

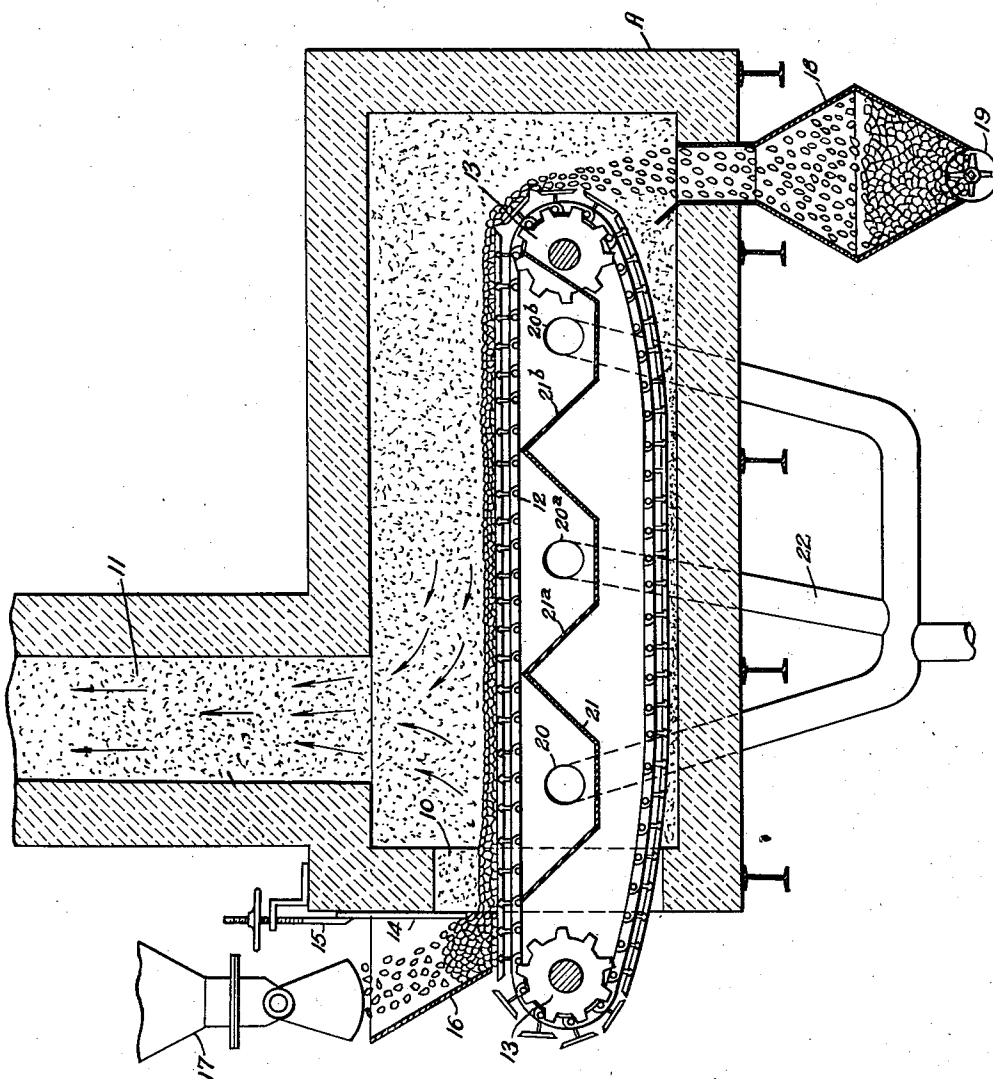
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COKE PRODUCTION

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COKE PRODUCTION

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Introduction

This invention relates to a process for coke production.

For a better understanding of the invention, reference will first be made to coke producing methods at present available. Today coke is usually produced simultaneously with gas, the charge of bituminous coal being carbonized out of contact with the atmosphere within an externally heated retort, the volatile matter being driven off and collected. The equipment required is quite elaborate and costly and the rate of production low, so that unless the output is large and there happens to be a ready market for the byproducts, its operation is not economical. The indirect heating of the charge is also inefficient, it being estimated that practically thirty per cent of the heat applied is wasted. Hence, these conventional methods are practically applicable only to the large scale production of coke and its byproducts.

Mention has also been made in the art, of processes wherein the coal is directly heated. In one such process, this is accomplished by partial combustion, in a shaft furnace, of a portion of the charge. An operation of this nature presents certain difficulties. For one instance, there is the tendency of the charge to coke above the coking zone to such an extent that it blocks the gas stream. To prevent this, coke is added to the green coal. This complicates the process, besides cutting down the capacity of the retort in making necessary, to render the process economical, the recovery of the sensible heat in the circulating coke load. In addition, the apparatus is elaborate and costly, being suited only, as in the case of more conventional coke producing devices, to large scale production.

Another process widely used a number of years ago, but practically in the discard today, in which the coal is directly heated, is the "Beehive" process. Here the coal is treated in an oven in a thick bed above which the gases are ignited and allowed to burn with air introduced at a point above the bed. The heat from the burning gas penetrates downwards to carbonize the coal but extremely slowly, at a rate of from one, to less than one half inch per hour, so that the process is most tedious. Heat recovery is out of the question owing to the very slow liberation of the gases. Only coal of good quality can be used. Besides it is not always possible to control the carbonization accurately, so that a large proportion of the fixed carbon of the coke is often burned. In addition, filling and emptying the

oven by the batch method has attendant disadvantages. These shortcomings remove the "Beehive" process from the practical sphere for present day operations.

Methods have also been described in which coal is carbonized in a continuous operation by carrying a bed through zones in which hot gases are passed down through it to drive off the volatile constituents. This, of course, requires relatively elaborate equipment for heating, conveying, and recovering the gases so that the apparatus is expensive and incompact. It is also difficult to attain and maintain sufficiently high temperatures to carbonize the charge rapidly. The applicants believe that, generally speaking, these prior art processes leave much to be desired.

Objects

With this in mind, it is an object of the present invention to provide an economical method of producing coke and combustible gases, capable of being carried out in a small compact plant of large output capacity, the installation involving a comparatively low capital expenditure and low operating and maintenance costs. A further object of the invention is to provide a process of this nature for producing simultaneously with the coke combustible gases for use in kilns, furnaces, dryers and under boilers.

A still further object of the invention is to provide a process of the nature mentioned, which is adaptable for the treatment of various grades of coal to produce coke of a desired quality.

The nature of the present method

With these objects and others in view, the applicants have, in contrast to generally accepted coking principles, discovered a method in which a body of carbonizable material, is progressively treated by the selective burning of a portion of the volatile constituents at least partially within the bed to supply the heat required to drive off the remainder of the volatile matter without burning any appreciable amount of the fixed carbon. That is to say, the burning of fixed carbon may be completely prevented under some conditions and under other conditions no substantial amount of fixed carbon will be burned. In any event, the heat required to drive off the volatile matter is derived from the burning of at least a portion of the volatile constituents of the carbonizable material at least partially within the bed and therefore the amount of fixed carbon which is burned is kept to a minimum by regulation of the air supply and the speed of

progress of the material. This process is conveniently accomplished in steps wherein the material is fed continuously on to a suitable carrier in a thin bed and moved through an oven adapted to form above the bed a gas passage of limited volume. Air or oxygen-containing gases are blown through the bed underneath the carrier, and the volatile constituents ignited, the air supplied being so regulated that only the desired proportion of volatile is burned in and above the bed.

The production of heat within the bed of coal and its application as described, is so efficient and the heat transfer to the coal so rapid that the output of coke and gas is very much greater for a given size of plant than for any type of retort or oven known to us. In general, the heat losses are only about 5% as opposed to the conventional 30%, as in the case of the standard retort. The gas produced may be cooled and collected in the usual manner, but preferably the gas is used directly for heating purposes; such as for raising steam under a boiler, heating cement or lime kilns, in reverberatory furnaces, or in any similar metallurgical process. The immediate use of the gas without cooling enables advantage to be taken of all the sensible heat of the gas, giving high over all thermal efficiency.

The coke produced according to the invention is as strong as most types of by-product coke. It may be a low or high volatile coke, as desired. High-volatile coal running 35% to 40% V. M. can be used to produce a strong coke with very little breeze, which it has not been found practicable to do in the ordinary retort. Because the coke is produced from the coal in a period of a few minutes, as compared with hours of standard processes, it has a higher degree of reactivity than ordinary coke. It is thus particularly suitable for use in processes where the coke is chemically reacted with other elements such as in the manufacture of calcium carbide, silicon carbide or in the production of phosphorus, etc.

In industries and municipalities where both coke and gas are required the present invention is particularly suitable. For instance, in a municipality the coke might be sold domestically and the gas burned to raise steam for the generation of electricity or it is possible that the gas could be carburetted and distributed directly to the consumer as gas. In chemical and metallurgical industries, also, where both gas and coke are used in quantities, the invention is of particular value.

Detailed description

The invention will now be further explained by reference to the accompanying drawing, which shows a diagrammatic cross section through a special coke oven embodying a preferred apparatus conveniently suitable for carrying out the process.

Referring now in more detail to the drawing, A represents the refractory lining of a coke oven with a fuel feed opening 10 and a gas outlet flue 11. Within the oven is mounted a carrier, in this case a continuous travelling grate 12 of suitable standard design, suitably driven by a standard drive 13. The oven has a relatively low ceiling, preferably being from 8 to 18 inches above the grate forming a passage of limited volume. The flue 11 is located adjacent to the feed end of the grate and the roof of the oven preferably slopes upwards slightly from the discharge end to the flue causing the gases, in pass-

ing towards the flue, to flow over and in contact with the coal bed.

According to this construction, the volume of the chamber above the grate is quite limited, being for instance only a fraction, usually less than a third, of that generally employed in combustion devices using travelling grates. The chamber should also be gas-tight and preferably under positive pressure in order to minimize leakages of air. A chute 16 leads from a fuel hopper 17 to the opening 10. The feed opening 10 is provided with a gate 14 operated by mechanism 15, as for instance, a hand wheel and screw arrangement, to control the depth of the coal bed on the grate. At the discharge end of the chain grate 12 and below it, is a coke receiving hopper 18 sealed at its outlet by a reasonably air tight coke extractor 19.

Below the grate 12, the oven is provided with air inlets 20 on which are valves or gates, which may be adjusted to regulate the air supply to separate air compartments or zones 21, 21a, 21b, underneath the grate. This grate is provided with passages for conducting air from the wind boxes to the bed of coal. The inlets are connected by ducts 22 to a convenient source of air supply such as a blower.

Operating procedure

In carrying out the process, the grate is started, coal being fed on to it to form a thin bed of between approximately one and a half inches to six inches thick. To induce working conditions, this bed is ignited so as to effect more or less complete combustion, by operating the grate at a slow speed while supplying air through the zones 21a, 21b and 21c in sufficient quantities to reduce the coal to ash before it is discharged. The chamber, being gas-tight, and preferably under positive pressure, leakages of air into the oven above the coal bed are minimized. The heat of the oven increases rapidly due to the relatively small chamber to be heated. When the oven has reached a suitable temperature, for example between 800° C. and 1400° C., the grate is speeded up and at the same time, the air entering the zones 21, 21a, 21b, from the air inlets 20 is so adjusted that only a portion of the volatile matter from the coal is burned, for example, just sufficient to evolve the heat necessary to drive off the remainder of the volatile constituents of the coal. The setting is maintained at this temperature. Under these conditions it has been found that the coking operation can be carried out in a time of the order of 10 minutes. In other words, the speed of the grate is preferably so regulated that the material passes through the carbonizing zone in this time.

Adjustment may be gauged by chemical analysis of the coke at the discharge end of the grate, or by observation of the coke dropping from the grate, to determine the presence of uncoked coal, indicating a deficiency of air, or the presence of partially burned coke, signifying an excess of air. Under certain conditions, to obtain uniform coking throughout the bed, the air is supplied to the respective zones in different quantities. For instance, if the coal is wet, slightly more air is supplied to the zone adjacent to the intake end of the grate and less adjacent to the discharge end. On the other hand, if it is found that the fixed carbon of the coke is being burned, the air supply is reduced adjacent the discharge end.

Results

When the oven is operated in this manner, the atmosphere above the coal bed consists of a mixture of combustible gases and nitrogen, plus a small quantity of water vapor and carbon dioxide. The speed of the grate and air supply are so adjusted that the product discharged from the grate is coke of the desired volatile content. On leaving the coke extractor the coke is hard and contains only a small percentage of dust. Furthermore, the coke is highly reactive and highly porous. The volatile matter in the coal, a portion of which has been burned to supply heat to carry out the coking process, passes out through the flue 11 to be completely burned under a boiler or in a kiln, or may be cooled and collected in a gasometer.

The proportion of volatile burned will depend to some extent upon the grade of coal used. For example, in the case of high volatile coals, less than 35 per cent of the volatile matter is burned, but for low volatile coals it may be necessary to burn more than this proportion.

Nevertheless, the usefulness of the invention is not limited to any particular type or form of coal, but is extremely flexible in that it can be adjusted to handle various types. For instance, briquetted bituminous or anthracite coal, with or without admixtures of inorganic materials such as lime or lime hydrate, may also be treated. Preferably, the coal or briquettes should not, however, contain more than 30 per cent through a 4 mesh screen. The upper limit of size is approximately 3 inch lumps.

In order to illustrate the invention further the results of a series of typical runs will now be given as examples.

Run 1

1030 lbs. per hour of a good grade coking coal was fed on to a small chain grate 3'6" x 9' and 600 lbs. per hour of coke discharged. The thickness of the coal bed was maintained at 3½ inches at the feed gate and the air introduced was 1.85 lbs. per pound of coal fed. The procedure that was followed for starting the run was the same as that already described. As soon as the temperature in the brick chamber has reached 1100° C. to 1200° C. (measured by an optical pyrometer) the air entering the wind boxes is decreased until the above temperature is maintained and the speed of the grate maintained at 50 feet per hour. The total coal used in this particular run was 84,400 lbs. dry weight and the coke obtained was 49,000 lbs. dry weight.

A typical analysis of the coal and the coke are given in the table below.

Coal	Coke
H ₂ O—2.5%.....	H ₂ O—0.4%.....
V. M.—39.0% dry basis.....	V. M.—2.1% dry basis.
Ash—3.9% dry basis.....	Ash—5.9% dry basis.
Fixed carbon—57.1% dry basis.....	Fixed carbon—92.0%.
Screen analysis:	Screen analysis:
On .742"—59.5%.....	On .742"—36.7%.....
.263"—32.2%.....	.263"—57.6%.....
Through .263"—8.3%.....	Through .263"—5.7%.....

End of Run 1.

Runs 2-4

Runs 2, 3 and 4, similar to Run 1, were conducted, with the following contents of materials

and with the results given in the table which follows:

Material	Quantities		
	Run No. 2	Run No. 3	Run No. 4
Coal feed, lbs. per hour, wet.....	1,253	1,470	1,535
Coke produced, lbs. per hour, wet.....	666	930	898
Depth of coal bed, inches.....	2½	2¾	2¾
Pounds of air per pound of coal fed.....	1.87	2.52	2.76
Total coal used, lbs. dry.....	139,700	136,900	79,730
Total coke made, lbs. dry.....	76,300	85,970	45,740
Analysis of coal:			
Moisture, percent.....	4.5	3.0	2.0
Volatile matter, percent (dry basis).....	36.3	34.7	39.3
Ash, percent (dry basis).....	6.2	8.8	3.9
Fixed carbon, percent (dry basis).....	57.5	56.5	56.8
Screen test of coal:			
ON .742, percent z.....	9.1	33.6	33.4
ON .263, percent z.....	50.1	44.6	47.0
PT .263, percent y.....	40.8	21.8	19.6
Analysis of coke:			
Moisture, percent.....	1.8	3.7	3.9
Volatile matter, percent (dry basis).....	2.8	3.2	2.8
Ash, percent (dry basis).....	9.8	14.1	6.3
Fixed carbon, percent (dry basis).....	87.4	82.7	90.9
Screen test of coke:			
ON .742, percent z.....	39.1	47.8	26.6
ON .263, percent z.....	50.5	46.7	66.6
PT .263, percent y.....	10.4	5.5	6.8

z—ON=Coke retained on a screen of the mesh given.

y—PT=Coke passed through a screen of the mesh given.

Advantages

This way of making coke may be suitably employed industrially to particular advantage, the convenient nature of the process rendering it useful as a step in manufacturing processes in which coke and gas are used. Besides, it may be carried on continuously in large or small scale operations.

The control is so flexible that the process may be varied to handle high or low grade coal and to produce high or low volatile coke. It may also be used for treating non-coking coals and for calcining petroleum coke. Feeding the coal in a thin layer enables a rapid heat progression and a consequent rapidity of the coking process which, carried on continuously, enables a large amount of coke to be produced in a short period. To those skilled in the art, other advantages will be evident from the description.

It will, of course, be understood that various modifications may be made in this invention without departing from the spirit thereof or the scope of the claims, and therefore the exact forms shown are to be taken as illustrative only and not in a limiting sense, it being desired that only such limitations shall be placed thereon as may be imposed by the state of the prior art or are set forth in the accompanying claims.

The sub-titles used throughout the specification are merely to simplify reference thereto and should otherwise be disregarded.

We claim:

1. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing a homogeneous bed of carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin layer while passing upwardly through the bed a controlled supply of air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed by combustion of at least a portion of the volatile constituents at least partially within the bed of

carbonizable material and to reduce the amount of combustion of the fixed carbon in the material substantially to a minimum, said carbonizing temperature being secured by the combustion of the volatile constituents and resulting in the production of a homogeneous layer of coke.

2. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin bed while passing upwardly through the bed a controlled supply of air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed solely by combustion of at least a portion of the volatile constituents at least partially within the bed of carbonizable material and to reduce the amount of combustion of the fixed carbon in the material substantially to a minimum.

3. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin bed while passing upwardly through the bed a controlled supply of unheated air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed solely by combustion of at least a portion of the volatile constituents at least partially within the bed of carbonizable material and to reduce the amount of combustion of the fixed carbon in the material substantially to a minimum.

4. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin bed while passing upwardly through the bed a controlled supply of air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed solely by combustion of at least a portion of the volatile constituents at least partially within the bed of carbonizable material and to reduce the amount of combustion of the fixed carbon in the material substantially to a minimum, the speed of progress of the material being such that the material remains in the chamber for a period of time of the order of ten minutes.

5. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin

bed while passing upwardly through the bed a controlled supply of air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed solely by combustion of at least a portion of the volatile constituents at least partially within the bed of carbonizable material and to prevent the burning of any appreciable amount of the fixed carbon.

6. A process of carbonizing a carbonizable material comprising the steps of initially heating a closed chamber to a temperature which will drive off and burn at least a portion of the volatile constituents of the carbonizable material, then passing carbonizable material progressively through the chamber in a substantially horizontal direction and in the form of a relatively thin bed while passing upwardly through the bed a controlled supply of air, and regulating the supply of air and the speed of progress of the material to maintain a carbonizing temperature within the closed chamber and within the bed solely by combustion of at least a portion of the volatile constituents at least partially within the bed of carbonizable material and to reduce the amount of combustion of the fixed carbon in the material substantially to a minimum while preventing the ingress of other air or gases.

7. A high temperature continuous process of producing coke in which there is employed a continuous feed chain grate passing through a closed carbonizing zone, comprising the steps of, advancing the grate continuously, progressively feeding directly on to the grate a single thin bed of high volatile coal, feeding air through the bed entirely from beneath while excluding ingress of other air or gases to the zone, igniting the material, causing in the absence of any other source of heat partial or complete combustion of the material for a time sufficient to attain within the zone a carbonizing temperature, then regulating the amount of air supplied in conjunction with the speed of the grate to effect carbonization of the coal, solely as the result of combustion of at least a portion of the volatile constituents of the coal and to discharge the material from the zone before any appreciable amount of the fixed carbon has been burned.

8. A process of producing coke, comprising, forming progressively and continuously in a carbonizing zone a single thin horizontal bed of high volatile coal, passing the coal continuously through the zone, causing combustion of the bed of coal, maintaining a relatively slow speed of progress in the bed and sufficient air supply to raise a carbonizing temperature in the zone between 800° and 1400° C. with said combustion as the sole source of heat, then passing a controlled amount of unheated air through the bed while excluding ingress of other air to the zone, regulating the amount of air supplied in conjunction with the speed of progress of the coal to effect carbonization of the coal as the result of combustion of at least a portion of the volatile constituents of the coal, the supply of air being within the approximate range of 1.8 to 2.8 pounds of air per pound of coal fed, and the speed of progress of the coal fed being such as to remove the coke from the zone after a period of time of the order of ten minutes.

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