A Simple and Efficient Method for the Recovery of Deodorizer Distillates

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Abstract

An improved method has been developed to permit simple and efficient recovery of the distillates from oil deodorizer systems. A description of system and unit operation as well as design parameters are presented. Limited development experience is discussed and related to unit performance. Test methods used to determine unit performance are also discussed. Advantages resulting from use of this method to recover distillates are described to permit relative evaluation of similar systems.

Introduction

Basic Problem. Contamination of processing plant cooling water with deodorizer distillates has received much attention in recent years. More stringent stream pollution restrictions, high sewage surcharge rates by municipalities, and resale value of the recovered product are the reasons for the increased efforts toward a simple solution to this problem.

A typical deodorizer system is comprised of a deodorizer vessel and a three- or four-stage ejector with direct contact intercondensers. The ejectors maintain a vacuum within the deodorizer vessel in the range of 2–6 mm Hg absolute pressure. Heat and stripping steam are applied to the oil as it passes through the deodorizer. The stripping steam becomes saturated with fatty acid vapors and carries them out of the deodorizer and into the ejector system. The steam and fatty acid vapors are then compressed to a higher absolute pressure and condensed in a direct contact condenser, where they become a part of the discharge water flow. The distillates are immiscible with water and they form an oil-water emulsion that is very difficult to separate in an efficient manner.

In open or "once through" cooling water systems, this mixture is discharged directly to a sewer or back to the source of the cooling water. High sewage costs or stream pollution result and all distillates are lost to the processor.

In closed cooling water systems, the same water is recirculated through cooling towers and back to the condensers. The result here is a rapid build-up of the emulsion on all surfaces of contact such as piping, pumps, valves, cooling tower surfaces, spray nozzles, etc. Cooling water system maintenance costs are high because of fouling and plugging of lines and other system components.

History. Settling basins, heating, and acidulation have been the means of distillate recovery for many years. Settling basins are required to permit concn of the emulsified material to an amt that can be recovered at an economic gain. This method is not very efficient and cannot recover those distillates that do not readily float to the surface. Distillate recovery is only partial, therefore the quantity available for resale is minimal. Required acidulation additionally keeps the resale value of the product low.

Early interest in the problem of distillate recovery was in the area of condensation of distillates in a closed system using water as the condensing fluid (1). The recycled mixture was maintained as a separate stream from condenser water flow, therefore permitting collection of the distillates before they could contaminate the condenser water. Heating, centrifuging, and recycling the mixture of distillates and water were included in this method. Market value and quantity of recovered distillates were increased. The difficulty of handling and separating a mixture of distillates and water was greater than expected, and resulted in a search for a better solution to the distillate recovery problem.

Several schemes were devised and equipment was designed to permit evaluation of the proposed solutions. The simplicity of complete distillate removal within a single vessel and low unit operating costs were the basic goals of the project.

Present Status. This project resulted in a more efficient method for recovering deodorizer distillates. Condensed distillates do not mix with water, thus eliminating the need for heating and centrifuging. A high rate of recovery, better than 95%, has been obtained through operation of an experimental unit.

The new method is accomplished in one vessel, called a scrub cooler, that is located between the first intercondenser and the ejector that would normally discharge to the first intercondenser.

The principle of operation of the unit is the reverse of the deodorizer. High temp, low absolute pressure, and high partial pressures are used in the evaporation process in the deodorizer. Low temp, higher absolute pressure, and low partial pressures are applied in the scrub cooler for condensation of the distillates. The end product is a moisture-free solution of distillates that is delivered to a shipping container or storage tank at atmospheric pressure.

Unit Operation

Description. A pictorial description of the scrub cooler in operation is shown on Figure 1. Steam, air, and fatty

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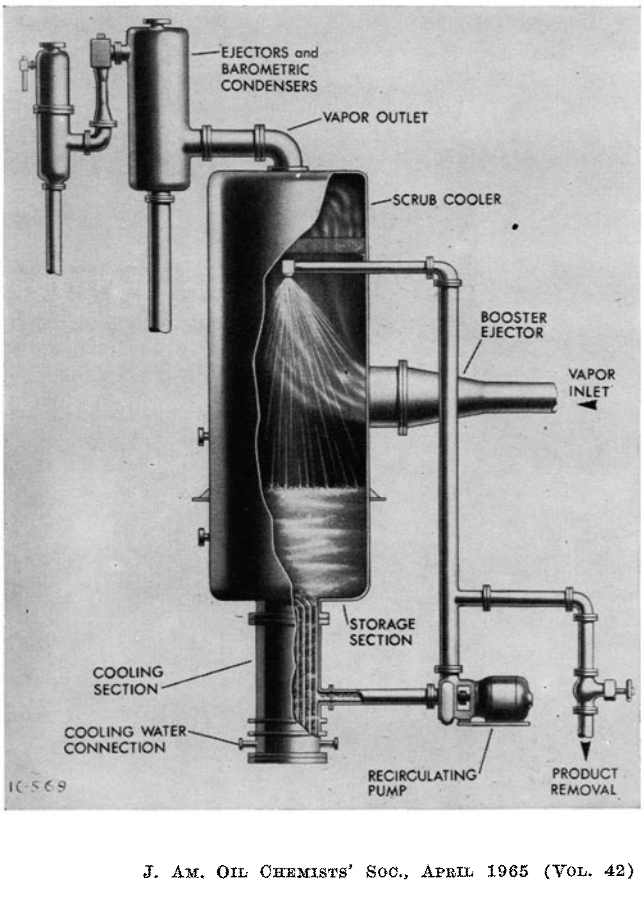

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acid vapors flow from the deodorizer to the booster ejector and then into the scrub cooler vapor inlet connection. The vapors rise vertically upward through a descending spray of recirculated fatty acid mixture in liquid form, where they are cooled by direct contact heat transfer and the fatty acid vapors are condensed, thereby separating them from the gaseous mixture. The quantity of fatty acid vapors that will condense is dependent upon the quantity contained in the inlet vapor flow and the particular saturation pressure-temp relationship maintained in the vessel.

It is virtually impossible to scrub all of the condensed particles of fatty acids from the vapor flow by the action of the liquid spray alone; therefore the vapor flow is passed through a liquid entrainment separator before flowing into the barometric condenser. Entrained particles are collected in the separator and drained back to the storage area of the vessel.

Heat absorbed by the recirculated liquid when cooling inlet vapors and condensing fatty acid is rejected to a shell and tube heat exchanger located in the storage section of the unit. A small quantity of cooling water is supplied to the tube side of the exchanger to carry away the heat transferred therein. Temp of recirculated liquid is maintained at an optimum level for maximum recovery of fatty acids.

A volume of liquid is maintained in the storage section of the scrub cooler to assure full flow across the exchanger. The level of the storage volume increases because fatty acids condense and collect in the recirculating liquid. A reasonable level is maintained by periodically pumping part of the condensed distillate to a shipping container at atmospheric pressure through a bypass valve located in the recirculating pump discharge line.

Initial liquid charge to start scrub cooler operation can be a neutral oil or a solution of previously collected deodorizer distillates. The liquid mixture will dilute to match the composition of the condensed distillates after a given period of operating time which is dependent upon the quantity of the initial charge and the rate of condensation.

Advantages. 1) Most plants still use mechanical or manual methods to recover some distillates from their recirculating water system. The remaining distillates foul piping, valves, cooling tower surfaces, etc., requiring frequent shutdowns for cleaning and unplugging lines. The new method eliminates the shutdown periods, resulting in an increase in oil processing time and the elimination of high maintenance costs.

2) Distillates recovered by this method are moisture-free and in marketable form. Heat and acidulation are not required in the recovery process, with resultant savings in steam, power, and acid. The total amt of product recovered is much greater than by the general method now in use and therefore revenue from sale of the product is much higher.

3) Many municipalities are enacting ordinances limiting the amt of suspended solids and the biochemical oxygen demand (BOD) of waste waters. Surcharges are applied when the limits are exceeded. Even the smallest deodorizer system would presently require payment of the surcharges in certain municipalities when operated as open or "once through" systems.

Since the use of this new method prevents most of the contaminants from flowing into the condenser water, suspended solids and BOD are minimal and well within present and expected municipal limits. Average experimental results show less than 5 ppm of contaminants.

4) The new method for distillate recovery can be adapted to existing deodorizer systems as well as new installations.

5) Actual operation of this method requires very little operator attention. Standard controls are easily adapted for complete system automation.

Economic Evaluation. The advantages of a new system or method are always measured against its operating and

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installation costs for justification or rejection. Cost comparisons for the new method will include increased steam and cooling water flow rates and power to recirculate the condensing fluid. When the added costs are compared with savings in maintenance and sewage charges plus additional revenue from recovered distillates, the difference must justify the investment in new equipment required.

Unit size, operating costs, maintenance costs, and sewage surcharge rates will vary widely from one locality to another; however, we feel that the following analysis will be representive of a typical installation.

Installed costs of new equipment	$30,000
Annual cost of additional utilities (300 days):	
200 lb/hr steam @ $1.00 per 1000 lb/hr	1,440
30 gpm cooling water @ $0.01 per 1000 gal/hr	130
75 HP recirculation of liquid	1,080
Annual Added Cost	$ 2,650
Annual savings or gain from use of the new method:	
Assume new recovery rate is 30 lb/hr greater than the old rate, ignore premium gain, and assume $0.06/lb resale value.	$13,000
Maintenance estimate.	2,000
Ignore savings in former steam and acid treatment of distillates.	0
Ignore sewage surcharges.	0
Annual savings	$15,000

Payback = Installed Cost/(Savings − Added Cost)
= 30,000/(15,000 — 2,650) = 2.4 yr.

It is expected that capital investments for equipment required by the new method will have payback periods of one to three years before taxes.

Equipment Design

Preliminary Considerations. Samples of hotwell skimmings were requested and obtained from several oil processors. The temp-viscosity relationship was derived for the distillate portion of each sample and plotted on Figure 2. It can be seen that pour points vary from 80F to 165F. Experimental unit recirculating liquid viscosity was also plotted for comparison with the expected values.

It was evident that a very flexible process would be required to operate with the large variety of deodorizer systems, each processing widely varying oil feed stock.

Published data relating vapor pressure and temp for deodorizer distillates were not available in the range that was anticipated for unit operation, so approximations were plotted by extending known vapor pressure data (2). Figure 3 is a plot of extended vapor pressure data.

Theoretical Basis. Since a wide variety of conditions were expected for processing of different oils, we assumed two operating conditions to illustrate the differences that might be encountered. Separate deodorizer system installations were assumed, with one processing coconut oil and the other processing soybean oil. We let scrub cooler inlet flow conditions for each include 2,000 lb/hr ejector steam, 500 lb/hr stripping steam, 50 lb/hr air, and 50 lb/hr fatty acid vapors all at 55.0 mm Hg of absolute pressure and 250F. It was also assumed that coconut oil distillates could be cooled to 110F without stiffening the mixture, and that the vapor pressure and mol wt considerations would approximate those of lauric acid, the major fatty acid component (3). Similarly we let soybean oil distillates approximate linoleic acid qualities, but at a temp of 175F. Calculations using Dalton's law of partial pressures were made to determine the maximum expected flow of distillate from the scrub cooler. A ratio to find scrub cooler efficiency was simply inlet flow minus outlet flow over inlet flow. Results were as follows:

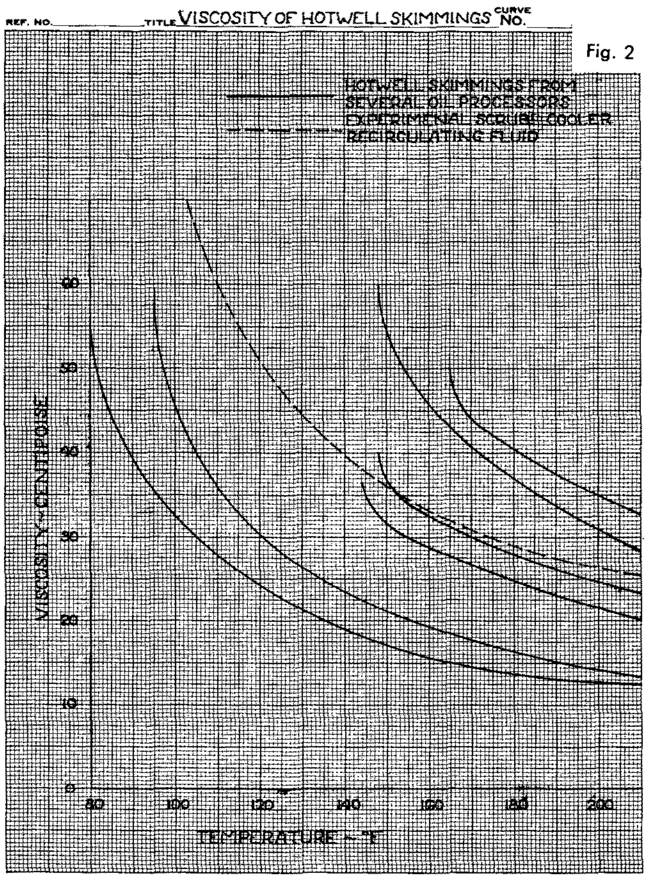

Fig. 2

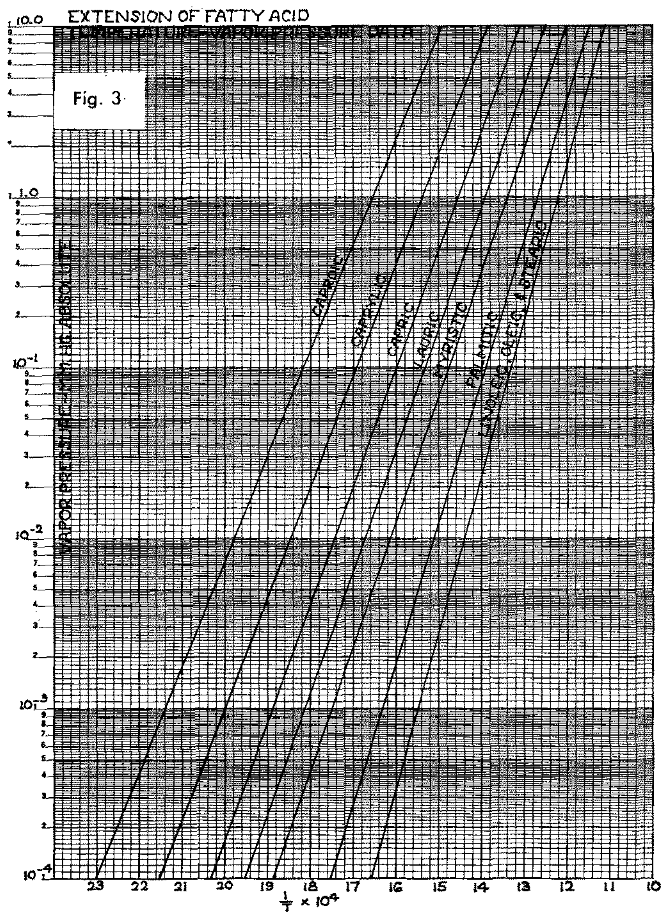

Fig. 3