CONTINUOUS DEODORIZATION OF EDIBLE OILS

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Abstract

This paper discusses the use of a counter current deodorizing process in which oil flows by gravity downward through a deaerating device and a specially designed tower. The steam is let in at the bottom and flows counter-current to the oil flow. The process results in more effective use of vacuum and in considerable steam economy.

The application of Dowtherm as a heating medium for the process is discussed.

A CLOSE similarity exists between the problems of the deodorization of vegetable and animal oils, and those met in the distillation of petroleum oils. Both are essentially distillation processes. It is logical, therefore, that methods used in petroleum distillation should be of considerable value to the vegetable and animal oil industry.

Generally speaking, deodorization has been a batch process. Large bodies of oil have been put into closed containers and have been heated to relatively high temperatures. Usually the container has been subjected to a vacuum, and superheated steam in an amount dependent on the degree of vacuum has been introduced as a carrier to strip out the fatty acids and other undesirable odor-bearing constituents. Operating periods of from four to eight hours are commonly necessary to bring about satisfactory deodorization.

The handling of an oil in batch has the following disadvantages:

1. Because of the necessary depth of the body of oil in the deodorizer tank, and since the high vacuum produced at the top of deodorizer is fully effective only at the top surface of the oil, a large portion of the oil below the surface is under a greatly reduced vacuum because of the hydrostatic head of the oil above it.
2. Steam introduced cannot be used with a great degree of effectiveness. It is impossible in a batch system to use the steam counter-currently—that is, present the steam as it is accompanied by increasing amounts of distillation products, to oil containing progressively greater percentages of such products.

As a corollary of the above:

(a) Excessive amounts of steam are necessary for effective deodorization.

(b) The oil must be kept at the high temperature for a long period. This may result in the formation of other undesirable products which must be removed.

3. Since it is desirable to heat the oil to full temperature as quickly as possible, large and intermittent demands are made on the heat generating equipment.
4. Heat recovery is usually impracticable with a batch system.

The Continuous Deodorizer

Figure 1 illustrates a type of continuous deodorizer designed to overcome some of these objections.

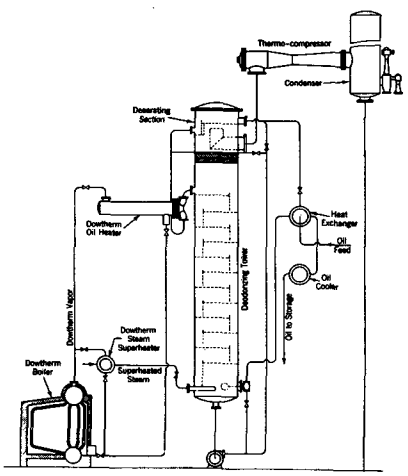

FIGURE 1

The equipment consists of the following elements:

Deodorizing Tower
Vacuum Equipment
Heat Exchange Equipment
Dowtherm Heating Equipment

Deodorizing Tower

The Deodorizing Tower is under high vacuum and is made up of two sections—the deaerating section and the deodorizer section.

It has been found to be desirable to release air, with its oxygen content from the oil before subjecting it to the final maximum temperature. The raw oil is introduced continuously into the deaerating section after having received a moderate preheat in the heat exchanger. Since the deaerator section is under the full tower vacuum, air, as well as some of the more volatile constituents of the oil, are released at this point.

From the deaerating section, the oil flows by gravity through a final heater, where it is brought up to the full temperature found to be desirable for deodorization. It reenters the tower at the top of the deodorizing section.

The deodorizing section consists of a series of bubble trays, the oil flowing across each of these trays laterally, at a fixed height of a few inches, as determined by a weir over which the oil flows to the next tray below it.

Each tray is provided with a number of openings covered by bubble caps, perforated by a large number of orifices below the oil level. Superheated steam which is admitted at the bottom of the tower passes up through the several trays in succession. Each tray, therefore, is a shallow pan of oil under full tower vacuum, violently agitated by, and in intimate contact with the stripping steam. It is to be observed that the flow of steam is counter to the flow of the oil. The pure steam as admitted to the bottom is in contact with the oil containing the minimum of volatile constituents, while the steam at the upper portion of the deodorizer section, which will have become charged with such volatiles in its passage through the tower, is in contact with the oil having the maximum volatile content.

This counter-current use of steam results in an appreciable steam economy, which is reflected not only in the amount of steam to be admitted to the tower for stripping purposes, but also in that required by the vac-

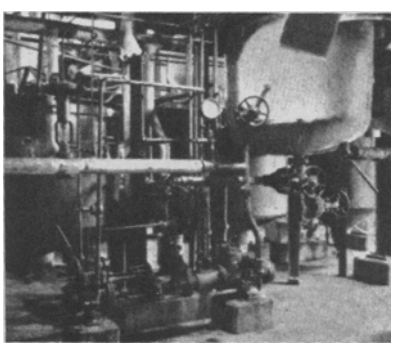

FIGURE 2

uum equipment for removing the vapors and the stripping steam. It is customary to provide entrainment eliminators to prevent carry-over of oil by the stripping steam. Figures 2 and 3 are photographs of a 1,200-lb. per hour Deodorizer unit. Figures 4 and 5 show views of a unit of 5,000 lbs. per hour capacity.

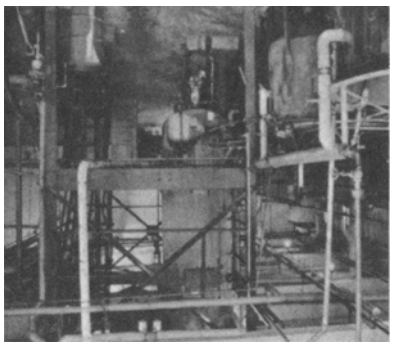

FIGURE 3

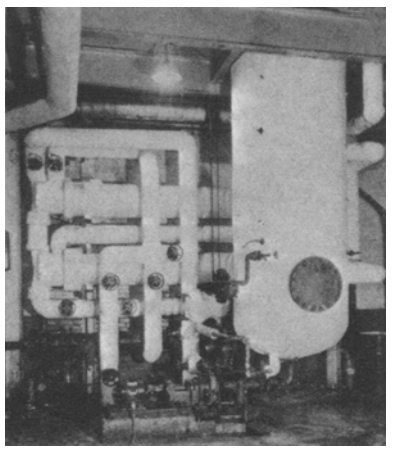

FIGURE 4

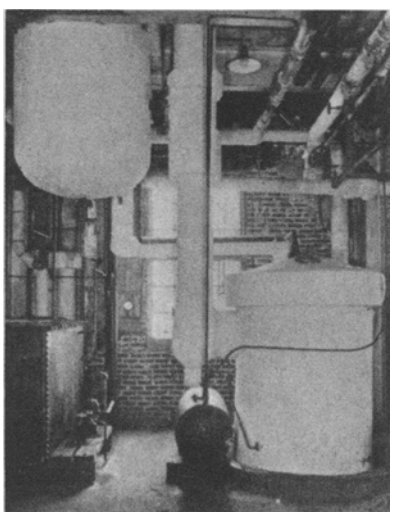

FIGURE 5

Vacuum Equipment

High vacuum, or low absolute pressure (5 mm. to 10 mm. Hg) is very essential for good deodorization, in order that excessive heating of the oil may be avoided. A steam ejector type Thermo-Compressor discharging into a counter-current type Barometric Condenser, served by a two-stage Steam Air Ejector, will satisfactorily remove the vapors from the tower while maintaining these low absolute pressures. Figure 6 shows a portion of such vacuum equipment as installed on a Continuous Deodorizer.

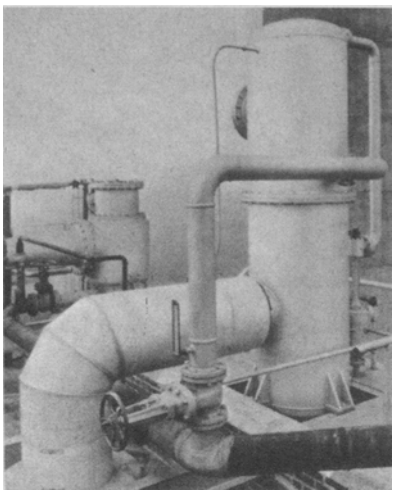

FIGURE 6

Oil Removal

A centrifugal, pressure sealed type, removal pump removes the finished oil from the tower. Recirculation of some of the oil has been found to be a useful procedure, increasing the tray efficiency and minimizing the temperature drop of the oil.

A liquid level controller permits the discharge of the oil from the system at a continuous rate, corresponding to the rate of raw feed. The oil thus remains in the tower a short time only.

Heat Exchange Equipment

Because of the continuous discharge of the hot finished oil, it is possible to cool this oil partially by means of raw oil, on its way to the deaerating section of the tower. A shell and tube type, or a double-tube type heat exchanger will accomplish this heat exchange. Usually 60 per cent or more of the necessary heating of the raw oil can be accomplished by heat recovered from the finished oil.

The finished oil, after passing through the heat exchanger, is required to pass in a closed circuit through a shell and tube water cooler, within which its temperature may be reduced from 100° F. to 120° F., before it is exposed to the air.

Dowtherm Heating Equipment

Temperatures on the order of 400° F. or slightly higher are desirable for proper deodorization. Heating in direct-firing tubular heaters, and indirect, hot recirculated mineral oil heaters, has been used in some instances. There are, however, some objections to both

PROPERTIES OF SATURATED DOWTHERM VAPORS

DOWTHERM "A"

73.5% Diphenyloxide
26.5% Diphenyl

Temperature		Pressure		Heat Content B.T.U./lb.			Spec. Heat	Density Lb./Cu. Ft.	
Deg. F.	Deg. C.	Lb./Sq. In. Abs.	Lb./Sq. In. Gauge	Liq.	Lat.	Tot.	Liq.	Liquid	Vapor
500.0	258.0	14.7	0	222.0	123	345	.63	54.1	.28
510.0	266.0	18.1	3.4	228.0	121	349	.63	53.7	.32
520.0	271.0	20.4	5.7	234.0	120	354	.64	53.2	.36
530.0	277.0	22.7	8.0	240.0	119	359	.64	53.0	.40
540.0	282.0	25.1	10.4	247.0	118	365	.65	52.7	.44
550.0	288.0	27.0	12.3	253.0	117	370	.65	52.3	48
560.0	293.0	30.8	16.1	260.0	115	375	.65	51.9	54
570.0	299.0	34.6	19.9	267.0	114	381	.66	51.6	.60
580.0	304.0	36.6	21.9	274.0	112	386	.66	51.2	.67
590.0	310.0	41.4	26.7	281.0	111	392	.66	50.8	75
600.0	315.0	44.3	29.6	288.0	110	398	.66	50.4	88
610.0	321.0	46.2	31.5	295.0	109	404	.67	50.1	1.00
620.0	327.0	53.0	35.4	302.0	107	409	.67	49.8	1.10
630.0	332.0	57.6	42.9	309.0	106	415	.67	49.3	1.17
640.0	338.0	63.6	48.9	316.0	105	421	.67	49.1	1.24
650.0	343.0	68.4	53.7	323.0	104	427	.67	48.6	1.29
660.0	349.0	74.2	59.5	330.0	102	432	.68	48.4	1.34
670.0	354.0	80.8	66.1	337.0	101	438	.68	47.9	1 40
680.0	360.0	87.7	73.0	344.0	99	443	.68	47.5	1.5
690.0	366.0	95.4	80.7	351.0	98	449	.68	47.2	1.6
700.0	371.0	104.0	89.3	358.0	97	455	.68	46.9	1.7
710.0	377.0	113.0	98.3	365.0	95	460	.68	46.3	1.8
720.0	382.0	119.0	104.0	372.0	93	465	.68	45.9	1.9
730.0	388.0	131.0	116.0	379.0	92	471	.68	45.5	2.1
740.0	393.0	142.0	127.0	386.0	90	476	.68	44.9	2.3
750.0	399.0	150.0	135.0	393.0	89	482	.68	44.4	2.5

FIGURE 7

systems. Heating the oil by means of a condensible vapor is most satisfactory, as close temperature regulation and good efficiency can most easily be obtained.

If steam were used as the heating medium, pressures on the order of 400 lbs. to 500 lbs. G. would be necessary to produce the desired oil temperatures, with reasonable temperature differences. These pressures have been found to give some operating difficulties.

Dowtherm has proved to be a very satisfactory heating medium. This is an eutectic mixture of Diphenyl and Diphenyl Oxide. It solidifies at a temperature of 54° F., only 22° higher than water. Its vaporizing temperature at atmospheric pressure is 500° F. Other properties are shown in Figure 7.

Dowtherm vapor, therefore, at pressures only slightly greater than atmospheric, will serve as a very satisfactory heating medium.

The final oil heater and the steam superheater are located at elevations above the top of the boiler. Dowtherm vapor is supplied to these units, and Dowtherm condensate returns to the boiler in a closed system. Dowtherm boilers are operated in the same manner as steam

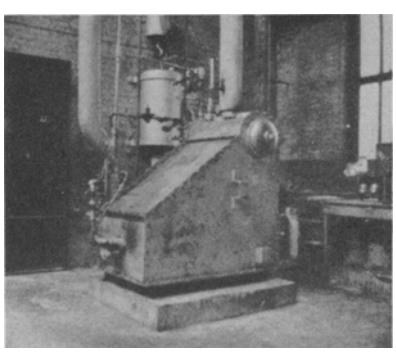

FIGURE 8

boilers, with semi-automatic control of gas or oil burners.

Figure 8 shows a unit having capacity of 100,000 B.t.u. per hour, and Figure 9 shows a boiler having a capacity of 2,200,000 B.t.u. per hour. Both of these boilers are operating in connection with vegetable oil deodorization systems, the former with a continuous system, and the latter with a batch system.

Two Continuous Deodorizer Units have been in operation for over one year. Operating results, flexibility of control, and excellence of the product have been proven.

A study of the results indicates that the free fatty acid content of the incoming oil has a bearing on the reduction in color of the finished deodorized oil. If the incoming oil has a low free fatty acid content, the color is somewhat reduced.

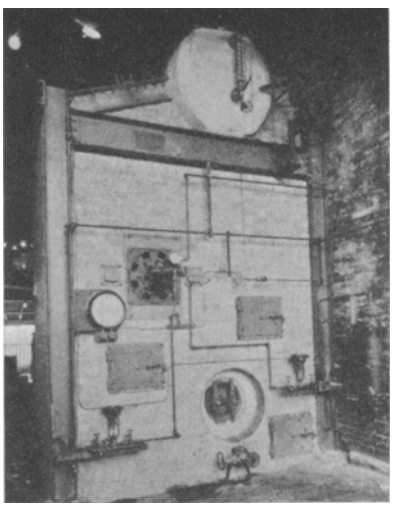

FIGURE 9

As the initial free fatty acid content increases, the reduction in color of the final product becomes less.

The removal of the free fatty acids, for a given capacity rate, steam flow, and vacua, is affected by the percentage contained in the incoming oil. A high fatty acid oil can be reduced to a minimum fatty acid content by lowering the through-put rate of oil.

Losses

Batch deodorization seems to involve some losses of oil due to hydroloysis of the glycerides, and subsequent distilling off of the fatty acids and glycerin, as well as any entrainment loss—judging from a study of numerous batch operating data, and specific tests made.

Continuous deodorization results in minimizing or completely eliminating such losses.

A test run on a 5,000-lb. per hour capacity Continuous Deodorizer Unit, checked by analyzing the condensing water discharged by the Vacuum Condenser, showed that the total carryover loss was 0.11%. This loss was that corresponding to the loss of free fatty acids in the incoming oil:

	Pct.
Free Fatty Acids in Incoming Oil	0.15
Free Fatty Acids in Finished Oil	0.04
Total loss by analysis	0.11

Thus no loss of original glycerides was found.

The entrainment of oil from the Deodorizer to the Vacuum Equipment is prevented by a special type of entrainment eliminator, having very low pressure drop built into the top of the Deodorizer Tower.

Three commercial deodorizer units are now being constructed, having designs essentially similar to the two units on which a year's record of operation has been obtained.

The following conclusions may be reached with respect to the operating characteristics and product of the Continuous Deodorizer:

1. The Continuous Deodorizer is satisfactory for the deodorization of salad oils, as well as the standard shortenings, of both the pure vegetable oil, and animal-vegetable oil type.
2. The flavor, color, and general quality of the finished product is in every way satisfactory.
3. The consumption of injection steam, and correspondingly, steam used for vacuum booster, is greatly decreased, as compared with batch operation.
4. The water required for the vacuum condensing equipment is decreased, in proportion to the decrease in steam.
5. The recovery of from 60 per cent and more, by heat exchange, considerably decreases the cost of heating the oil.
6. The continuous process allows of great flexibility as to capacity, operating efficiently at low rating, yet is instantly available for peak requirements.
7. Operation is less subject to variation than with batch operation, resulting in the finished product being more uniform.
8. Automatic control is easily adapted to the Continuous Deodorizer.

Erratum

Oil and Soap, Vol. 15, page 129, middle of 3rd column.

For the sentence on composition of Antarctic whale and cod liver oils substitute:

Approximate molar percentage composition of Antarctic whale and cod liver oils, respectively, were myristic 9, 2; myristoleic 4, 2; palmitic 17, 14; palmitoleic 17, 10; stearic 2, 1; C_{18} unsaturated 35 (mean unsaturation —2.6H), 26 (—3.3H); C_{20} unsaturated 12 (—5.6H), 25 (—5.5H); C_{22} unsaturated 4 (—9H), 20 (—7.4H); and C_{24} unsaturated ——, less than 1 per cent.