Solvent Extraction Successfully Applied

*Extraction Practical and Economical for Vegetable Oils and Press Cake Under Controlled Conditions**

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THE modern trend is clearly away from numerous small oil mills to a smaller number of larger and more efficient mills. In the movement for economy through better efficiency, the greater yield of oil obtainable by solvent extraction cannot be ignored indefinitely. Despite the fact that this method has been used so extensively and successfully in Europe, its use has not spread rapidly in this country. It will bring the subject much nearer home to discuss the experiences of a domestic corporation which for several years has extracted vegetable oils by solvents.

This Corporation started with standard hydraulic equipment and later on began the operation of a branch plant using solvent extraction. In slightly over a year, the original pressing plant had been abandoned but the solvent extraction plant has been enlarged and operated steadily. During nearly eight years, oil has been extracted from five varieties of seeds and one variety of press cake, using two different kinds of batch extractor and one kind of continuous extractor. Perhaps the most significant point is that for several years operations were confined to press cake. During that time the Corporation made its profits solely by extracting such oil as hydraulic presses had failed to remove. Steady progress has been made although the experience has been more expensive in money and hard work than would have been the case had more information been available. It is with the hope of aiding the cause of solvent extraction by helping others to avoid certain preventable difficulties that this discussion is presented.

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Design of Plant

FIRST, do not expect any given layout to be equally efficient or equally economical for all materials. Modern extraction systems must keep in step with modern conditions. The old concept of economy of space and apparatus that led to combining as many functions as possible in one piece of apparatus is yielding to specialization of function in the larger scale installations. Also there is the fact that while it may be both scientifically and economically feasible for a small operator to have his system so flexible as to handle a large variety of raw materials, the larger scale operator who makes such an installation is treading on dangerous ground economically. For example, take a plant designed to extract both 65% copra and some presscake with only 8% of oil. The distillation equipment and the apparatus for removing solvent from the meal and handling, grinding and bagging it are designed accordingly. While operating on copra, the distillation equipment is running to capacity but all the apparatus for the meal is up to but roughly one-third of capacity. While operating on presscake only about one-fifth or less of the distillation capacity is utilized while the meal handling apparatus is busy. No matter which raw material is used, either operation must carry the overhead of a lot of excess capacity. Obviously this would not be true of a plant designed for only one, or only for similar raw materials.

Any good system must have some flexibility but to be prepared to handle a large variety of raw materials is expensive. Not only will the requirements of capacity vary for the several units but there may be a necessary change in some unit when turning from one raw material to another. For example, it might be necessary to use different crushing equipment. Changes of procedure, like going from hot to cold extraction, would not necessitate any change in equipment but there are many possible changes which would require new apparatus.

The manufacturer of vegetable oils on a large scale must operate on a narrow margin and so cannot afford to overlook small differences of yield, steam consumption and cost of solvent which quickly mount up to sizable items in a large plant. Therefore, in changing raw materials, he must expect to have to make some changes in equipment, procedure, or both if the most economical results are to be obtained.

Controlling Factors

BEFORE considering any special system of extraction, certain questions should be answered.

A. Capacity
  1. What tonnage per day?
  2. How many hours in the working day?

B. Raw Material
  1. How many materials must this particular Installation handle?
  2. Name them.

C. Yield
  1. Which takes precedence, quantity or quality? For example a hot extraction might yield higher quantity but poorer quality.
  2. Which takes precedence, cost of extraction or specification of residue? For example if it proves cheaper to leave 1.5% oil in the residue than to extract down to 1%, will you be satisfied or must the 1% specification be met?

D. Quality of Extract.
  1. Is the oil very sensitive to heat?
  2. Is color an important factor?
  3. Do you want to extract anything besides the oil? Example, Bollmann's process of using mixed solvents to extract both oil and lecithin from soya beans.

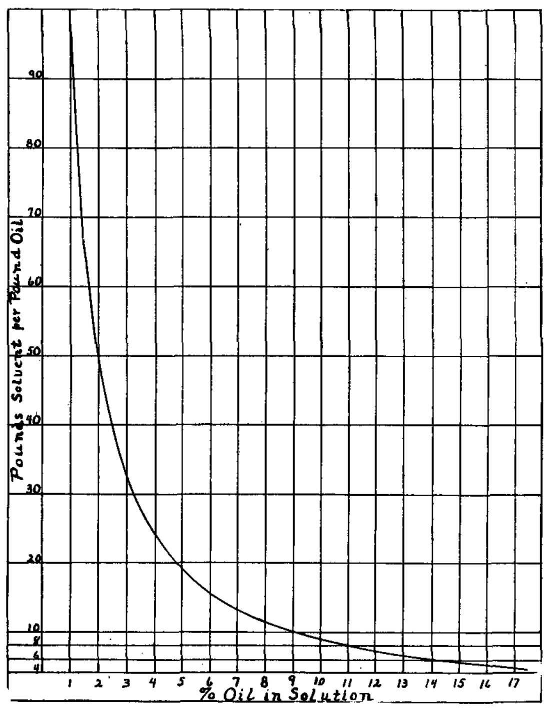
E. Quality of Residue.
  1. What use is contemplated? Fertilizer? Feed? Special use?
  2. What moisture specifications?

These questions sound extremely elementary but solvent extraction systems have been installed without either the buyer or seller having a clear idea of exactly what is expected of the installation. Instances where both parties have been indefinite on account of "trade secrets" have been known to cover mere ignorance.

Another preventable source of trouble and misunderstanding is the statement of percentages without specifying the bases. This frequently results in the comparison of percentages which are not on the same basis and so are not comparable. For illustration, take copra and extract 64 out of 65 lbs. of oil present in 100 lbs. and some presscake and extract 7 out of 8 lbs. present. The percentages of residual oil might then be expressed:—

	Copra	Presscake
1. Basis of raw material	1.00%	1.00%
2. " " total oil in raw mat.	1.54%	12.50%
3. " " the residual meal	2.78%	1.18%

The moisture content of the residue will vary so the safest way is to check extractor operations by percent of oil in the bone dry residue. Knowing the moisture and oil contents of the raw material used over a period, it is a simple matter to convert the average of the checks back to the basis of the original raw material and obtain a direct check on production.



Curve Showing Pounds Solvent per Pound Oil Plotted Against Percent Oil in Solution

Specific Systems

COMING now to the consideration of specific types of extraction systems, a hypothetical case will be considered which is a composite of various conditions actually demonstrated by laboratory determinations, plant practice or both. With this seed, certain determinations have been made.

Crushing: With standard crushing equipment it has been found that a small percentage of the raw material goes through not sufficiently ground to permit complete extraction. In other words, a sample from the crushing equipment cannot be completely extracted without further grinding. The laboratory analysis shows 45.2% oil extractable from the sample as received and 45.5% total after further grinding. Basis raw material there is therefore 0.3% oil unavailable for extraction. To crush finer in the plant would increase crushing costs out of proportion to the increased yield, complicate the operation of the extractors, and injure the quality of the oil. That much residual oil is therefore part of the calculations but the extractor operations must not be held accountable for that portion of the oil in the residue.

Extraction: It has been demonstrated that, given proper agitation, early in the extraction, all the *available* oil is in solution, but part of the solution is soaked up in the seed. Subsequent extraction merely dilutes the absorbed solution, the weight of solution retained being constant. In other words as more oil is removed, more solvent is retained. (The percent of solution retained varies with the material, state of subdivision, moisture content, and solvent used.)

At the completion of extraction when the solvent is distilled off, any oil in solution will be re-absorbed by the fiber. The oil in the residue may then be considered in two classes; first unavailable for extraction, and second, dissolved but not washed out and so re-absorbed when the solvent is driven off.

Now follow 100 lbs. of the raw material through the process:

1. Before Extraction: Here the weight of the component parts and the percentages are identical.

	lbs.	%
Moisture	5.5	5.5
Available Oil	45.2	45.2
Unavailable Oil	.3	.3
Fat and Moisture—free residue	49.0	49.0
	100.0 lbs.	100.0%

2. At the end of extraction but before the absorbed solvent has been driven off: During extraction most of the available oil has been removed, but the weights of the other components remain the same even though the percentages have changed, due to removal of oil and absorption of solvent.

	lbs.	%
Solvent	27.5	33.33
Moisture	5.5	6.67
Available Oil	.2	.24
Unavailable Oil	.3	.36
Fat and moisture—free residue	49.0	59.40
	82.5 lbs.	100.00%

Note:

A. The solvent and moisture together, the total volatile matter, constitute 40% of the wet residue.

B. The bone dry residue would weigh 49.5 lbs. of which 0.5 lb. is oil or 1.01%.

C. At the completion of extraction there was 0.2 lb. available oil in solution in 27.5 lbs. of solvent, which is a 0.72% solution.

Therefore under these conditions, in order to obtain a residue analyzing 1.01% on the dry basis, extraction must be continued until the final solutions test only 0.72% oil. If, then, the extraction system is one of those which in final analysis are glorified Soxhlet extractors where all solutions are distilled, the picture on distillation would be as follows:

% Oil in Solution	Lbs. solvent distilled per lb. oil
20%	4.0 lbs.
15%	5.7 "
10%	9.0 "
5%	19.0 "
4%	24.0 "
3%	32.3 "
2%	49.0 "
1%	99.0 "
0.72%	138.1 "

For efficient and economical large scale production, the following are suggested:

1. *Extraction Efficiency*: The simplest apparatus possible to wash out the maximum amount of oil with a minimum of solvent.
2. *Steam Consumption*:
   A. Removing solvent from oil. Distill only the most concentrated solutions feasibly obtainable.
   B. Removing solvent from meal. Use apparatus specially designed for that purpose and used continuously so as to avoid steam loss in heating the apparatus periodically.
3. *Solvent Loss*: A tight system, good recovery apparatus and a minimum solvent turnover.
4. *Labor*: A system requiring a minimum of changes such as opening valves, shifting solutions, etc.
5. *Control*: Use of mechanical control of flow of solids and liquids, eliminating human element where possible, but yet subject to adjustment.

Summary

EXTRACTION efficiency clearly points to counter-current extraction and with the other requirements indicates continuous operation. So our investigations and plant experience together with consideration of modern production methods have led us to the firm conclusion that the future of large scale solvent extraction of vegetable oils lies in continuous counter-current extraction.