Filters and Filtration Systems for the Vegetable Oil Industry

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Abstract

This paper discusses new innovations in the use of filtering equipment in various vegetable oil processes. The ultimate goals are reduction in plant space requirements, lower operating costs, upgrading of product being processed, reduced labor expense, increase of in-plant cleanliness.

Deodorizing

The filtering process of deodorized oil is rather straightforward but the filtration equipment itself can stand a closer look.

Popular filter units in the past have been horizontal plate type units which, while doing a good filtration job, required at least two men and an overhead hoist to service. A reduction in labor and auxiliary equipment is desirable.

By the use of a vertical tank, vertical tube filter with paper dressed elements much of the labor and equipment can be eliminated. High flow rates per unit of area are achieved due to the hydraulic design of this filter. Long cycles and no unfiltered heel are also realized. This is particularly desirable where various stocks are being processed.

The papers used in this unit are rectangular in shape and may be readily replaced by one person. No overhead hoist is required as each tube is individually removable. The cost of completely redressing a unit 30 in. in diameter by 42 in. long is approximately $4.00 (exclusive of labor).

Clay Bleaching

The filtration of bleaching clay from vegetable oil has not been a complex problem and many different types of filters have been employed successfully. In the past the Plate Frame press was extensively used. These are being replaced by pressure leaf filters of various descriptions. The factors precipitating this change have been: A desire to increase productivity; increasing the quality of the product; reducing labor costs; reducing operating expenses; and improving housekeeping conditions.

The use of a horizontal tank, vertical leaf filter is a move toward realizing most of these objectives.

The leaves of this unit are covered with a fine mesh wire cloth (24 × 110 Dutch weave) which does not require a precoat. The clay bleach and oil slurry is recirculated on the clay bleach tank until clarity is established. A dry cake discharge may be effected with the filter open or closed depending on the desires of the customer, using a patented leaf vibrator. Due to a unique preventive maintenance procedure designed into the operation of the system (which requires 1 min) the leaves are prevented from blinding without the need to remove them from the filter for manual cleaning.

The filter can be successfully manned by one operator and may be automated to almost any degree desired.

The most popular system today features a push-button control panel for the remote operation of valves or combined valve operations which perform complete steps in the operational sequences.

The trend is toward further automation which can be accomplished with present equipment and technology.

Tank Loading Filters

There has been a constant search for a good tank loading filter over the past years. This unit must possess many features which gives it flexibility to handle different types of oil. Frequently this filter is installed away from the processing plant where overhead hoists are not available. Therefore, it is desirable to have a filter requiring no special facilities to operate and maintain it.

Since different types of oils may be handled in a single day, the process of switching from one type of oil to another must be accomplished without the expensive handling or processing of unfiltered "Heel" or unfiltered product which remains in the filter vessel at the completion of a run. The elimination of this Heel in the filter design, becomes quite important.

High flow rates and maximum clarity are most desirable to keep the physical size of the unit small and the processing time at a minimum.

It is preferred to use a design which can be operated and maintained by one person to reduce the labor expense assigned to the station.

The overall cost of this final filtration should be as low as possible; the use of an inexpensive yet effective filter media is important.

The use of the vertical chamber, vertical tube filter produces the most satisfactory answer to all these problems.

From experience, a unit 30 in. in diameter and approximately 42 in. high has been selected and used economically over the past several years. This unit is efficiently operated at flow rates between 60-90,000 lb/hr with total thru-puts of 750,000 to one million pounds of oil between cleanings.

The tubular elements are 36 in. in length and approximately 3 in. in diameter. Since filtration is effected from the inside of the tube, little or no unfiltered heel remains in the unit when the filtration operation is completed. Acceptance of this type of unit has been excellent.

Nickel Catalyst

Conventional Method

The most common method of hydrogenating vegetable oils is to place the nickel catalyst and a quantity of filter aid in the converter. Upon the completion of the hydrogenation process the nickel catalyst and filter aid must be removed from the oil. This process is normally done at a temperature much lower than that used for hydrogenation to avoid oxidation of the oil. Therefore, it is necessary to reduce this temperature before filtering. This is usually done by retaining the oil in the converter until the desired temperature reduction has been realized. In some cases an auxiliary "Drop tank" is used for this purpose which frees the converter for a new batch of oil.

Conventionally the next processing sequence is filtration of the oil through a precoated filter (Black press) to a storage tank where a post bleach and nickel scavenging step is performed. This is followed by another filter (White press) to remove bleaching clay and all traces of the nickel catalyst. In some instances these presses are followed by "trap" or "guard" filters to insure a solids-free final product.

In recent years some plants have found that they have been able to eliminate the precoating operation on both the nickel catalyst and post bleach operations by using a fine mesh metallic filter cloth (24 × 110 Dutch weave) and recycling back to the converter for a short period of time. Termination of this step is determined by visual check of effluent clarity. This procedure eliminates the need for precoating equipment which includes tankage, valves and pumps. It also reduces the amount of floor space required for the station and eliminates the quantity of oil in inventory needed for the precoating procedure.

Hot Process

A recent investigation has proven the feasibility of filtering the nickel catalyst at converter temperature. There are a number of advantages for doing this.

1. The converter can quickly be evacuated and readied

for a new batch of oil without the time-consuming need of holding the oil in the converter while the temperature is being reduced. If drop tanks were used, these can be eliminated freeing valuable floor space.

2. The oil may be filtered at this elevated temperature because the system is a closed one and the possibility of oil oxidation is eliminated.

3. When the nickel catalyst is filtered at the higher temperature, a higher flow rate is possible than experienced in the conventional system. This means that a reduced square footage of the filtration area is required and a smaller filter may be used. Reduced floor space requirements and also reduced initial purchase price of the equipment result.

4. Due to the clarity obtained on this equipment the post bleach tank has been eliminated and final nickel scavenging can be accomplished by direct injections of citric acid and filter aid into the discharge line. This passes through an in-line mixer and finally through the post bleach filter or white press. A large filter is no longer required at this point, which again reduces the amount of floor space required and the cost of equipment.

5. The heat of the processed oil is reduced by passing through an oil to oil heat exchanger which transfers its heat to the incoming oil on its way to the converter. This reduces the amount of time and heat input needed to bring the converter to processing temperature. A final oil to water heat exchanger may or may not be required to further reduce the processed oil temperature to a limit suitable for storage.

Filters Used

Black Press. The filter associated with this process is a horizontal tank vertical leaf unit which features leaves dressed with fine mesh wire cloth (24 × 110 Dutch weave).

The unit is designed to drop the nickel catalyst in a slurry state where the nickel is to be re-used, without the need of opening the filter. A dry cake discharge may be used when the nickel is spent or where the nickel is used only one time. In either case the cake may be dropped in approximately 1 min.

The Black Press uses flat heads, front and rear, to minimize the amount of heel to be considered.

The filter may be operated manually, semi-automatic (push-button) or fully automatic depending upon the customer's wishes.

No precoat is used as the nickel slurry is recirculated back to the converter until clarity is established (usually 5–15 min).

Thru-Puts are 750 to 1000 lb/min.

White Press. The White Press is a horizontal plate unit which is paper dressed and does not require a precoat. By the use of a scavenger element there is no unfiltered heel to be considered. This is very important when changing stocks. It is normally recommended that two small units be used instead of a large one. This adds flexibility to the station.

Since the components of this system are so closely related to the overall successful operation of the station, a "package-purchase" concept should be considered.

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New Food Sources

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Scientists keep warning us that the world's rapidly rising birth rate, generally longer individual life span, plus a ravenous-rate consumption and prevalent pollution and depletion of our conventional food sources and supplies, relentlessly are hastening us to an "over-populated" world, at least in terms of available and foreseeable food production.

The U.N.'s Food and Agriculture Organization (FAO) as early as 1965, in fact, ruefully noted that we are heading toward large-scale malnutrition and even starvation in various areas, and more—and more efficient—food production, particularly of proteins, probably is going to have to be the big answer.

The Institut Français du Pétrole (French Petroleum Institute, or I.F.P.), a nonprofit research organization of the French oil industry, some time ago clearly posed challenge by pointing out that: "In the case of human or animal feed, any method capable of massively and cheaply producing substances containing appreciable amounts of proteins is of vital importance in stopping existing protein deficiency and preventing it from becoming worse."

As for the potential solutions, a report by I.F.P.'s Claude Gatellier noted:

"There is no doubt that crude oil and natural gas, pound for pound, are far cheaper than other available organic substrates. According to A. Champagnat, of the Comité Consultatif de la Recherche Scientifique, 'the production potential of the oil industry could be sufficient to supply an additional amount of the proteins needed by billions of people.'

"In theory, the idea of microbial food is attractive because of the high rate of multiplication of micro-organisms, the large measure of control possible and the opportunity afforded for utilizing a large variety of materials. For example, whereas every 24 hrs a 10 cwt steer can synthesize 0.9 lb of protein, and 10 cwt of soybeans can yield a crop equivalent to the production of about 92 lb of protein, the same quantity of yeast can produce over 50 tons of protein in the same time period.

"For over 50 years efforts have been made by many groups of research workers to establish microbial food as a commercial proposition with an economic process. Undoubtedly the best-known microbial nourishment is food yeast, which was produced as a protein and vitamin supplement for the human diet in both World Wars and is a recognized animal foodstuff in many countries."

Hydrocarbon Help

In a later 1969 report by Gatellier and S. Franckowiak of the I.F.P. and C. Decerle of the French Bureau d'Etudes Industrielles et de Coopération, there was this practical development to record:

"In 1967, I.F.P. chose its own method of cultivating yeast with a hydrocarbon feedstock that was well refined so as to come up to the standards of microbial fermentation. Without any sophisticated or costly installation, a one-stage urea-paraffin clathration, developed by I.F.P. scientists R. Avrillon and H. Van Landeghem, produces a marketable gas-oil with a diesel index and pour point which are adjusted to refinery demands. At the same time, an oil cut is produced which is very rich in normal paraffn.

"The fact that the purity of the fermentation feedstock is liable to adjustments provides corresponding reductions in further solvent treatments of the biomass. Moreover, the quality of the fermentation feed will in no way be diminished, however different the distillation cuts may be (gas, oil or light fuel oil). The urea-paraffin actually provides an additional parameter, independent of the fermentation stage.

"The nutrition tests required for official approval will help set the standards for the feedstock, no matter what the initial petroleum cut may be. These tests will only concern standardized methods of washing and drying the yeast for feed or food purposes.

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"Whereas the preparation of the feed has to be done in a refinery, the growth of the yeast is the job of the food industry. With the I.F.P. system, however, there is no obstacle to separating the two phases as desired so as to conform to local regulations and customs, or to take advantage of a traditional fermentation industry already on the spot. . ."

Commercial Start

A French research team at Société Française des Pétroles B.P. (S.F.B.P.) in its Lavéra refinery, just west of Marseille, in 1967, announced its solid progress toward producing food from oil. Petroleum will soon be turned into pork chops on an industrial scale, giving mankind an important new source of food.

In French test feeds of animals, this oil-derived protein has indeed been found "more efficient" in building the weight of poultry, pigs, etc. than conventional fodder. And latest word is that S.F.B.P. at Lavéra expects to be in commercial production of edible foods from oil later this year.

I.F.P. Investigates Algae

Meanwhile, the research of the Institut Français du Pétrole for ways in which oil can contribute to solving the world's nutrition challenges, led it into examining the possibilities of accelerated photosynthesis under the effect of high partial carbon dioxide pressure. It found that:

"Advantage can certainly be taken of the combined existence of solar energy and natural gas deposits in certain regions to use photosynthesis and carbon dioxide for the economical creation of products that can be used as foodstuffs."

So I.F.P. began a thorough examination of large-scale cultivation of several types of algae which, of course, were known to be a vegetal species "offering excellent nutritive qualities and growing very rapidly."

Active, intensive research in this line by I.F.P. had not begun sooner because, while "Chlorella," a monocellular green alga, looking like a sphere a few microns in diameter, had been studied for a dozen years—and is still the subject of highly scientific work, I.F.P. had come to the conclusion that its culture, its collection by ultracentrifugation and its conservation presented difficulties that made, up to now at least, its industrial-size production "unattractive." I.F.P.'s decision, therefore, was to search for a new species of food alga whose nutritional value would be at least as good as "Chlorella" and whose culture, collection and use would be simpler and, therefore, more economical.

Since Earliest Times

In any case, toward the end of 1962, as a result of observations and research by Max-Yves Brandily, I.F.P. learned that, since earliest times, people living in isolation in parts of the Chad Republic in central Africa had been growing in pools and harvesting and consuming a type of alga. (The women collect it in straw baskets, then transport it in jars and dry it on the sand in the sun. Afterward, they make up the *dié* which is cooked as a sauce to accompany the local staple diet of millet balls.)

Investigation of samples brought back to I.F.P. from Chad showed this food source to be "Spirulina," a blue-green alga growing in shallow ponds where the water contains large amounts of bicarbonate giving it a high salinity and alkaline value. But nothing, really, was known about the "Spirulina"—it had not been studied and its nutritional value had never been fully assessed. It was learned, however, that Aztec Indians on Mexico's Lake Texcoco also have been harvesting and making edible food of the "Spirulina" over the centuries.

Excellent Food Supplement

Most important, I.F.P.'s research before long showed that the 60% to 68% of protein content of "Spirulina" makes it one of the richest protein food bases ever found. (Composiiton of its dry matter: proteins—62% to 68%; glucides—18% to 20%, lipids—2% to 3%; vitamins—rich in pro A, B1, B2, B6, B12, C.) The proteins are make up of all the essential amino-acids, in quantities equal to or higher than those indicated in the standard combination (established by the U.N.'s FAO in 1955), except for a slight deficiency in sulfur amino-acids, which should be corrected.

"Consequently," I.F.P. could report by 1967, "this alga should theoretically be an excellent supplement for unbalanced protein diets," and indeed it is now highly regarded by pertinent international organizations like FAO.

Already in Production

It all works well in practical practice: Under the sponsorship of and in partnership with I.F.P., culture of the "Spirulina" alga is well under way at the factory near Mexico City of a private Mexican enterprise, Sosa Texcoco, an important local sodium carbonate producer. Which fits: "Spirulina" is found in its natural state in a part of the factory's solar evaporation.

The "harvest" already occurs on a considerable scale, with production due to reach the rate of a ton per day of dry algae by the middle of this year. Sosa Texcoco, in cooperation with I.F.P., also experiments in the synthetic culture of this alga in a covered 7535 ft^2 basin.

Both the algae derived from the factory's evaporation area, and from the synthetic culture in the basin, are entirely suitable for human and animal consumption. Meanwhile, tests to measure their nutritional value are being carried out with babies at Mexico's National Institute of Nutrition.

In Algeria too, following on I.F.P.'s work, experiments in open air culture of this alga are being made at Oran at the Algerian Petroleum Institute toward determining the possibilities of large-scale synthetic production. Other public and private research, in cooperation with I.F.P., is being carried out in France, Quebec and Puerto Rico.

Besides the United Nations' FAO in Rome, UNICEF in Paris and New York and WHO in Geneva all support the French-originated research which has demonstrated the potentialities of using "Spirulina" as a source of inexpensive and available protein to boost insufficient nutrition whereaver it exists in the world.