

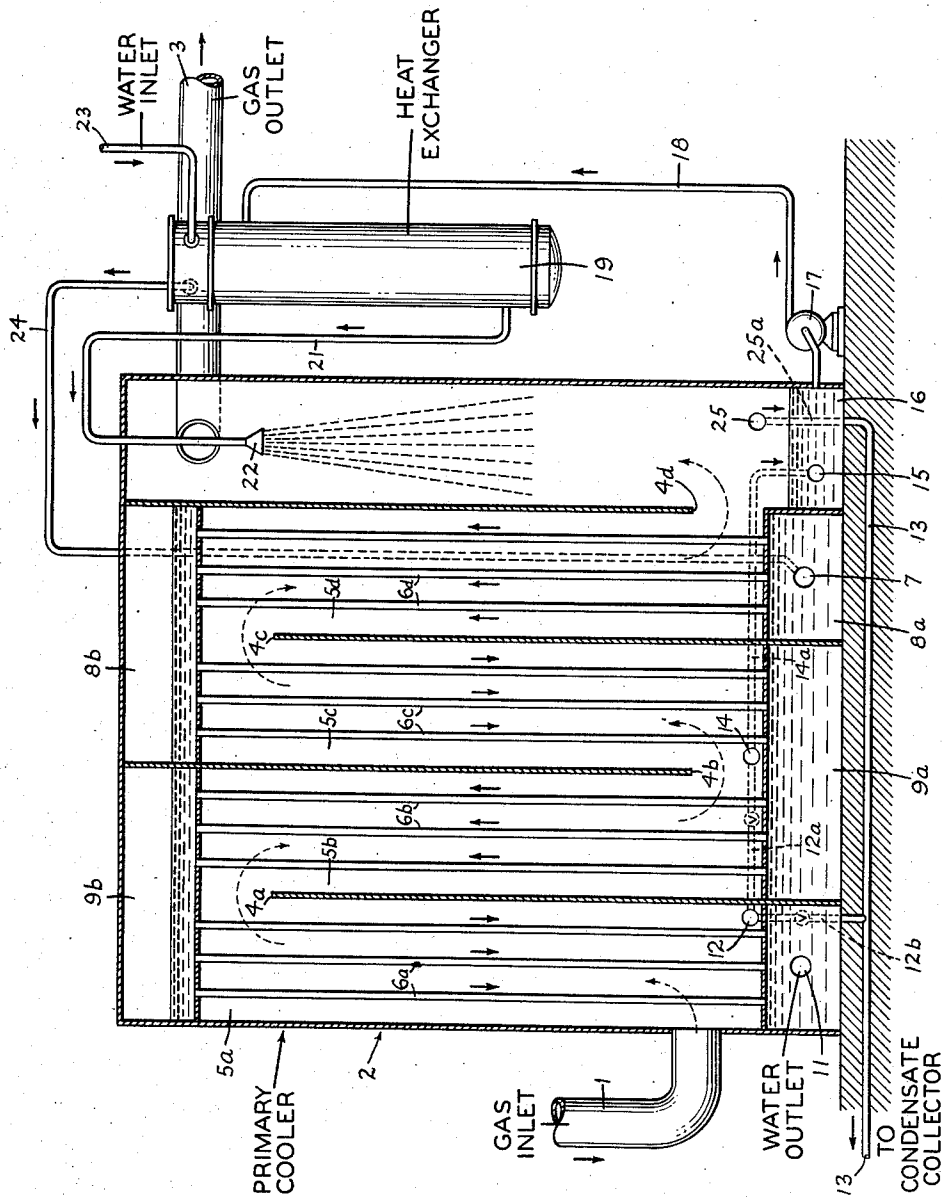
Aug. 11, 1959

G. A. DAVIS

2,899,012

PROCESS AND APPARATUS FOR COOLING COKE OVEN GAS

Filed Oct. 2, 1957



INVENTOR
 GEORGE A. DAVIS,
 DECEASED
 BY ETHEL M. DAVIS,
 LEGAL REPRESENTATIVE
 BY *Ernest A. Polin*
 ATTORNEY

1

2,899,012

PROCESS AND APPARATUS FOR COOLING COKE OVEN GAS

George Allen Davis, deceased, late of Mountain Lakes, N.J., by Ethel Marie Davis, legal representative, Mountain Lakes, N.J., assignor to Allied Chemical Corporation, New York, N.Y., a corporation of New York

Application October 2, 1957, Serial No. 687,793

6 Claims. (Cl. 183—2)

This invention relates to a continuous process for effecting primary cooling of coke oven gas obtained from the collecting main of a by-product coke oven plant and to apparatus adapted for carrying out such process.

Coke oven gas generally exits by-product coke ovens at a temperature of about 900° to 1200° F. This hot gas is quenched in a collecting main with flushing liquor, thereby reducing the temperature of the gas to a temperature upwards of about 170° F., usually about 174° to 180° F. The gas withdrawn from the collecting main of by-product coke ovens contains naphthalene in non-saturating amount together with water, tar (heavy oils), ammonia and light oils, and is then delivered for recovery of tar and lighter products, including naphthalene and light oils. Conventionally, the first step in processing this gas is to cool it in a primary cooler to a temperature of about 90° to 100° F., thereby condensing water and tar. In the past, it has been recognized common practice to cool the gas by passing it through a multi-tubular, indirect-type primary cooler.

In a typical primary cooler, vertical tubes containing cooling water are arranged in several passes separated by baffles. The hot coke oven gas enters the first pass outside the tubes, passes up and down through the successive passes and then out of the last pass. Simultaneously, the cooling water passes through the tubes countercurrent to the gas. This type of primary cooler exhibits fair heat exchange efficiency at its hot end, but the heat transfer coefficient falls off progressively towards the cool end of the cooler. Furthermore, naphthalene precipitates out and accumulates as blocking and insulating deposit on the walls of the cooling tubes. In order to permit operation for reasonable lengths of time between shutdowns to remove naphthalene deposit, it has been necessary to use quite wide tube spacing at the expense of substantially decreased efficiency of heat transfer. However, even with such construction, it has been found necessary to take the cooler out of service at frequent intervals to steam out the naphthalene.

An object of the present invention is to provide an improved, economical and efficient continuous process for effecting primary cooling of raw coke oven gas evolved from by-product coke ovens without incurring the deposition of naphthalene in the cooler.

Another object of the invention is to provide apparatus adapted for carrying out the improved process.

Other objects and advantages of the invention will appear hereinafter.

According to the process of the present invention, coke oven gas, withdrawn from the collecting main of by-product coke ovens and containing naphthalene in non-saturating amount together with water, tar, ammonia and light oils, is continuously cooled by passing the coke oven gas in indirect countercurrent contact with a fluid cooling medium to partially cool the coke oven gas to a temperature of about 105° to about 140° F., preferably about 105° to about 115° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate, spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled

2

gas to completely cool the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

According to a more specific aspect of the process of the present invention, the condensate to be employed as spray in completing the cooling of the coke oven gas is preliminarily cooled by passing the condensate through a heat exchanger provided with a circulating fluid cooling medium. The cooling medium exiting the heat exchanger is then used as the cooling medium for effecting the indirect cooling of the coke oven gas.

By means of the present process wherein coke oven gas obtained from the collecting main of by-product coke ovens is partially cooled by indirect contact with a fluid cooling medium to a temperature of about 105° to about 140° F. and is then finally cooled to a temperature of about 90° to about 100° F. by direct contact with condensate recovered from the partial cooling step, economical and efficient cooling of the coke oven gas is accomplished without incurring deposition of naphthalene on any part of the cooling equipment. Thus, this process permits use of cooling equipment designed for maximum heat transfer efficiency, and shutdowns to remove naphthalene deposit from the cooling equipment are virtually eliminated. In the partial cooling stage of the process, part of the naphthalene vapor in the coke oven gas is absorbed in the condensed tar. However, the temperatures employed during partial cooling are sufficiently high to preclude deposition of naphthalene on the cooling equipment. In the final cooling stage, the tar present in the condensate promotes absorption of naphthalene and minimizes the presence of naphthalene particles in the condensate. Simplicity and economy of operation are realized by that aspect of the present process wherein the fluid cooling medium exiting the heat exchanger employed in cooling condensate to be used as spray in the final cooling step is reused as the cooling medium in the primary, indirect cooling step of the process.

The attached drawing represents a diagrammatic elevational view of the apparatus employed in carrying out the continuous process of the present invention.

Referring to the drawing, coke oven gas coming from the collection main of a battery of by-product coke ovens (not shown) at a temperature of at least about 170° F., typically about 174° to about 180° F., contains naphthalene in non-saturating amount at that temperature (i.e., about 350 to 700 grains of naphthalene per 100 cu. ft. of gas) together with water, tar (heavy aromatic oils having a boiling point of, e.g., about 440° to about 650° F., and comprising anthracene oils, creosote oils and middle oils), ammonia and light oils (aromatic oils having a boiling point of about 175° to about 350° F., and comprising benzene, toluene and xylenes). The coke oven gas is introduced through inlet 1 of primary cooler 2 and exits the cooler through outlet 3. Within cooler 2 are disposed a series of baffles 4a, 4b, 4c and 4d, alternate baffles being secured at the top and at the bottom of the cooler, respectively. These baffles define a plurality of passes 5a, 5b, 5c and 5d through which the gas flows. Passes 5a, 5b, 5c and 5d are provided with groups of tubes 6a, 6b, 6c and 6d, respectively, within which a suitable fluid cooling medium, preferably water, circulates countercurrent to the direction of the coke oven gas flow.

The cooling medium enters the tubular section of cooler 2 through inlet 7 and fills lower chamber 8a. The cooling medium then flows upwardly through tubes 6d to par-

3

tially fill upper chamber 8b. In a similar manner, the cooling medium flows downwardly through tubes 6c to lower chamber 9a, upwardly through tubes 6b to upper chamber 9b and downwardly through tubes 6a. The spent cooling medium exits through outlet 11.

The number of passes and the temperature of the cooling medium are so controlled that the coke oven gas exiting the final pass is partially cooled to a temperature of about 105° to about 140° F., thereby condensing water and tar (heavy oils) contained in the coke oven gas and producing a gas containing naphthalene in nearly saturated quantities (i.e., about 90 to 150 grains of naphthalene per 100 cu. ft. of gas at the temperature about 105° to about 140° F.). Although four passes are shown in the attached drawing, more or less passes may be found suitable. Preferably, the cooling medium is introduced into the cooling tubes at a temperature varying from about 85° to about 100° F.

In first pass 5a, condensate containing water and a substantial amount of the tar present in the coke oven gas (usually a major proportion of the total tar), together with some absorbed naphthalene, is withdrawn through drain 12. The coke oven gas exits pass 5a at a temperature of about 150° to about 170° F. Condensate comprising water and the residual tar content of the coke oven gas, together with additional absorbed naphthalene, forms in passes 5b and 5c, flows through drain 14 where it combines with condensate flowing from drain 12 via valved line 12a. The combined condensates flow from drain 14 via line 14a to outlet 15 and then enter the bottom of spray pass 16. Condensate composed essentially of water collects in pass 5d and flows downwardly by gravity to the bottom of spray pass 16 where it combines with the combined condensates exiting outlet 15. The coke oven gas exits pass 5d at a temperature of about 105° to about 140° F. If desired, part or all of the condensate formed in pass 5a may flow from drain 12 via valved line 12b to line 13, and thence to a condensate collector (not shown).

During the entire passage of the coke oven gas through passes 5a to 5d, there is no deposition of naphthalene on the tubes or baffles of the cooling equipment.

From the bottom of spray pass 16, tar-containing condensate having a temperature of about 90° to about 120° F., is pumped by pump 17 via line 18 to the top portion of conventional heat exchanger 19. In heat exchanger 19, the condensate is cooled, preferably to a temperature of about 80° to about 95° F. The cooled condensate passes from exchanger 19 via line 21 to spray means 22 situated in the upper portion of spray pass 16.

The cooling medium for heat exchanger 19 is supplied by introducing suitable fluid cooling medium, e.g. water, through line 23. After passing through the heat exchanger, the cooling medium which has been slightly heated by contact with the condensate passing through the exchanger, preferably to the aforesaid temperature of about 85° to about 100° F., exits the exchanger via line 24 and passes through inlet 7 of cooler 2. The cooling medium then passes through tubes 6d, 6c, 6b and 6a in countercurrent relationship to the coke oven gas flowing around the tubes.

Recirculated condensate is sprayed downwardly out of spray means 22 at the rate of about 3 to 6 gallons per 100 cu. ft. of gas exiting cooling pass 5d so that it contacts the rising partially cooled coke oven gas and cools it to the desired final temperature of about 90° to about 100° F., thereby producing a gas supersaturated with naphthalene. At the same time, the downwardly sprayed condensate serves to remove particles of naphthalene which have precipitated out of the cooled gas at the final temperature of about 90° to 100° F. Substantial amounts up to all of the naphthalene particles are absorbed by the tar content of the condensate. The finally cooled coke oven gas is saturated with naphthalene (i.e., it contains about 50 to 100 grains of naphthalene

4

per 100 cu. ft. of gas at the temperature of about 90° to about 100° F.) and also contains ammonia and light oils.

The finally cooled coke oven gas may then be subjected to further conventional processing in order to recover naphthalene, ammonia and light oils therefrom.

Residual condensate collected in the bottom of spray pass 16 and not recirculated to spray means 22 is withdrawn through drain 25 and passes via lines 25a and 13 to the condensate collector. The tar and liquor collected in the condensate collector may be layer separated and naphthalene recovered from the tar layer by any suitable procedure. Alternatively, residual condensate collected in the bottom of spray pass 16 may be sent to a separate condensate collector when separate processing of the tar-rich condensate removed from pass 5a is desired.

The invention will be further illustrated by the following specific example.

Example

Coke oven gas is withdrawn from the collecting main of a battery of by-product coke ovens at a temperature of about 180° F. and contains naphthalene in non-saturating amount at that temperature (about 350 grains of naphthalene per 100 cu. ft. of gas) together with water, tar, ammonia and light oils.

The gas is introduced at velocity of about 1250 ft. per minute into inlet 1 of primary cooler 2 and exits the cooler through outlet 3. The gas first flows through passes 5a, 5b, 5c and 5d countercurrent to cooling water flowing through tubes 6d, 6c, 6b and 6a. Cooling water at a temperature of about 88° F. enters the tubes through inlet 7 and exits the tubes through outlet 11. Each of the tubes of cooler 2 is spaced about 3/4" from the adjacent tubes.

In flowing through passes 5a, 5b, 5c and 5d, the gas is partially cooled to a temperature of about 105° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene (100 cu. ft. of the gas at the temperature of about 105° F. contains about 100 grains of naphthalene). A portion of the naphthalene present in the gas is absorbed by the condensed tar.

Part of the last-named condensate which has a temperature of about 96° F. is cooled in heat exchanger 19 to a temperature of about 92° F. The cooled condensate is then sprayed downwardly through spray means 22 at the rate of about 5 gallons per minute per 100 cu. ft. of gas exiting cooling pass 5d so that the rising partially cooled coke oven gas is cooled to a final temperature of about 95° F., thereby producing a gas supersaturated with naphthalene. The downwardly sprayed condensate also removes precipitated particles of naphthalene present in the finally cooled gas. Naphthalene particles are absorbed by the tar in the condensate. The finally cooled coke oven gas is saturated with naphthalene (containing about 65 grains of naphthalene per 100 cu. ft. of gas at the temperature of about 95° F.), and contains ammonia and light oils. This gas may then be subjected to further conventional processing in order to recover naphthalene, ammonia and light oils.

The cooling water utilized in heat exchanger 19 enters at a temperature of about 85° F. and is heated to a temperature of about 88° F. by contact with condensate passing through the heat exchanger. This cooling water then serves as the cooling medium passing through tubes 6a to 6d of cooler 2.

The operation described in the above example permits continuous cooling of coke oven gas withdrawn from the collecting main of coke ovens for an extensive period without accumulation of insulating or blocking naphthalene deposit or of other undesirable deposits on the cooling equipment. By prior practice, however, using a conventional, indirect-type primary cooler having tube spacing similar to that described in the example,

shutdown at frequent intervals is necessary in order to keep the apparatus free of harmful deposits.

Since various changes and modifications may be made in the invention without departing from the spirit thereof, the invention is deemed to be limited only by the scope of the appended claims.

The invention claimed is:

1. A continuous process for the primary cooling of coke oven gas, withdrawn from the collecting main of by-product coke ovens and containing naphthalene in non-saturating quantity together with water, tar, ammonia and light oils, which comprises passing the coke oven gas in indirect countercurrent contact with a fluid cooling medium to partially cool the coke oven gas to a temperature of about 105° to about 140° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate, spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled coke oven gas to complete cooling of the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

2. A continuous process for the primary cooling of coke oven gas, withdrawn from the collecting main of by-product coke ovens and containing naphthalene in non-saturating quantity together with water, tar, ammonia and light oils, which comprises passing the coke oven gas in indirect countercurrent contact with a fluid cooling medium to partially cool the gas to a temperature of about 105° to about 115° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate, spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled coke oven gas to complete cooling of the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

3. A continuous process for the primary cooling of coke oven gas, withdrawn from the collecting main of by-product coke ovens, said gas having a temperature of at least about 170° F. and containing naphthalene in non-saturating quantity together with water, tar, ammonia and light oils, which comprises passing the coke oven gas in indirect countercurrent contact with a fluid cooling medium to partially cool the coke oven gas to a temperature of about 105° to about 140° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate by passing the condensate through a heat exchanger provided with a circulating fluid cooling medium, using the cooling medium exiting the heat exchanger as the cooling medium for effecting the aforesaid indirect cooling of the coke oven gas, spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled coke oven gas to complete cooling of the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

4. A continuous process for the primary cooling of

coke oven gas, withdrawn from the collecting main of by-product coke ovens, said gas having a temperature of about 174° to about 180° F. and containing naphthalene in non-saturating quantity together with water, tar, ammonia and light oils, which comprises passing the coke oven gas in indirect countercurrent contact with cooling water introduced at a temperature of about 85° to about 100° F. to partially cool the coke oven gas to a temperature of about 105° to about 115° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate to a temperature of about 80° to about 95° F., spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled coke oven gas to complete cooling of the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

5. A continuous process for the primary cooling of coke oven gas, withdrawn from the collecting main of by-product coke ovens, said gas having a temperature of about 174° to about 180° F. and containing naphthalene in non-saturating quantity together with water, tar, ammonia and light oils, which comprises passing the coke oven gas in indirect countercurrent contact with cooling water to partially cool the coke oven gas to a temperature of about 105° to about 115° F., thereby condensing water and tar and producing a gas still not saturated with naphthalene, collecting said condensate from the partially cooled gas, cooling at least part of the condensate to a temperature of about 80° to about 95° F. by passing the condensate through a heat exchanger provided with circulating cooling water, using the cooling water exiting the heat exchanger for effecting the aforesaid indirect cooling of the coke oven gas, spraying said cooled condensate downwardly in direct countercurrent contact with the partially cooled coke oven gas to complete cooling of the gas to a temperature of about 90° to about 100° F. and to produce a gas supersaturated with naphthalene, said sprayed condensate simultaneously washing precipitated naphthalene particles out of the completely cooled gas, and recovering said completely cooled gas containing naphthalene in saturating amount together with ammonia and light oils.

6. Apparatus adapted for continuous primary cooling of coke oven gas withdrawn from the collecting main of by-product coke ovens which comprises a cooler provided with an inlet and outlet for the coke oven gas and an inlet and outlet for a fluid cooling medium, said cooler being divided into a multi-tubular section of several passes followed by a spray pass provided in its upper portion with a spray means, said tubes containing the fluid cooling medium flowing countercurrently to the flow of the coke oven gas, means for collecting condensate comprising water and tar from the passes of said multi-tubular section and for directing at least part of said condensate to the bottom of the spray pass, a heat exchanger provided with a circulating fluid cooling medium, means for delivering condensate from the bottom of the spray pass through said heat exchanger and then to the spray means in the upper portion of the spray pass, means for withdrawing excess condensate from the bottom of the spray pass, and means for directing the fluid cooling medium exiting the heat exchanger to and through the tubes of the multi-tubular section of the cooler.

References Cited in the file of this patent

UNITED STATES PATENTS

2,810,450 Hartmann ----- Oct. 22, 1957