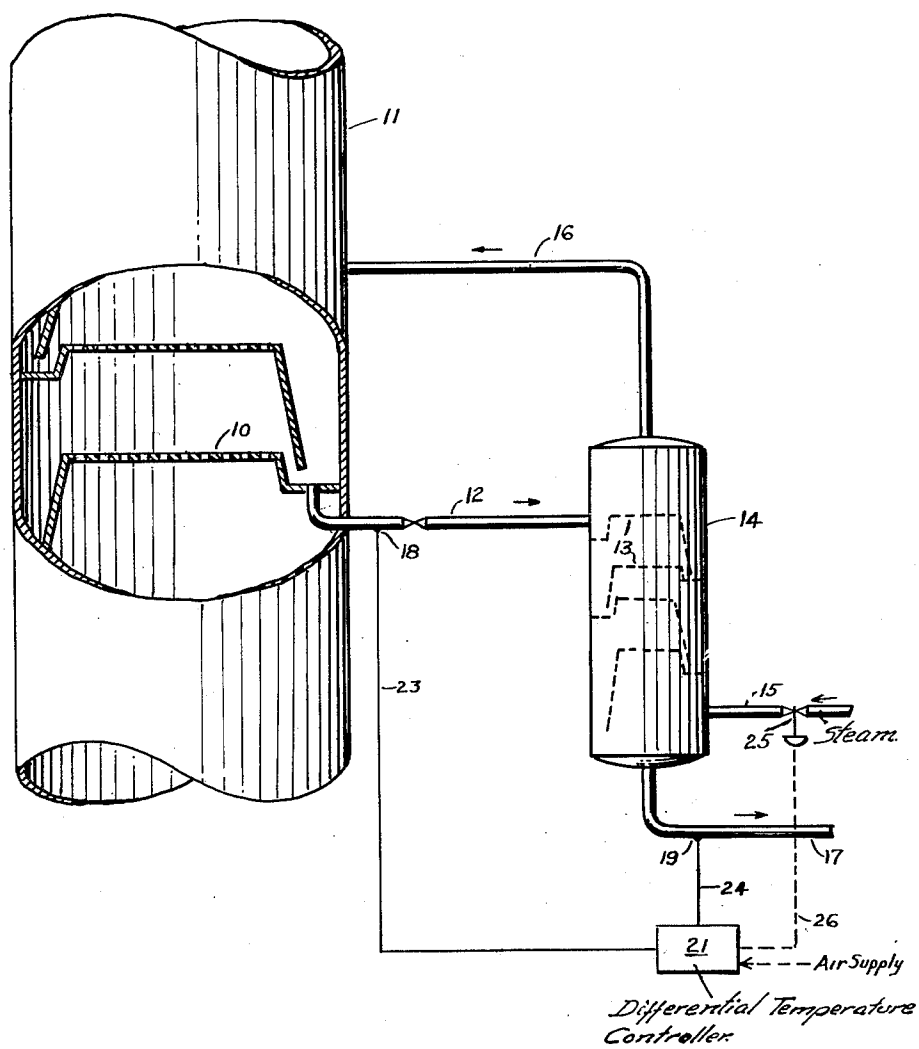


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PROCESS AND APPARATUS FOR CONTROLLING STEAM
DISTILLATION OF PETROLEUM
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PROCESS AND APPARATUS FOR CONTROLLING STEAM DISTILLATION OF PETROLEUM

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This invention relates to steam distillation and more particularly to a method and apparatus for controlling the steam stripping of a fractionating column liquid product stream.

In fractionating wide-boiling range mixtures such as crude petroleum oil, several liquid product streams, including side streams and a bottom product, are withdrawn at different levels from the fractionating column. The liquid streams as withdrawn from the column are not completely fractionated, however, because of the fact that during fractionation products lighter than the particular liquid streams pass upwardly in vapor phase through the trays from which the liquid streams are withdrawn. Some of this vapor dissolves in the liquid which is drawn off as side streams. To remove the dissolved light ends and complete the fractionation, the side streams conventionally are stripped with steam in auxiliary stripping columns. The bottoms liquid is ordinarily stripped with steam introduced in a stripping section at the bottom of the fractionating column.

The conventional stripping operation is a steam distillation in which the light ends dissolved in the liquid are vaporized. The side stream from the fractionating column is charged to the upper end of a stripping column which contains vapor-liquid contacting means such as bubble-cap trays. Steam is fed to the lower end of the column. The steam lowers the partial vapor pressure of the oil. Vaporization results and vapor which contains the low-boiling material passes out the top of the column.

In the conventional operation of a steam stripper the valve in the steam line to the bottom of the stripper is kept open sufficiently to insure that enough steam will be supplied for the required degree of stripping regardless of fluctuations in the rate at which the oil stream is fed to the stripper and regardless of fluctuations in the steam pressure. This means that for a considerable portion of the steam stripping operation an excess of steam is charged to the stripper. More steam than is necessary is charged during periods when the steam requirement is less than maximum and during such periods there is a waste of steam.

The method and apparatus of the present invention prevent or reduce the waste of steam and also ensure that sufficient steam is provided for the required degree of stripping. The amount of steam introduced into the stripping column is controlled to provide a substantially constant degree of stripping despite fluctuations in the rate at which the oil stream is fed to the column and despite fluctuations in the steam pressure which occur in normal refinery operations.

The method of the invention comprises controlling the rate of steam introduction in a steam distillation or stripping column in response to changes in the temperature differential between the feed liquid stream to the column and the bottoms product liquid or stripped oil stream. The apparatus of the invention comprises a steam distillation or stripping column with a feed line at its upper end, means for measuring the temperature in said feed line,

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a bottoms liquid line, means for measuring the temperature in said bottoms liquid line, a steam line at the lower end of the column, a flow control valve in the steam line, and a differential temperature controller for measuring the temperature differential between the feed line and the bottoms liquid line and for controlling the flow control valve in the steam line in response to changes in said temperature differential.

The invention can best be described in detail by referring to the drawing, the sole figure of which shows diagrammatically and partially in section an intermediate portion of a fractionating column and an associated side stream stripper equipped with a system of controls in accordance with the invention.

A liquid side stream such as a gas oil cut of a crude petroleum oil is withdrawn from tray 10 of column 11 via line 12. This stream contains a minor amount of dissolved vapors, for example, ten weight percent, which must be removed by steam stripping to produce a product of the required flash point. The side stream is fed by oil feed line 12 into the upper end of the auxiliary stripping column 14 which is provided with vapor-liquid contacting means such as the bubble-cap trays 13 indicated diagrammatically in the drawing. Steam is fed into the bottom of stripper 14 by steam line 15 to lower the partial vapor pressure of the oil and to cause vaporization of the dissolved light ends. The vaporized light ends together with steam are returned to the fractionating column 11 by the stripper overhead vapor line 16. The stripped liquid, freed of light ends, is recovered as product from the stripper by bottoms product line 17.

The temperature in line 17 will be somewhat lower than the temperature in line 12 because of the cooling of the oil in the steam stripper. The cooling results from three principal effects, namely, cooling of the unvaporized liquid by the vaporization of light ends, loss of heat through the walls of the column and any cooling due to difference in temperature of the oil and steam. Heat loss through the walls of the column can be kept small by insulating the column. The rate of loss will remain substantially constant throughout the stripping operation. Any cooling caused by difference in temperature of the steam and oil will also not vary appreciably. Therefore, the principal cause of variations in the temperature differential between the feed oil in line 12 and the stripped oil in line 17 is variation in the degree of stripping which takes place in column 14. The temperature differential is substantially directly proportional to the percentage of material vaporized from the liquid entering by line 12.

In accordance with the invention, temperature measurements are made in lines 12 and 17 and a constant differential temperature between the oil in line 12 and the oil in line 17 is maintained to provide a constant degree of stripping in column 14. The oil feed line 12 and the bottoms product line 17 are provided with temperature-sensitive or detecting devices which are primary elements of temperature measuring instruments, the temperature taps being at points 18 and 19, as shown in the drawing. Devices which can be used include industrial thermometers, bimetallic thermometers, capillary tube and bulb system thermometers, electrical resistance thermometers, thermocouples and the like. The temperature-sensitive devices transmit indications of the temperatures of the liquid streams in lines 12 and 17 to a differential temperature controller 21 by pneumatic or capillary tubing or by electrical conductors, whichever are appropriate for the particular device, as indicated by lines 23 and 24 in the drawing. Temperature recording or indicating instruments can be placed in the lines 23 and 24 connecting the temperature-sensitive devices with the differential temperature controller but preferably the temperature indi-

cations are transmitted directly to the differential temperature controller as shown.

The differential temperature controller 21, which can be a recording control, an indicating control, a recording-indicating control or a blind control instrument of conventional design, operates the flow control valve 25 in the steam line 15 in response to changes in the differential temperature between points 18 and 19. Valve 25 is an automatically-controllable valve such as a pneumatic diaphragm motor operated valve or an electric motor operated valve or the like. Advantageously, as shown in the drawing, valve 25 is a diaphragm valve which is operated pneumatically by differential temperature controller 21 through the air line 26.

In steam stripping a side stream from a crude oil fractionating column, in accordance with the invention, the differential temperature controller 21 is set for a temperature difference between the oil entering and the oil leaving the stripper which is determined by test or calculation as being the degree of cooling which corresponds to the required degree of stripping. For example, in a column designed to fractionate a particular crude oil it may be determined that 10 percent of the particular side stream must be removed by steam stripping to yield a gas oil product of the required specifications. In vaporizing 10 percent of this side stream by steam stripping the self-cooling effect reduces the temperature of the unvaporized oil, for example, by 15° F. Other heat losses reduce the temperature of the oil, say by about 10° F. so that for 10 percent stripping of the side stream the temperature difference between the oil entering the stripper and the oil leaving the stripper is about 25° F.

In the particular operation under consideration the flow control valve 25 in steam line 15 is opened to a position which will provide enough steam for 10 percent stripping of the side stream from the fractionating column at the particular initial steam pressure and at the particular initial rate of withdrawal of the side stream from the fractionating column. The differential temperature controller 21 is set for the required constant temperature differential, 25° F. in this particular example. The automatic controls of the invention begin to function with fluctuations in the operating conditions such as fluctuations in the flow rate of the side stream oil into the stripper or fluctuations in the steam pressure in steam line 15. If the side stream entering the stripper decreases in flow rate because of reduction in the crude oil rate to the fractionating column while the steam rate to the stripper remains constant there will be an increase in the degree of stripping in the steam stripper because of the increased ratio of steam to oil. If the steam rate is not decreased the oil will be over-stripped and steam will be wasted. Similarly, if there is an increase in the side stream rate to the stripper with a constant steam rate, the steam to oil ratio will decrease, the side stream will be under-stripped and will not meet flash point specifications.

These undesirable results are avoided in my method of control because the steam rate is automatically adjusted to maintain a substantially constant degree of stripping. If the side stream rate tends to decrease while the steam rate remains constant there will be a tendency toward increased stripping and since the degree of stripping is directly proportional to the degree of cooling of the oil there will be an increase in the temperature differential between the oil entering the stripper and the oil leaving the stripper. When the temperature difference tends to increase, the differential temperature controller 21 by changing the air pressure in line 26 operates the diaphragm flow control valve 25 in steam line 15 to the steam stripper to decrease the steam rate. The steam rate is thus adjusted to the decreased oil rate and the degree of stripping of the oil remains at the desired value of about 10 percent. Similarly, when the oil rate to the stripper increases, the temperature differential tends to decrease and the differential

temperature controller 21, to maintain a constant differential, increases the steam rate and the degree of stripping is maintained at about 10 percent. Thus, with my system of control, fluctuations in the rate of flow of the side stream from the fractionating column to the steam stripper are automatically compensated for by adjustments in the steam rate.

Another condition in steam stripping which may fluctuate substantially is the steam pressure to the steam stripper. If the steam pressure increases substantially for a particular setting of the flow control valve in the steam line the amount of steam entering the stripper increases. The ratio of steam to oil in the stripper increases, and the oil is overstripped and steam is wasted. Similarly, if the steam pressure in the line drops without a change in the setting of the flow control valve, an insufficient amount of steam is fed to the stripper for the particular oil feed rate and the oil stream is under-stripped. In my method of control when the steam pressure increases, thus causing a tendency of over-stripping and a rise in the differential temperature of the feed oil and stripped oil, the differential temperature controller 21 partially closes the steam flow control valve 25 to maintain a constant rate of steam introduction into the stripper and a constant differential temperature. The control functions in an opposite manner to compensate for a decrease in steam pressure.

In the foregoing description I have discussed specifically the steam stripping of side streams from a crude fractionating column. It should be understood, however, that the apparatus and method of control of my invention are applicable to steam distillation of any liquid mixture in which automatic control of the steam rate to compensate for variations in the feed rate or steam pressure is desired.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In the steam stripping of a petroleum oil stream from a fractionating column wherein the oil is introduced into the stripping column at about the temperature at which it is withdrawn from the fractionating column, open steam being introduced at the lower end of the column primarily to reduce the partial vapor pressure of the light ends of the oil, and in which, except for a minor amount of heat transfer at a substantially constant rate through the walls of the column, heat is put into column only by the oil feed and the steam, and heat is taken out of the column only by the vapor withdrawn overhead from the column and by the stripped liquid withdrawn from the bottom of the column, the improvement which comprises measuring the difference between the temperature of the stream of petroleum oil being fed to the stripping column and the temperature of the stream of stripped oil being withdrawn from the bottom of the stripping column and maintaining said temperature difference substantially constant by regulating the flow rate at which steam is introduced to the stripping column in response to changes in said temperature difference, the flow rate of steam being increased as said temperature difference decreases and being decreased as said temperature difference increases.

2. Apparatus for steam stripping a petroleum oil stream withdrawn from a fractionating column which comprises a stripping column having vapor-liquid contacting means therein, a feed line at the upper end of said stripping column for introducing said petroleum oil stream from said fractionating column, an overhead line at the upper end of said stripping column for returning stripped vapor to said fractionating column, a bottoms liquid line at the lower end of said stripping column, temperature-sensitive means in said feed line and temperature-sensitive

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means in said bottoms liquid line, a line for introducing steam to said stripping column, a flow control valve in said steam line, and a differential temperature controller connected with said temperature-sensitive means for measuring the temperature differential between the feed line and the bottoms liquid line, said differential temperature controller being also operatively connected with the flow control valve in the steam line for controlling said valve in response to changes in said temperature differential.

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