Solvent Extraction: Recent Developments

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ABSTRACT

Each individual extractor operator must analyze his process and apply appropriate solutions. It would seem that larger plants, possibly using supercritical extraction and mechanical desolventizing, all monitored or controlled by some type of computer interface, will be the more efficient plants of the future.

INTRODUCTION

Today's successful solvent extractor is interested and concerned with what is happening in his industry and how it affects his process. This concern stems partially from today's economy – the most significant area being energy efficiency. The basic process is relatively unchanged since the advent of continuous solvent extraction some 35-40 years ago. In this short time, the industry has grown to include 30 or 40 very large plants operating worldwide, each processing up to 4000 tons daily. The successful extractor is no longer just a "super operator." He utilizes sound theory, and keeps abreast of new developments and techniques to operate from a more remote attitude. The objective of this paper is intended to lay out some basic ground rules, look at new developments and relate them to present and future operations. It must be recognized that each process differs in the operating format and the type of oilseed handled.

OPERATING THEORY

The successful solvent extractor has to be concerned with: (a) plant operating personnel; (b) well prepared extractable material; (c) plant and personnel safety; (d) the type(s) of oilseed processed; (e) the end use of the products; (f) the environment; (g) sufficient amount of good quality solvent; (h) sound procedures; and (i) suitable effective equipment. The list is not conclusive and no attempt has been made to prioritize. Each extractor has his own methods of describing and dealing with these parameters.

Well trained operators are essential. They are motivated and they understand their equipment and its function. They are inquisitive, and take an interest in new developments, i.e., equipment and techniques. They will accept most new things willingly and will help test and implement these ideas. Once the novelty wears off, they will use the new item to do a better job. The successful extractor must tailor his continuing education program to suit the local labor situation.

Preparation can be accomplished in many ways, but the important factor is to make the oil readily available to the solvent in the extractor. Each oil seed has its own idiosyncrasies that require different preparation. The design and type of extractor will dictate that preparation be handled a certain way. Some of these requirements were addressed in the 1976 World Conference. Multiseed (switch) plants would also add to the considerations in the preparation of the extractable material. Generally speaking, efficient adequate preparation yields superior solvent extraction results.

Every effort must be made to minimize risk or reduce it to an acceptable level. Extractor design, operating procedure, a fail-safe alarm system, and construction material affect plant and personnel safety. Again, well trained operators are a key factor.

Certain types of oilseeds will extract differently than others.

Operating conditions need to be adjusted to the specifications of the finished products, i.e., an edible oil product will require different handling as will a soy extract. There has been discussion recently in terms of enzyme inactivation affecting extractor design.

The extractor is not a source of emissions, since under most conditions it will operate at a very slight vacuum. Some of the other solvent extraction equipment (solvent water separator, final vent, skim pit, steam ejectors and cooling towers) can affect water, odor, thermal and noise pollution. There are some reports of aesthetics being a condition in general plant design.

There is more than one case documented of solvent being out of specification and causing all sorts of problems, particularly in distillation. Five degree hexane continues to be the industry standard. Other solvents have been used and there are more being considered. Generally, the extractor requires fresh solvent in proper amounts, free of water and at proper temperatures.

Each plant must develop a procedure that works efficiently and safely for it. Along with other tiems, it should help a plant run consistently from shift to shift, day to day. It should also allow for safe start-ups and shutdowns (emergency and planned).

SUITABLE EFFECTIVE EQUIPMENT

Equipment in the extraction plant must be carefully selected and matched to the rest of the plant. This is one key area where it pays off in efficiency and safety to have oversized components. This paper deals with the extractor specifically. Selecting an extractor can be influenced by many factors. Several are listed to help define and evaluate an existing unit or select a new one.

Adequate Contact Time

Since the extractor has no mechanical means of making oil available, the only way to extract oil from the solid (flakes) is to allow enough time for solvent to leach the oil or allow the oil to combine with the solvent. Some of the "super operators" talk about available or unavailable oil (sometimes referred to as extractable and unextractable oil). One way to determine this analytically is to extract a sample in the laboratory. Then regrind (mortar and pestle method) the solid sample. Extreme care must be exercised to ensure that none of the sample is lost, then to reextract this. The added fat from this step would be the unavailable oil. The extractor, or at least the percolation type of extractor, cannot be expected to extract this. Stein and Glaser (1) have mentioned this same idea.

Once the extractable oil amount is identified, it is then a matter of comparing time vs amount of oil available to the solvent. A plot similar to the graph shown in Figure 1 might be used in conjunction with a computer model to determine extractor volume and rate. Since most modern extractors are countercurrent and multistage, one could use some density (concentration) of miscella at the various stages as an input to control extractor speed and solvent/miscella flow to enhance or parallel the computer model developed in Figure 1.

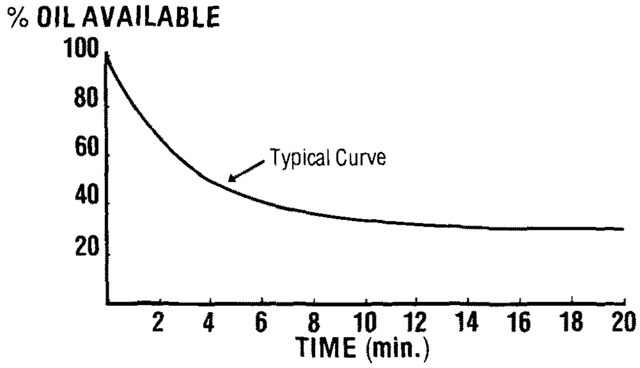

FIG. 1. Extraction time.

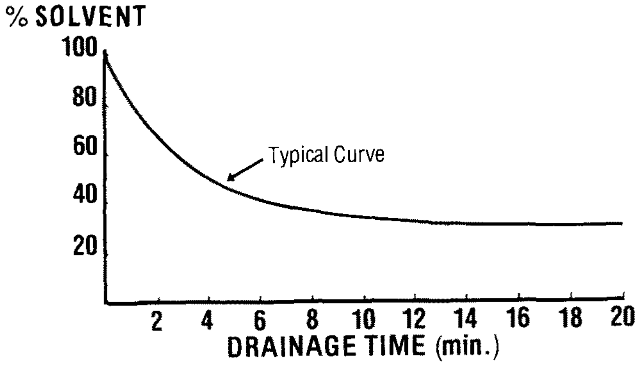

FIG. 2. Solvent holdup.

Solids Suspended in the Miscella

Fines must be recognized as undesirable. Good extractor design must utilize some technique to separate and retain fines with the solids and leave only liquid in the miscella since nozzles, wires, pumps, and piping can become clogged and cause not only efficiency loss, but safety risks when attempt is made to clear the clogs. Distillation, desolventizing, refining and product quality are also affected when fines are allowed to migrate into improper areas.

Drainage

Every effort must be made to separate or dry the extracted solid prior to leaving the extractor or before it gets to the desolventizer. This becomes a more important factor as the cost of desolventizing and solvent continues to increase. Most extractors allow some area for the solid to drain before discharging to the desolventizers. It would seem that the drying, draining, desolventizing area in the extractor would want to be at or near the temperature and pressure that would enhance the "drying" or at least, let it occur quickly. Some thought could go toward placing a properly designed nozzle from the vent system in this area.

The "Direx" (2) process has an interesting approach with the wet flaker between the two extractors. In addition to improving extraction, free miscella could be removed at this point. An additional flaker just prior to the desolventizer, might be considered. A sealed, solid bowl centrifuge might also be appropriate just prior to the desolventizer. An adapted screw press or Stork roto-press might also be considered prior to the desolventizer. French Oil Mill Machinery has a desolventizing conveyor available. Care would have to be exercised because of possible safety risk involved. A graph and/or a computer model could be developed to better analyze this step (Fig. 2).

NEW CONCEPTS AND INNOVATIONS

The newest extractors available are designed for larger capacities. The new models follow the various types that Milligan (3) described in 1976. However, they have been modified to reduce unit cost and also give better efficiencies. Three of these new extractors are the Extraktionstechnik "Carrousel," The French Oil Stationary basket extractor and the Crown reversed-flow design. The first two machines "stack" single units one on top of the other to give added volume. The latter has not only increased volume, but has reversed the chain flow and discharges on the bottom. All three use a self-cleaning, modified wedge wire screen "bottom," for the miscella to drain through and have added refinements to insure better discharging. These newer machines should not only yield cheaper unit costs because of their increased capacities (up to 4000 ton/day), but should have fewer maintenance problems. It remains the buyer decision to procure equipment that best suits his needs, be it a new design or an older one.

Another concept that is becoming more popular is the use of computers or microprocessors. Several companies now make extensive use of computers in design and process modeling. An operator could certainly use this same approach in troubleshooting his process. Several companies have gone to computer control in their extraction and related processes.

Witte (4) presents some theory on economics of computer control. A typical extractor might be controlled as indicated in Figure 3. Several companies will build tailor-made systems as complex or as simple as desired. Ideally, any computer system should be flexible and expandable with thought given to ability for easy updating.

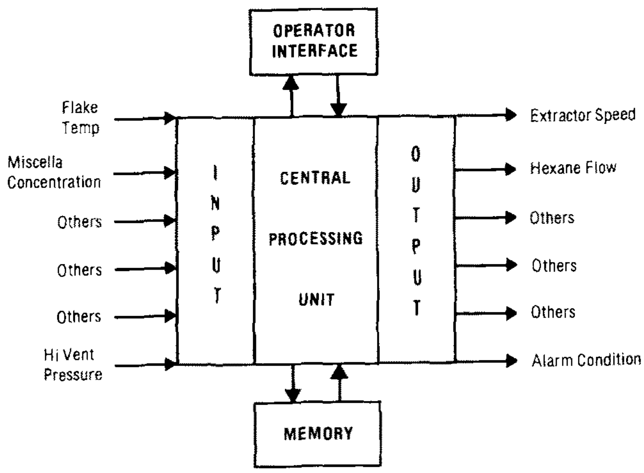

FIG. 3. Process control scheme.

ACKNOWLEDGMENTS

I would like to thank the many people and companies that contributed knowledge, material, and/or time to this effort. The largest thanks go to the "super operators" I have enjoyed working with in the past.

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