June 13, 1950 C. E. HEMMINGER 2,511,709

CARBONIZATION BY DIRECT HEATING IN A ROTARY RETORT

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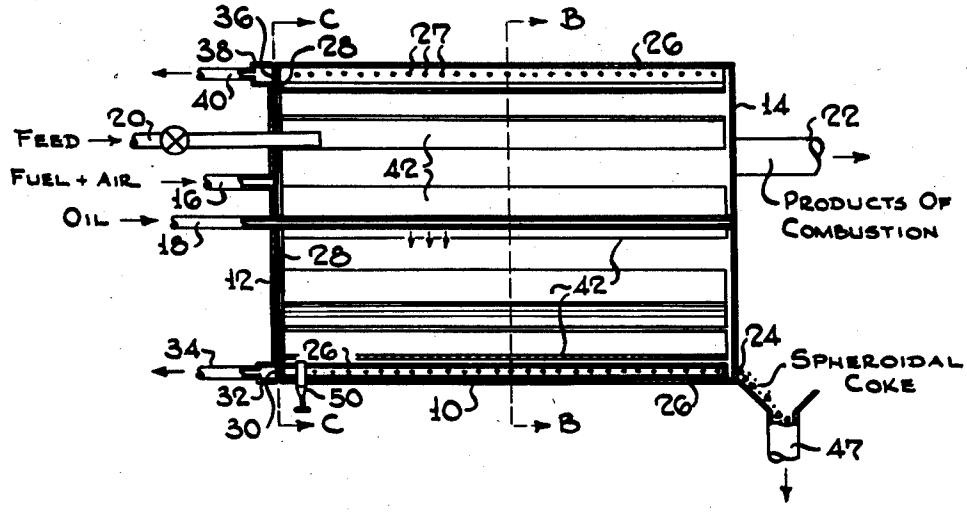


FIG.-1

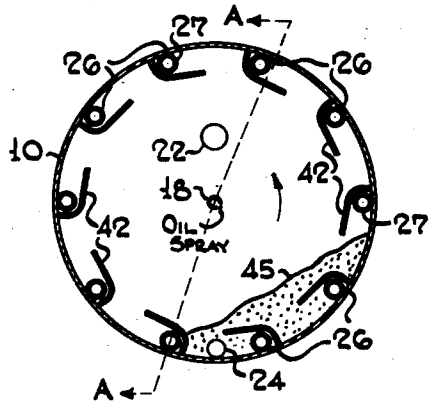


FIG.-2

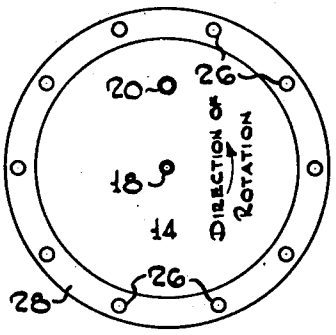


FIG.-3

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CARBONIZATION BY DIRECT HEATING IN A ROTARY RETORT

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12 Claims. (Cl. 202—12)

1

The present invention relates to the carbonization of carbonaceous materials and, more particularly, to an improved method and apparatus for producing volatile carbonization products and highly reactive smokeless coke agglomerates in the form of lumps or spheroidal briquettes from carbonizable fuels such as all types of coal, lignite, brown coal, asphalt, oil residues and sludges, petroleum, cellulosic materials, including lignin, etc.

Prior to the present invention, spheroidal coke briquettes and volatile carbonization products have been produced by a process utilizing the property of certain strongly coking coals to pass through a plastic state and to develop agglutinating tendencies within a definite range of elevated temperatures.

In this process, fines of strongly coking coals having a particle size of minus ⅜ in. and less, which may be preoxidized in any conventional manner, are passed through an inclined rotary kiln heated externally by a countercurrently flowing heating gas to a final temperature of about 850°–900° F., which is slightly above the minimum carbonization temperature of the coal charge. The coal, while undergoing carbonization, passes through the plastic state at about 600°–800° F. The rotating motion of the kiln causes the plastic agglutinating particles to agglomerate to form spheroids or balls of low temperature coke, having diameters of about 1–6 in. Coal gas, light oil, tar and acidic liquor are the volatile carbonization products which are removed from the kiln by suction.

Coke fines obtained, in addition to the coke balls, are returned to the kiln to establish the proper ratio of dry and agglutinating materials required for ball formation. On the other hand, liquid carbonizable materials such as various pitches or other heavy residues may be injected into the kiln and carbonized on less volatile coal fines placed therein.

The indirect heat supply through the kiln walls in combination with the large size of the coal aggregates to be heated to carbonization temperatures leads to excessive temperature requirements in the heating jacket and seriously limits the carbonization temperature. This results in undesirably low yields of volatile carbonization products.

In actual operation, the temperatures permissible for practical construction materials are insufficient to heat the kiln charge indirectly to efficient carbonization temperatures. It has, therefore, been necessary to admit an oxidizing

2

gas, such as air, into the discharge end of the kiln so as to generate additional heat by a partial combustion of solid and/or volatile carbonization products, resulting likewise in product losses.

Further losses of low temperature tar result from excessive tar-cracking taking place during the relatively long residence time of the volatile carbonization products in the high temperature zone of the kiln.

The present invention overcomes the aforementioned difficulties and affords various additional advantages. These advantages, the nature of the invention and the manner in which it is carried out will be fully understood from the following description thereof, read with reference to the accompanying drawing.

It is, therefore, the principal object of my invention to provide an improved method of producing volatile carbonization products and spheroidal coke agglomerates from carbonizable materials.

A more specific object of my invention is to provide an improved apparatus for producing spheroidal coke briquettes and volatile carbonization products from carbonizable materials.

Other objects and advantages of my invention will appear hereinafter.

In accordance with my invention, a direct and highly efficient heat transfer to the carbonaceous material undergoing carbonization is accomplished by injecting a burning combustion mixture of fuel and oxidizing gas into the rotating carbonization zone, at a point removed from the solid charge, and withdrawing volatile carbonization products from the carbonization zone immediately upon their liberation. In this manner, radiant heat is provided for the coking operation resulting in more efficient heat utilization and increased liberation of distillation products. The short residence time of the distillation products in the high temperature zone limits cracking to a minimum so that the yield of volatile carbonization products is substantially increased.

I have found that the rapid removal of the distillation products from the carbonization zone and at least qualitative simultaneous separation of these products from gaseous products of the heat-generating combustion may be accomplished in a highly efficient manner by utilizing the solids bed of carbonaceous materials undergoing carbonization to establish an appreciable pressure differential between the gaseous combustion products and the volatilized distillation products. For this purpose, the gaseous combustion prod-

ucts are passed through and withdrawn from the rotary carbonization zone above the layer of solids undergoing carbonization and at substantially atmospheric pressure while the distillation products are withdrawn from points beneath the layer of solids undergoing carbonization and at a slightly reduced pressure which may be generated, by suction, on the lines withdrawing the distillation products.

In this manner, a negative pressure differential is established across the solids layer from its top to its bottom and distillation products of increasing purity, with respect to their content of combustion products, are withdrawn from points within the solids layer of increasing proximity to the low pressure withdrawal lines.

By properly regulating the pressure differential across the solids layer substantially quantitative recovery of volatile distillation products containing considerably less than 30% and normally less than 10% of gaseous combustion products may be accomplished. Pressure differentials varying from about 0.4 lb. per sq. in. to about 3 lbs. per sq. in., as they may be readily established across solids layers of about 1 ft. to 4 ft., are suitable for this purpose.

In accordance with the preferred embodiment of my invention, a series of perforated tubes, closed at one end and open at the other, is arranged close to the inner wall of the rotary kiln, extending preferably over the entire length of the kiln, and evenly distributed over at least a substantial portion of its circumference. At least one stationary suction line, arranged outside the kiln, cooperates with the open ends of the perforated tubes in succession as the kiln rotates to withdraw volatile products from any tube while the latter is covered with solids undergoing carbonization. A burning combustion mixture is introduced, preferably into an upper section of the free space of the rotary kiln, from a stationary burner means arranged outside the kiln at one end thereof while combustion gases leave through a stationary discharge pipe at the other end of the kiln.

If desired, one or more of the suction lines may cooperate with tubes out of contact with the solids charge of the kiln so as to draw hot combustion gases containing residual oxygen through said tubes. In this manner, tar and coke deposits may be burnt off and clogging of the tubes prevented.

Highly reactive coke balls of the conventional physical and chemical characteristics may be recovered from the lower end of the inclined rotary kiln in any manner known per se.

Having set forth the general nature and objects, my invention will be best understood from the more detailed description hereinafter in which reference will be made to the accompanying drawing wherein

Figure 1 is a sectional elevation of equipment suitable to carry out a preferred embodiment of my invention, taken along line A—A on Figure 2;

Figure 2 is a cross-section taken along line B—B on Figure 1; and

Figure 3 is a cross-section taken along line C—C on Figure 1.

Referring now in detail to the drawing, the numeral 10 designates an inclined rotary carbonization retort or kiln which may be supported and rotated by any conventional means such as a roller support or the like (not shown). Rotary kiln 10, at its feed and discharge ends respectively, is provided with stationary end plates 12 and 14. End plate 12 covers the feed end of kiln 10 and carries in its upper section suitable means, such as a pipe or burner head 16 for supplying a burning combustion mixture or hot flue gases to kiln 10. A feed line 18 for liquid carbonizable material, which may have the form of a perforated pipe extending over the entire length of kiln 10, may be supported by the middle sections of plates 12 and 14. The top section of plate 12 carries a feed line 20 for solid subdivided carbonizable material.

Plate 14 supports, in its upper section, a flue gas withdrawal pipe 22. An orifice 24, in the bottom section of plate 14, serves the recovery of solid carbonization product.

A series of tubes 26 having suitable perforations 27 and extending preferably over the entire length of kiln 10 is arranged on or close to the inner surface of kiln 10 and so supported by the latter that tubes 26 rotate around the axis of kiln 10. Tubes 26 are closed at their ends adjacent to plate 14 and open at their ends adjacent to plate 12. However, the open ends of tubes 26 contact plate 12 so as to effect an, at least, partial seal of their open ends over a major portion of their circular path. An annular sealing plate 28, supported by tubes 26 adjacent to and contacting plate 12 rotates together with kiln 10 and tubes 26.

Plate 12 is provided, in its lower section, with a recess 30 which extends along the circumference of plate 12 over a distance equal to or greater than the distance between two adjacent tubes 26. The width of recess 30 may correspond approximately to the diameter of a tube 26. Recess 30 is sealed from the kiln inside by sealing plate 28 except for the openings of such tubes 26 as communicate with recess 30 at any time.

A suction shoe 32 connected to a suction line 34, for the withdrawal of volatile carbonization products from kiln 10 through tubes 26, covers and seals recess 30 on the outside of plate 12. A recess 36 similar to recess 30 may be provided in an upper section of plate 12 to cooperate with a suction shoe 38 similar to suction shoe 32, and a suction line 40, to withdraw combustion gases from tubes 26, if desired.

Tubes 26 are preferably covered by baffles 42 over their entire length in order to prevent solid particles from piling up around tubes 26 and plugging the perforations 27.

In operation, a carbonizable solid such as a carbonization coal having a particle size of preferably less than ⅜ in., say mostly between 8 and 100 mesh, is supplied to solids feed pipe 20 by any conventional means such as an aerated standpipe, a pressurized feed hopper, a mechanical conveyor, or the like (not shown) and enters the slightly elevated feed end of kiln 10 behind plate 12. As a result of the rotary motion of the kiln, the coal piles up on the side of the kiln about as shown at 45 in Figure 2. The downward slope of the kiln position causes the coal to move toward the discharge end of kiln 10 and discharge orifice 24.

A burning fuel mixture such as a mixture of fuel gas or finely divided fuel oil with air and/or oxygen is supplied through burner head 16. The radiant heat supplied by the combustion mixture from burner head 16 should be sufficient to maintain the lower sections of kiln 10 and its charge at a suitable carbonization temperature of about 850°–1400° F., sufficient to liberate the desired amounts and types of volatile carbonization products. Heating gas temperatures of about 1000°

to 1800° F. are normally adequate for the purpose in commercial operation. The bulk of the flue gas is withdrawn through pipe 22 at normal or slightly reduced pressure.

Suction is applied from line 34 to suction shoe 32 and such tubes 26 as are covered by the solids undergoing carbonization. As a result, volatile carbonization products are drawn through perforations 27 into said tubes 26 and removed from kiln 10 at the rate at which they are liberated. Perforations 27 are spaced along tubes 26 so as to uniformly carry away the products as formed. Since the vapor evolution is greatest in the middle section of the kiln, about 60% of the perforations are arranged in the middle third of the pipe, while only about 10% of the perforations are distributed over that third of the tube length which is adjacent to the coal feed end and about 30% of the perforations over that third of the tube length which is adjacent to the discharge end. The dimensions of suction shoe 32 are so chosen that no suction is applied to tubes 26 prior to their entering and after their leaving solids pile 45. The pressure in suction line 34 is preferably so regulated that small amounts, say up to about 10%, of combustion gases from the upper sections of kiln 10 are drawn together with the volatile carbonization products through solids pile 45 into tubes 26. In this manner, a substantially quantitative withdrawal of the volatile carbonization products from kiln 10 is assured. A suction pressure of about 0.5 to 4 in. mercury is generally suitable for this purpose at a greatest solids layer thickness above any pipe 26 of about 1 to 4 ft. Baffles 42 prevent solids particles from entering or plugging perforation 27 of tubes 26.

The carbonaceous solids fines, while undergoing carbonization, agglomerate as a result of the tumbling motion on their path through kiln 10 to form spheroidal coke briquettes which are withdrawn through orifice 24 and collected and, if desired, cooled in a conventional coke receiving device 47. The volatile carbonization products are passed from line 34 to a usual product recovery system (not shown) for the production of coal gas, light oils, tar and chemicals.

The deposition of tar and/or coke in tubes 26 cannot entirely be avoided. In order to prevent plugging of tubes 26 by these deposits, it is desirable to provide means for the removal of such deposits from tubes 26, which will not appreciably affect the yield of desirable distillation products. To accomplish this, the combustion mixture fed through burner head 16 may contain a slight excess of oxygen, of say about 10 to 40%, and suction may be applied to suction line 40 and suction shoe 38. In this manner, a hot oxidizing gas mixture is drawn through such pipes 26 as reach the upper section of the circular path of kiln 10, after having been freed of volatile distillation products by suction means 32 and 34. The oxygen in said oxidizing gas will, at the prevailing high temperatures of the upper kiln section, burn off a substantial proportion of the carbonaceous tube deposits and thus prevent an undesirable accumulation of such deposits.

When a liquid carbonizable feed such as crude oil, heavy residues, pitch, molten asphalt or the like is used in place of a solid carbonizable charge, the liquid feed is introduced through pipe 18 and sprayed on a finely divided, preferably carbonaceous, solid introduced through feed pipe 20. Coke, petroleum coke, low volatility coals or carbonizable materials may be used as solids. The carbonizable or non-carbonizable solid particles carrying the liquid sprayed thereon agglomerate during the carbonization treatment to form spheroidal coke briquettes in the manner described above.

While I have described above specific means including sealing plate 28, recess 30 and suction shoe 32 for removing volatile distillation products through tubes 26, it should be understood that my invention is not limited to these specific means but is intended to cover any suitable means for establishing a pressure differential across solids pile 45 so as to make possible a rapid selective removal of distillation vapors from the high temperature carbonization zone. For example, tubes may be provided adjacent to their open ends with automatic valves 50 which are open while a tube 26 is in contact with the solids pile 45 and/or while communicating with suction line 40 and which are closed over the remainder of the circular path of tubes 26.

These valves may take the form of slide valves in the open end of tubes 26, which are spring operated, the spring pressing the slide closed. When the tubes are adjacent to shoes 30 and 32 cams press open the slide valves to allow communication between the tubes and the respective shoes.

Other modifications of the means for withdrawing vapors from tubes 26 may occur to those skilled in the art without deviating from the spirit of the present invention.

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

EXAMPLE

Yield data of the process of the invention are tabulated below in comparison with yields of conventional operation involving external heating supplemented by the injection of air into the discharge end of the kiln at otherwise identical conditions of preoxidation, a coke fines recycle ratio of about 25–30%, a coal preheating temperature of about 600° F., a carbonization temperature of about 900° F., and a residence time of about 1–1.5 hours for Pittsburgh Seam coal having a particle size of minus ⅜ in.

Type of operation

Products	Conventional, Wt. Per Cent of Coal Charged	Process of Invention, Wt. Per Cent of Coal Charged
Coke	72.0	70.3
Gas	12.5	8.8
Air in Gas	3.9	---
Tar	7.5	9.4
Light Oil	0.8	1.0
Liquor	5.5	5.5
Loss	5.6	5.0
	103.9	100.0
Heating Value of Gas, B. t. u./cu. ft.	390	700
Nitrogen Content of Gas, per cent	50	5
300° C. Pitch in Tar, wt. per cent	67	40
Amount of Heat Consumed per lb. of Total Solids Feed, B. t. u.	550	450

The above data demonstrate the advantages of my invention with respect to tar yield, heating value of product gas and heat economy.

While the foregoing description and exemplary operations have served to illustrate specific applications and results of my invention, other modifications obvious to those skilled in the art are within the scope of my invention. Only such limitations should be imposed on the invention as are indicated in the appended claims.

I claim:

1. The process of producing spheroidal coke briquettes and volatile carbonization products from carbonizable materials at elevated carbonization temperatures which comprises subjecting said carbonizable material in the form of a pile of subdivided solids to a tumbling motion adapted to promote the formation of spheroidal agglomerates of said subdivided solids within a confined space, introducing heating gases having a temperature substantially above said carbonization temperature into said confined space above said pile in amounts sufficient to heat said pile to said carbonization temperature, establishing a negative pressure differential across said pile from its top to its bottom, withdrawing volatile carbonization products from said space beneath said pile, withdrawing spent heating gas from said space above said pile, and recovering spheroidal coke briquettes from said confined space.

2. The process of claim 1 wherein said pressure differential is so controlled that not more than about 10% of spent heating gas, based on withdrawn volatile carbonization products, is forced across said pile from its top to its bottom.

3. The process of claim 1 wherein said volatile carbonization products are withdrawn by suction through a plurality of passages, individual passages being operated alternatingly for the withdrawal of volatile carbonization products.

4. The process of claim 1 wherein said carbonizable material is a solid.

5. The process of claim 1 wherein said carbonizable material is liquid at the carbonization conditions and is sprayed on a subdivided carbonaceous solid forming said pile.

6. The process of claim 1 wherein said heating gases are generated by the combustion of a mixture of fuel and oxidizing gas in said space.

7. The process of producing spheroidal coke briquettes and volatile carbonization products from carbonizable materials at elevated carbonization temperatures which comprises subjecting said carbonizable material in the form of a pile of subdivided solids to a tumbling motion adapted to promote the formation of spheroidal agglomerates of said subdivided solids within a confined space, introducing heating gases having a temperature substantially above said carbonization temperature into said confined space above said pile in amounts sufficient to heat said pile to said carbonization temperature, establishing a negative pressure differential across said pile from its top to its bottom, withdrawing volatile carbonization products by suction from said space beneath said pile through a plurality of individual passages alternatingly operated in rotation for the withdrawal of volatile carbonization products, passing an oxidizing gas through passages not operated for products withdrawal, at a temperature not below the ignition temperature of carbonaceous deposits within said lines, withdrawing spent heating gas from said space above said pile and recovering spheroidal coke briquettes from said confined space.

8. An apparatus for producing spheroidal coke briquettes and volatile carbonization products which comprises an inclined rotary kiln, a stationary cover plate at the elevated end of said kiln, a second stationary cover plate at the lower end of said kiln, a series of tubes supported by and within said rotary kiln and arranged close to the inner surface of said kiln, said tubes extending over at least a substantial portion of the length of said kiln, having perforations distributed over at least a substantial portion of their length, and having each one open and one closed end, stationary suction means outside said rotary kiln, said suction means being connected to said open ends, means for alternatingly establishing and interrupting communication between said suction means and the open ends of such of said tubes as pass a desired section of the circular path of said rotary kiln, means eccentrically arranged for introducing a radiant heating medium into the upper inner space of said rotary kiln, said means being supported by one of said cover plates above the horizontal center plane of said kiln, means supported by the other of said cover plates above the horizontal center plane of said kiln for withdrawing spent heating medium and means supported by said first mentioned cover plate for supplying finely divided solids to said rotary kiln, said second named cover plate being provided with an orifice for the withdrawal of spheroidal coke briquettes.

9. The apparatus of claim 8 which comprises baffle plates supported by and within said rotary kiln, arranged above and close to each of said tubes, the length of said baffle plates approximating the length of said tubes and the width of said baffle plates exceeding the diameter of said tubes while failing to bridge completely the free space between two adjacent tubes said baffle plates having a free back edge in the direction of the kiln rotation and a front edge connected to said kiln in front of said tubes, in said direction, in a manner preventing solids from piling up directly on said tubes.

10. The apparatus of claim 8 which comprises means for feeding a fluid to a middle section of said rotary kiln.

11. The apparatus of claim 8 wherein said means for alternatingly establishing and interrupting communication between said suction means and the open ends of such of said tubes as pass a desired section of the circular path of said rotary kiln comprises a suction shoe as a part of said suction means outside said first mentioned plate, said first mentioned plate having a recess opening into said suction shoe and a sealing means sealing said recess except for the opening of such of said open ends as communicates with said suction shoe.

12. The apparatus of claim 8 wherein said means for alternatingly establishing and interrupting communication between said suction means and the open ends of such of said tubes as pass a desired section of the circular path of said rotary kiln comprises spring and cam-operated slide valves arranged in said tubes adjacent to their open ends.

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