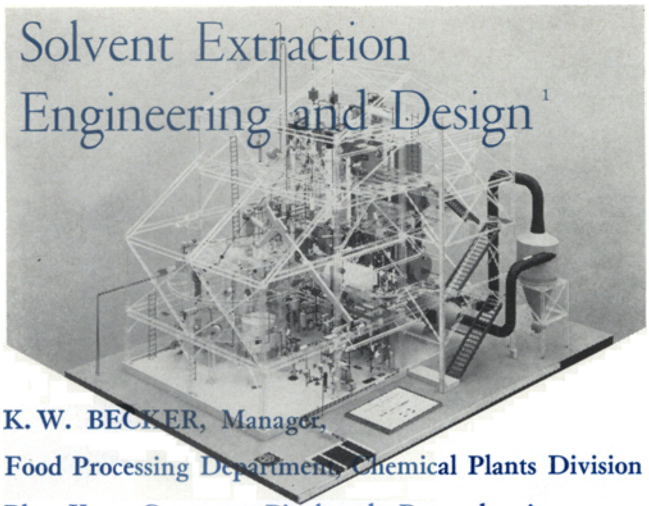
Solvent Extraction Engineering and Design[1]



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Abstract

Many component parts of solvent extraction plants are standardized. However, factors such as different raw materials, meal and oil product requirements, company marketing practices, local economic conditions, future design considerations, layout requirements, individual company standardization programs, utilities characteristics and structural considerations always vary from plant to plant. Therefore, the design of solvent extraction plants can never be completely standardized. Economic considerations must be given for each individual case for steam economizing facilities, mineral oil recovery systems, integration of a new plant with existing plant facilities, and location and availability of existing facilities. Safety and housekeeping cannot be separated from good design. An unprofitable and unsafe plant is never a bargain.

Introduction

THIS PRESENTATION on solvent extraction engineering and design is intended as a broad discussion of many factors which affect solvent extraction plant design rather than as a detailed discussion of any one factor. It is suggested that subsequent presentations be considered for such topics as plant standardization; safety, sanitation, and housekeeping; raw materials; meal products; oil products; engineering considerations for immediate and future expansion; and bid specifications.

Why is it necessary to perform engineering for solvent extraction plants? Aren't these plants completely standardized by now? The answer is yes and no. Many component parts of solvent extraction plants are standardized to the point where minimum engineering effort is required. On the other hand, many factors dictating design of these plants are not standardized and never will be. Different raw materials, meal and oil product requirements, company marketing practices, local economic considerations, anticipatory design for future programs, layout requirements, individual company standardization programs, utilities characteristics and structural considerations always vary from plant to plant. These variations are further increased if a solvent extraction plant must be installed in a limited area and integrated with existing processing facilities. In one case, two plants of identical capacity were installed at the same time for the same company at different locations. To the casual observer, they would appear to be identical. However, local conditions peculiar to each plant dictated that each of these individual plants be designed differently so that optimum economical operations could be realized.

In regard to standardization, no one wants to standardize to the point where progress is stopped. Today a solvent extraction plant of a given scope and capacity costs less than it would have cost ten years ago. However, today's plant is better built, easier to maintain, less expensive to operate, simpler to start and stop and more flexible in throughput rate. In addition, it is safer to operate and keep clean than a solvent extraction plant of ten years ago. A single type of percolation extractor can be employed at opt efficiency for all materials that percolate. Desolventizers have been developed that can tailor-make meal products to the desired degree of protein solubility. Steam economy can be optimized consistent with good design and operating practice. Solvent losses of 0.06% based on raw material input (less than 0.25 gal/ton) have been achieved. In today's competitive market, such progress cannot be ignored.

Some of the factors dictating design of solvent extraction plants that do not lend themselves to across-the-board standardization are enumerated below, but every plant should be properly designed to effectively carry out safety and housekeeping programs.

Raw Materials

Common raw materials in the U.S. are soybean, cottonseed, corn germ, safflower, flaxseed and rice bran. In foreign countries such materials as copra, peanut, rapeseed, sunflower, sesame, in addition to common U.S. raw materials, are processed. For Japan, soybean flakes 20–35 mils thick must be extracted sometimes at temp below 125F. Some of these materials are extracted as presscakes while others are direct extracted. The extraction and percolation rates, upon which extractor size and design are based, not only vary from one type of material to another but also vary depending upon flake thickness, the degree of pressing a cake, or size of cake granules. It is advisable to obtain percolation and extraction rates on all nonstandard materials.

Based upon extraction and percolation data and other physical properties of the raw material, an extractor design is made considering the following factors:

a) Adequate volumetric capacity for extraction and drainage.
b) Correct position of manifolds (both forwarding and recycle).
c) Adequate individual manifold swing (forward and backward) for adjustment to variations in raw material properties.
d) Proper solvent wash and miscella pumping rates to achieve flooding of the bed.
e) Sufficient range of extractor rotation speed to vary production rate as needed, and to accommodate different feed materials.
f) Addition of drainage pans, if needed, to lengthen drainage period.
g) Choice of bed retaining medium to hold the bed and permit opt percolation.
h) Correct type of fines washback system.
i) Mechanical simplicity.
j) Proper feed and discharge materials handling system to and from the extractor.

In addition to extractor design, the type of preparation facilities, the desolventizer, the miscella distillation system, and solvent recovery facilities are all affected considerably by the raw material. Some raw materials in preparation lend themselves to granulation; other materials must be flaked; and a few must be pelletized. Normally, materials that have a long extraction time likewise take a long time to desolventize. Desolventizer capacity is affected by drained solvent hold-up, which is different for each type of raw material processed. Consideration must be given to special stickiness and dust elimination problems in desolventizer design for some raw materials. Naturally, different ratios of solvent wash and percentages of oil in the raw material will affect the design capacity of miscella distillation and solvent recovery facilities.

The facilities for unloading, storage, cleaning and drying of raw materials must be selected properly in order to assure that the physical properties of the raw materials are like those upon which design is based.

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[1] Presented at the AOCS Meeting, Minneapolis, 1963.

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Meal Products

In the United States most soybean extraction plants produce only 44 and 50% toasted meal for animal food. The 50% toasted meal requires dehulling facilities. Toasted meal is processed through a desolventizer-toaster unit, commonly known as a D-T unit. The D-T unit destroys urease activity and also very effectively degrades protein solubility so that in some instances less than 10–12% soluble protein (1,2) is left in the meal.

There is an every increasing trend to produce high soluble protein meal. For cottonseed, such meal sometimes commands a premium value for chick and pig ration. However, the largest demand for high soluble protein meal in the U.S. is for the preparation of isolated and industrial protein. In countries such as Japan, where most soybean meal is used for human food, high soluble protein meal is used as a source of tofu and medium soluble protein meal is used as a source of miso. Vapor desolventizing and deodorizing systems have been developed which permit the processing conditions to be controlled so that both tofu and miso can be produced at different times in the same equipment. Tofu is a white curd-like material, and miso is a bean paste made by fermentation of soya flakes.

In addition to planning for different types of meal products, consideration must be made of immediate and anticipated facilities for meal grinding, hull grinding, bagging, bulk loading and storage requirements as part of a well-designed over-all plant.

Oil Products

Oil product requirements vary considerably throughout the world. Some processors' requirements make it absolutely necessary to minimize time and temp in the oil recovery system. Sometimes exceptionally low moisture and volatile content must be obtained. Miscella refining might be necessary for certain situations. It may be essential as a marketing practice to take special precautions to minimize settlings in oil tanks, especially if long oil storage periods are required. In the event that some of these considerations are not part of an immediate program but are anticipated as part of a future expansion, the immediate design should be planned to facilitate the future program in the best possible manner at minimum over-all cost.

If oil tanks are installed within the limits of a city, it is especially advisable, and often mandatory, to install dikes around them in the event of rupture.

Engineering Considerations

The over-all engineering design is normally dictated by immediate and future economic considerations. An additional capital investment may be justified immediately or may be anticipated in the future for steam economizing facilities. Today, mineral oil absorption solvent recovery systems are almost always installed as part of new plants. It is important to anticipate future expansion programs and sometimes install oversize items such as the extractor and desolventizer and provide space in the layout design for the installation of processing items that require multiple units such as flaking and cracking rolls.

The plot plan of the solvent extraction plant must be integrated with other processing areas of the plant to max advantage as dictated by local conditions (present buildings, storage, railroads, parking areas, surrounding factories and homes, etc.). The recommended National Fire Protection Association distance between buildings and an elevated electrical control room rather than equivalent firewall protection is preferred when possible.

The layout plan (or model) must then be designed to provide at min cost the max accessibility to equipment for operational and maintenance purposes. Wide stairways and passageways around equipment groups are desirable. The plant should be designed to minimize housekeeping problems and to maximize sanitation standards. Spouting, ductwork and conveying should receive special design attention. Plenty of cleanouts should be provided in the solids-handling system.

Today, most companies are standardizing to some extent on conveyors, elevators, pumps, blowers, drives, motors, condenser tubes and instruments. These standardization programs not only simplify spare parts inventory but normally assure better service and maintenance programs. However, these standardization programs always vary from company to company and frequently vary from one plant to another within a single company.

Structural and architectural considerations are very important. Is the solvent extraction area of the plant to be entirely outdoors, partially housed, or indoors? Is it important from an architectural standpoint to match building design to that of an established plan? Will it be necessary to coordinate new footings and columns with those of existing buildings? Is piling necessary beneath footings in certain areas? Must stairways and platforms be matched with those of an existing building? What are the controlling codes for the particular area?

Utility considerations always vary from plant to plant. Sometimes a cooling tower is required and provisions must be made for proper water treatment and blow down. If the available cooling water is dirty, condensing will likely be accomplished on the shell side of heat exchangers. The temp of water is very important in determining how much condenser surface area is required. The water pressure and quantity of water that may be used are also important factors in over-all plant design. It is essential to know steam pressure accurately at the delivery point for design purposes. For electrical systems, consideration must be given to safety, local standardization requirements, ease of start-up and shutdown sequence and to proper interlocking sequence.

Instrumentation requirements not only vary according to the nature of the particular solvent extraction process and to company standardization programs but also according to plant layout and to individual operating philosophy. In general, important temp, pressures, levels and other process variables are controlled automatically. However, it is the usual practice to install instruments in positions where it is desirable for the operator to travel in his normal route so that lubrication, visual observation and other operating functions will be performed while routine operating data are being collected.

As indicated previously, safety and housekeeping cannot be separated from good plant design. Proper design for raw materials, meal products, oil products and proper engineering considerations in design will result in a plant that has safe features and is easy to keep clean. For future safety, anticipatory design must be carefully considered so that a safe and easy-to-keep-clean plant is not converted to a dirty, unsafe plant. An unprofitable and unsafe plant is never a bargain.

Time and money can be saved by both the client and the engineering-contractor if thorough specification of requirements and scope of work are prepared by the client before bids for a solvent extraction plant are requested. If the client does not have the time to prepare bid specifications, a qualified consultant or engineering-contractor then can be employed to prepare bid documents. Such planning in the initial bidding or conception phase will result in higher profits per dollar invested, better planned plants for future expansion and much safer and cleaner operating plants.

REFERENCES

1. "Modification of Method," Soy Flour Assoc., Rev. Dec. 10, 1946.
2. Witte, N. H., JAOCS *38*, (No. 3), 11 (1961).

New Products . . . .

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F. L. Mosley Co., Pasadena, Calif., now offers a low-cost, ultra-compact basic systems X-Y recorder. Model 7050A is adaptable to almost any system requiring high accuracy x-y readout at minimum cost. Single input spans from 100 mv full scale to 100v full scale, each axis, are available.

Lindberg/Hevi-Duty Marketing Services, Chicago, Ill., has introduced a portable electronic infrared instrument for analyzing and recording constituents of gases, vapors or liquids. CARBOCHEK was designed to detect the desired component present in a chemical or petrochemical process stream—responding to within 90% of the final reading.

Fairfax, Inc., New York, N.Y., is offering a new pipetting gun which can be set to dispense liquids at any volume from 2–30 cc indefinitely. The Man-O-Pet was designed for use in accuracy and repeatedly dispensing liquids.

Central Scientific Co., Chicago, Ill., has introduced a combination hot plate and magnetic stirrer that will accommodate up to six flasks or beakers. Cenco Multiple Hot Plate-Magnetic Stirrer has a cast aluminum surface and can be used for heating only.

A. Gross & Co., New York, N.Y., has developed a new coconut fatty acid of interest to manufacturers of alkyd resins and protective coatings. It is designated GROCO 25—Low Iodine Value Coconut Fatty Acid, and valuable for its light color.

• *Obituary*

A. E. Aaland (1955) died July 21, 1964, subsequent to surgery earlier this year. He had been associated for the past five years with the Packaging Research Dept. of General Mills Research Laboratories, Minneapolis, Minn.