	893,400	53,068	9,500	0.95	7,195	0.71
2	1,067,100	63,107	14,100	1.14	5,150	0.42
3	1,359,500	69,580	14,750	1.11	4,030	0.30
4	1,310,200	62,264	16,100	1.24	6,350	0.49
5	1,317,500	67,294	19,100	1.15	8,620	0.52
6	1,291,400	60,013	14,900	1.08	6,350	0.46
Total	7,239,100	375,326	88,450		37,690	
Average	1,206,515	62,554	14,741	1.12	6,281	0.47

It is apparent from the table that the solvent extraction of the soya bean by this process is an existing commercial enterprise. The table may serve as a basis for both estimating extraction costs and for comparison with the operation of other existing processes providing certain unique features of this process are taken into account.

As stated above, this process is working side by side with Expellers, the cake of the latter forming part of its raw material. This procedure, aside from the extra power used for pressing, increases power consumption due to extra handling and milling necessitated by it. Then too, it results in supplying the extractor with a raw material of lower oil content. Experience has shown, however, that unpressed beans are as easily extracted as the pressed.

The table is based on the use of a double solvent consisting of alcohol and benzol. The recovery of such a solvent entails a large expenditure of steam, for the actual oil solvent, benzol, is increased by the quantity of alcohol used. The latter, after the first distillation from oil must be separated from the benzol by use of water and subsequently re-distilled and rectified. Of the required steam shown in the table, about 52% is used for the distillation and rectification of the solvents. Using one solvent the steam consumed would be reduced by 50% or the total steam consumption reduced to 75% of the figure given in the table.

The use of alcohol not only adds an extra alcohol loss, but tends to increase the benzol loss, which otherwise would be well under 1%. Actual operation has shown that the use of alcohol is not necessary to complete oil recovery, but that it greatly increases the yield of phosphatides and materially affects the quality of the latter. The phosphatide fraction consists of approximately 15% water, 30% oil and 55% crude phosphatides.

One month's qualitative operation is given in the table below. The averages of daily determinations have been grouped as weekly averages.

Ethyl ether was used as solvent for the fat determinations of cake and meal. With this solvent extracted meal usually shows a 0.5% fat content. Lower figures are often obtained but to consistently extract below 0.5% would unduly increase the extraction period and cut the capacity.

Soya Beans		Pressed Cake		Extracted Meal		Extracted Oil		Pressed Oil	
Fat	Moisture	Fat	Moisture	Fat	Moisture	F.F.A.	Color	F.F.A.	Color
%	%	%	%	%	%	%		%	
17.56	11.00	12.95	10.07	0.86	14.50	0.29	6.2	0.15	5.8
17.47	12.10	12.50	11.23	0.48	15.30	0.28	6.2	0.11	5.8
17.47	11.10	12.70	11.20	0.78	14.60				
16.90	10.80	12.10	10.00	0.53	13.00				
17.30	11.40	11.80	10.60	0.50	13.60				
Monthly average									
17.30	11.30	12.70	10.60	0.67	13.90	0.29	6.2	0.14	5.8

Comparison with Pressed Oils

For the purpose of comparison, representative samples of pressed and extracted oils were carried through the usual refining process with the results given in table on next page.

In comparing pressed with extracted oil it is to be noted that the pressed oil represents the first fraction of expressed oil while the extracted oil is a combination of the oil extracted from the press residue and from the bean. It is seen, however, that the extracted oil is equally as good as the press-

Comparative Analyses and Refining Results on Pressed and Extracted Soya Bean Oils

	Extracted Oil	Pressed Oil
Percentage volatile matter	0.43	
F. F. A.	0.73	0.30
Color (Lovibond)	35y, 16.5r, 2.5b	35y, 9.8r
Iodine No.	134.7	133.8
Loss of refining	3.6%	3.3%
Color	35y, 9.6r	35y, 7.2r
6% Pikes Peak Bleach	28y, 2.8r	22y, 2.2r
Deodorized color	7y, 0.7r	7y, 0.7r
Flavor	Good	Good
Cold test	Better than 48 hrs.	Better than 48 hrs.

Another sample compared as follows:

	Extracted Oil	Pressed Oil
Percentage volatile matter	0.13	0.08
Iodine No.	122.8	122.4
F. F. A.	0.70	0.35
Sp. gr. 15° C.	0.9262	0.9293

Still another sample compared as follows:

	Extracted Oil	Pressed Oil
Color	35y, 11.3r	35y, 10.6r
F. F. A.	0.70	0.35
Iodine No.	132.6	132.2
Moisture per cent	0.13	0.08
Total fatty acids	94.59	94.73

ed for both technical and edible purposes.

Typical analyses of extracted meals are as follows:

Moisture	Fat	Protein	Fibre	Ash
8.60	0.90	47.40	3.53	
11.90	0.80	48.30	5.00	5.10
13.50	0.40	47.20	4.70	5.40
15.53	0.48	48.45	5.00	5.40

Extracted meal is solvent free. It is from white to light straw in color and when finally milled has much the same appearance as wheat flour. Aside from its use as a cattle feed, for which it is highly valued, it is regularly used in Germany for human consumption, as such, and incorporated with such materials as cake chocolate, soup cubes, wheat flour for bread making, etc. In Europe this meal commands a premium over pressed soya meals, although this is contrary to American preference.

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