An Edible Oil Deodorizer with a Direct-Fired Heater

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Engineers have long believed a direct-fired heater (DFH) for deodorization is always in danger of overheating. Commercial tests done in recent years have proved this danger can be avoided by proper furnace design. At least ten commercial deodorizers with this system are now used in Asia. A new deodorizer with a DFH was designed and built in 1986 in Taiwan. It features a single-shell design and steam-stripping of deep oil layers. It has been operated successfully for several years. The deodorized oil was compared with oil produced by conventional deodorizers. The new deodorizer with a DFH revealed several advantages.

A DFH liberates heat by burning fuel within an internally insulated enclosure and transfers the heat to fluid flowing in tubular coils. It has a radiant section which can receive heat directly from the flame, and a convection section which recovers heat from the hot gases traveling to the stack. The DFH supplies a specific quantity of heat at elevated temperature levels to the fluid being heated. It must be able to do so without local overheating of the fluid.

The DFH has long been used in process industries, but strangely enough, not for oil and fat processing. Industry labels these heaters as a fired heater, a process heater, a furnace, and a tubular furnace. All these labels are interchangeable. The oil heater which recently became popular for a large autofrier is also a DFH, but it is called a heat exchanger. Most literature on oil deodorization says the DFH has difficulty avoiding localized overheating, and risks ruining an entire batch with an oil circulation accident.

In 1973 Kuroda (1) tried to improve the heating system for deodorization. A single-path DFH was employed in the usual semicontinuous deodorizer at Oosaka Seiyusyo, Inc. (Japan) instead of a Dowtherm heater. The unit was modified for continuous heating. The modified deodorizer was put into operation as a pilot plant. Many tests were tried on a wide variety of feedstocks. The quality of deodorized oils was the same as before. Power failure or inaccurate operation did not damage the oil because of the relatively low temperature levels at the refractory wall. This wall is cooled by the radiant coils during the process. Therefore, if the furnace is properly designed, the oil never overheats. More than ten commercial deodorizers (capacities from 36–150 MT per day) were then modified to employ the DFH. The first commercial unit, which was modified in 1975, is still in use.

All-welded coils can be easily cleaned by an air-decoking procedure if clogged by polymerized materials. The decoking procedure is common in the DFH for petroleum refining to remove tube coke deposits. This procedure is done several times a year in the DFH for deodorization. One unit, used for the deodorization of rice bran oil since 1982, has not needed decoking procedure because there was no tube clogging. If the operation is normal, polymerized materials do not stick to the tube wall. The inside surface of the tube is always clean.

This paper primarily concerns a deodorizer recently built in Taiwan. It has several features in addition to the DFH.

MATERIALS

The new deodorizer with a DFH (60 MT per day) was constructed in 1986 at President Enterprises Corp., Tainan Hsien, Taiwan, ROC (2). Figure 1 shows the flow diagram for the deodorizing plant.

A single-path tubular furnace (Fig. 2) heats the oils. The tube material is type 304 stainless steel. The tube dimensions are 27.2mm outside diameter, 2.5 mm thick, and 60 m long. The tube is rolled into helical coils in which the inlet and exit are conveniently located side by side. The center-to-center distance is twice the tube diameter. It is arranged horizontally to line the walls of the radiant section. The radiant rate is 30,000 kcal/m^2/h,

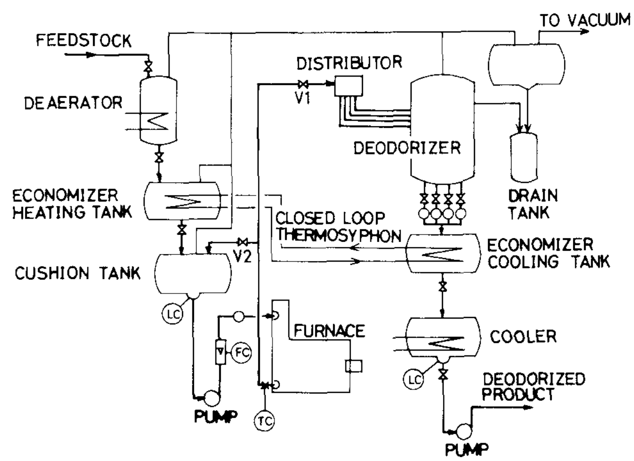

FIG. 1. Flow diagram for deodorizing plant.

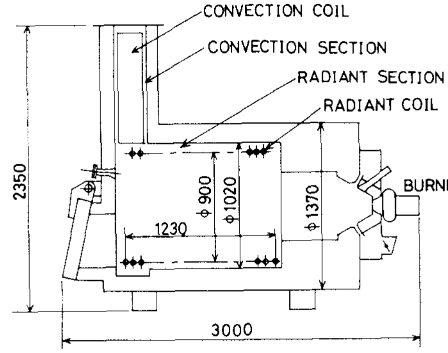

FIG. 2. Tubular furnace. Unit: mm.

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based on the outside area of the tube. The convection coil has welded finned tubes made of type 304 stainless steel.

The deodorizer (Fig. 3) is semicontinuous but different than that by Bailey (3). It is a vertical cylindrical unit with four peripheral compartments. Each compartment is fitted with baffles, umbrella, and steam sparger in the usual manner. The heated oil from the furnace flows continuously through the distributor into one of the compartments. The oil is accumulated during the period required for processing. The oil depth in the compartment is 2 m under the oil level at rest. The distributor then switches the oil flow to the next compartment. The oil in the previous compartment is kept under steam stripping for deodorization. It is then discharged to the heat recovery system. The deodorized oil is processed as usual in a batch-continuous flow. The heating and cooling are continuous, but the deodorization is discontinuous. It will be called a parallel semicontinuous deodorizer in contrast to the conventional one (3), which is called a series semicontinuous deodorizer. The parallel one of a smaller capacity (36 MT per day) was first built and successfully operated in 1983 at Haba Co. in Tokyo. This design reduces both capital costs and installation space.

The heat recovery system has two economizer tanks. A closed loop thermosyphon is between them.

Feedstock change occurs because the oil flows in a single path from the cushion tank outlet to the distributor through the furnace. It also occurs because the deodorizer has only batch tanks. The unit is furnished with an automatic feedstock change system: a level switch in the cushion tank, two control valves (V1 and V2), and a programmable controller.

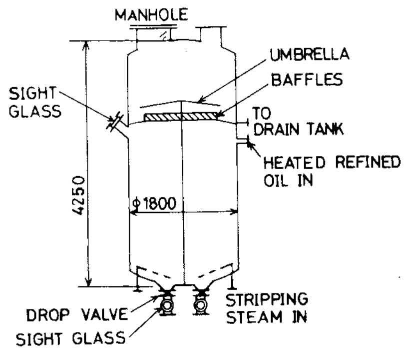

FIG. 3. Deodorizer. Unit: mm.

RESULTS AND DISCUSSION

President Enterprises Corp. already had two conventional deodorizers. One had a Mobiltherm boiler and the other had a high pressure steam boiler. The new deodorizer with the DFH was added. The same lot of soybean oil was deodorized under the same conditions with the three different deodorizers. Table 1 shows that the new deodorizer is equivalent to the others in general anaylsis and evaluation, and better in stability of the product.

The new unit is a single-shell deodorizer. It has operated without oxidation leaks. Today's improved welding techniques eliminate the risk of oxidation leaks through the single-shell. The oil depth is three times that in the tray of the conventional deodorizer. Even so, it has been producing top-quality oils. Hydraulic pressure due to the oil depth theoretically decreases the vacuum effect. Test results show oil depth is not important in this case. The oil depth described above is not actual but nominal. The oil level during the process fluctuates violently due to the agitation of the injected steam. These conditions alter the theoretical predictions.

This little known deodorizer works well and has several advantages over the conventional deodorizers. The automatic feedstock change system can handle stock-changes with lower contamination than conventional ones, because of the smaller piping and pump. Capital costs are cut by 50%, fuel by 20%, and installation space by 50% (2).

Heating of edible oils in the commercial deodorizer has not been fully discussed. The conventional heating system using a heat-transfer medium has two heating stages: the first is for heating the medium in the boiler, and the second stage is for heating the oil with that medium. Usually the second stage occurs in the heating tray inside the deodorizer. Cleaning and maintenance of coils take a lot of time and effort because the heating tray has many coils in a small space. The deodorizer with the DFH has only one stage for heating the oil in the external furnace. It does not need a heating tray inside

TABLE 1

Comparison of Quality of Deodorized Oils

Deodorization conditions: 260°C, 4–5 torr, 3% steam flow, + citric acid

Deodorizer	General analysis and evaluation					Stability test Heated at 105°C for 6 hrs		
	Acid value	Color lovibond[d] Y/R	POV	AOM[e]	Flavor score[f]	Acid value	Color lovibond[d] Y/R	POV
HTM System[a]	0.038	5/0.7	0.1	16.5	4.5	0.052	12/1.5	6.8
HPS System[b]	0.044	6/0.7	0.0	17.0	4.5	0.059	12/1.5	6.3
DFH System[c]	0.044	3.5/0.6	0.0	17.0	4.5	0.070	16/1.2	3.2

[a]Mobiltherm heating system.
[b]High pressure steam heating system.
[c]Direct-fired heating system.
[d]5–¼ inch cell.
[e]hr to PV 100.
[f]Based on a 5-point scoring scale.

the deodorizer. The DFH system is thus simpler and more efficient.

Kuroda (1) noted the maximum tube wall temperature in the DFH system is close to that in the conventional one. It seemed there would be no difference in the quality of deodorized oils between the two systems. However, one cannot overlook the effect on product quality of the heater type. The oil in the conventional system is heated "outside" the tube. The oil is heated along with the dirty deposits because the polymerized materials usually precipitate onto the outside surface at the heating tube. This will injure the product, especially at high temperatures. The oil in the DFH is heated "inside" the tube. It does not hurt the product because the inside surface of the tube is always clean. There is thus a marked difference in the types of heaters between the two systems. The better quality deodorized oils heated with the DFH must be related to this difference.

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