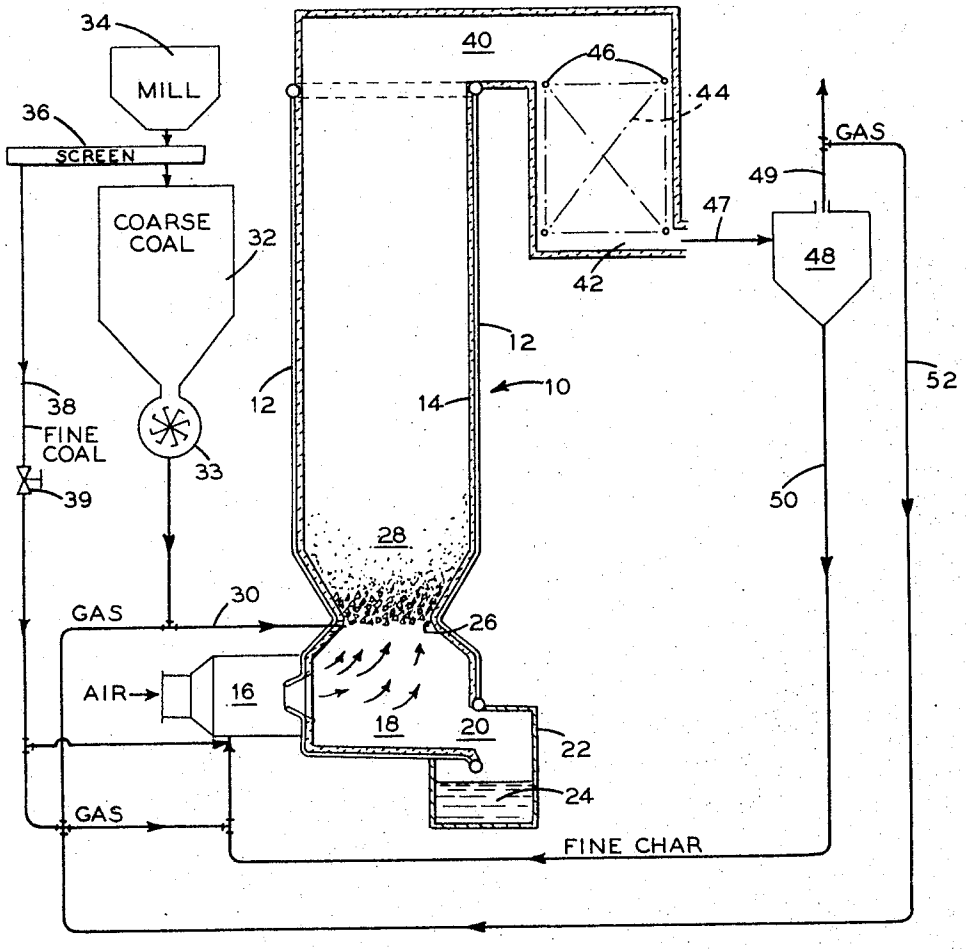
July 8, 1969 E. A. PIRSH ET AL 3,454,383

GASIFICATION METHOD AND APPARATUS

Filed Feb. 24, 1966



INVENTORS
Edward A. Pirsh
Warnie L. Sage

BY

ATTORNEY

United States Patent Office 3,454,383 Patented July 8, 1969

3,454,383

GASIFICATION METHOD AND APPARATUS

Edward A. Pirsh, Akron, and Warnie L. Sage, Louisville, Ohio, assignors to The Babcock & Wilcox Company, New York, N.Y., a corporation of New Jersey

Filed Feb. 24, 1966, Ser. No. 529,872
Int. Cl. C10j 3/48, 3/46; C10b 49/08
U.S. Cl. 48—101 6 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for the gasification of carbonaceous material by passing hot combustion gases through a fluidized bed and including a cyclone furnace for producing these hot combustion gases. The carbonaceous material is precrushed and screened into fine particles which are fed to the cyclone furnace as fuel and coarse particles which are discharged into the inlet of the gasifying zone. The gasifying zone comprises a passageway of upwardly divergent cross sectional area so that the hot combustion gases flowing upwardly therethrough attain a maximum flow velocity at the inlet of the passageway and thereafter experience a gradual reduction of velocity.

This invention relates to a method and apparatus for generating carbon monoxide and other useful gases from particles of coal or other solid carbonaceous material.

Apparatus of the type set forth gasifies a relatively coarse carbonaceous substance in a secondary or gasifying zone by utilizing the heat of combusion gases obtained from a primary or combustion zone. The char or relatively fine particles present in the generated gases are separated therefrom and, together with raw coal screenings, are delivered as fuel to the primary zone for making the combustion gases.

Improved results are obtained, according to the present invention, by introducing and then suspending the relatively coarse particles of raw fuel in a high velocity gas stream flowing through a throat portion connecting the gasifying zone with the combustion zone. By providing a restriction and a diverging gas passageway at the entrance portion of the gasifying zone, the combustion gases flowing upwardly from the combustion zone encounter first a reduced flow area and then a gradually increasing flow area, so that the combustion gases flowing through the throat attain maximum velocity at the restriction and thereafter experience a gradual reduction of velocity. So long as the gravitational force on an individual particle is in balance with the lift force applied thereto by the combustion gases the particle is in a state of suspension; and, thus, the particles to be gasified are stratified according to size and density and they remain suspended in the entrance passageway of the gasifying zone by the high velocity combustion gases until they experience a change either in density or lifting force. The heavier particles occupy the lower portion of the throat where the gas velocity is highest; and the particles which are lighter tend to occupy the upper portion of the throat, where the gas velocity is relatively lower.

Stratifying the suspended particles as aforesaid in a dilute phase bed is advantageous because the greater resistance of the larger or denser particles to devolatilization is offset by their greater proximity to the hot combustion zone during the devolatilizing phase, in which heat from the combustion gases at temperatures of approximately 3000° F. drives off gaseous hydrocarbons. A particle is reduced in density and possibly size too, as a result of devolatilization, and its position in the throat will be shifted upwardly to a region of lower gas velocity

until lift force and gravitional force are again in balance. Thereafter, with little or no oxygen present, the devolatilized carbon residue may combine chemically in the gasifying zone with the carbon dioxide combustion gases from the primary zone to produce carbon monoxide. The latter is of course useful as a fuel, as are the hydrocarbons which were obtained as aforesaid by devolatilization.

As the particles decrease further in density and size they move upwardly still further in the gasifying zone, and eventually they are reduced to dust-like particles which are carried off by the generated gases. The entrained dust-like particles, sometimes termed char or fly ash, are delivered to auxiliary separating apparatus which serves to separate these fines from the gas, after which they are delivered to the combustion zone for use as a fuel to generate hot combustion gases which are then employed for gasifying newly introduced coarse fuel particles. The gas from which the char has been separated is delivered to a point of use; and, if so desired, some of this make gas may be employed as a vehicle for feeding the fine particles to the combustion zone and the coarser raw particles to the gasifying zone.

In the drawing:

The single feature of the drawing is a schematic illustration of a gasifying plant incorporating gasification apparatus constructed and arranged according to the invention.

The gasifying apparatus shown in the drawing includes a vertically elongated shell **10**, preferably having a metal skin and provided with cooling coils **12** or other fluid cooling means to protect the shell from overheating. In addition, the shell **10** is provided interiorly thereof with a refractory lining **14** to minimize the heat transferred to the cooling coils **12**.

A cyclone furnace **16** is operatively associated with a lower end portion of the shell **10**, this bulbous portion defining a furnace chamber **18**. The latter has slag outlet **20** in the bottom thereof for discharging molten slag into a slag tank **22**. The slag tank **22** may contain a suitable liquid such as water, as indicated at **24**, for chilling and solidifying the molten slag dropped into the water from the outlet **20**.

For the purposes to be described, at a point immediately above the furnace chamber **18** the wall of the shell **10** is bent inwardly at an angle to its longitudinal axis, and then bent outwardly to its original dimension so as to define a throat **26**. The wall of the shell **10** may otherwise be cylindrical. The throat **26** serves first as a restriction and then as a diverging entrance passageway of a reaction or gasifying zone **28** for gases flowing upwardly from the furnace chamber **18**.

The interior of the shell **10** above the restriction at the throat **26** comprises the gasifying zone **28**. As will be explained more fully hereinafter, gasification takes place primarily in the diverging entrance passageway of the throat **26**, immediately above the narrowest portion of the throat.

Raw solid carbonaceous material to be gasified is injected through a conduit **30** into the shell **10** at or near the narrowest portion of the throat **26**, after which it is carried upwardly into the gasilying zone **28** by high velocity combustion gases issuing from the furnace chamber **18**. Preferably, the solid carbonaceous material to be gasified is in the form of coarse coal fed from a storage bunker **32** by a coal feeder **33**. The coal supplied to the bunker **32** is previously crushed by a hammer mill **34** to a size which may be in the range of between ¼ inch to ⅜ inch, next screened by a 100 mesh screen **36** to remove fine coal and then conveyed through the conduit **30** into gasifying zone **28** by a portion of the generated gas or another suitable conveying medium. The fine coal separated by the screen **36** may be fed by a pipe **38** to the

cyclone furnace **16** for use as a fuel. Flow through pipe **38** may be controlled by a suitable valve **39**.

The upper portion of the gasifying zone **28** communicates with a horizontal gas pass **40** leading to a downwardly extending outlet chamber **42** containing a heat exchanger **44**. The heat exchanger **44** may comprise water-conducting tubes **46** which are contacted by the product gas leaving the gasifying zone **28** at a temperature of about 1800° F. As a result of the contact between the product gas and the tubes **46**, the water flowing through the heat exchanger **44** absorbs heat from the gas and lowers its temperature to about 1000° F., after which the gas is conveyed through line **47** to a dust collector **48** and conveyed by discharge line **49** to a point of use. It is the function of the dust collector **48** to separate the fine solid carbonaceous material, sometimes termed char, from the product gas so that it may be conducted by a suitable conveying line **50** to the cyclone furnace **16** for refiring. The char separated from the product gas in the dust collector **48** usually consists of entrained particles of a size smaller than 50 mesh.

As in the case of the coarse particles delivered to the throat **26** for gasification, both the char fed through the line **50** and the fine coal fed through the pipe **38** may be conveyed through their respective conduits for discharge into the cyclone furnace **16** with the help of hot product gas tapped from discharge line **49** by line **52**. The cyclone furnace **16** receives theoretical to slightly excess air in sufficient quantity to effect complete combustion of the carbonaceous solids supplied thereto. As a result, carbon dioxide combustion gases at a temperature of about 3000° F. issue from the furnace chamber **18** to the gasifying zone **28** at high velocity.

From the foregoing, it can be seen that a cyclone furnace **16**, a furnace chamber **18**, a gasifying zone **28**, and a dust collector **48** are arranged in series for flow of combustion gases therethrough in the order named, with coal to be gasified being injected at the oxygen-starved throat **26** intermediate the combustion chamber **18** and the gasifying zone **28**. Coal is injected into the hot gas stream where gasification occurs at a rate in excess of that which can be gasified; and the residual or ungasified char subsequently separated in the dust collector **48** is charged to the furnace **16**. The char returned as a fuel for the cyclone furnace **16** may be supplemented by fine carbon material screened at **36** from the coarse particles destined to be gasified.

According to the present invention, the divergent passageway at the entrance of the gasifying zone **28**, and forming a part of throat **26**, provides a flow passageway of varying cross section which effects a gradual reduction in velocity of combustion gas flowing upwardly therethrough. The velocity in the lower portion of the diverging entrance passage is such as to suspend the larger particles of coal. For example, combustion gas having an upward velocity between 100 and 150 feet per second will suspend 1 inch diameter coal particles, and ⅜ inch diameter coal particles will be suspended in a combustion gas stream having a velocity of 80 feet per second. In gas streams of such velocity the smaller and lighter particles are carried upwardly thereby to a higher elevation in the gasifying zone **28** where the combustion gases move more slowly and where, for example, a ¼ inch particle is suspended by gas moving 60 feet per second. Fine particles, for example, smaller than 50 mesh size, are elutriated by the continuously moving combustion gases, while the larger particles remain in suspension at the lower end of the gasifying zone **28** until they are reduced to such fine size by thermal cracking and the chemical process of gasification through carbonization with the carbon dioxide combustion gases to produce carbon monoxide.

The process of the present invention involves the steps of:

(a) Introducing the coarse carbonaceous raw material into an oxygen-starved gasifying zone,

(b) Burning relatively fine carbonaceous material in a furnace to produce hot combustion gases,

(c) Delivering the hot combustion gases to a lower portion of the gasifying zone at sufficient velocity to maintain the largest particles of the coarse material in suspension,

(d) Passing the combustion gases from a lower portion of the gasifying zone toward an upper portion thereof while reducing its velocity to thereby suspend the smaller particles of the coarse material in the gasifying zone and to carry off generated gases and the fine particles which result,

(e) The rate of delivery of the combustion gases to the gasifying zone being sufficient to yield a product gas with carbon monoxide and hydrocarbons as its major constituents at the temperatures and reaction conditions in the gasifying zone,

(f) Maintaining the solids concentration in said gasifying zone to a dilute phase bed and gasifying the carbanaceous material therein,

(g) Separating the ungasified solids from the product gas, and

(h) Delivering the separated solids to the furnace.

What is claimed is:

1. A process for making gas from solid carbonaceous material comprising the steps of:

(a) introducing the relatively coarse carbonaceous material at the lower end of an oxygen starved gasifying zone,

(b) burning relatively fine carbonaceous material in a cyclone furnace to produce combustion gases of about 3000° F. temperature,

(c) delivering the 3000° F. combustion gases from the cyclone furnace to said lower portion of said zone at a flow velocity of between 100 and 150 feet per second, said velocity being sufficient to suspend the heavier particles of carbonaceous material in the combustion gas stream.

(d) passing the combustion gas upwardly from the lower portion of said zone while reducing its flow velocity to below 60 feet per second, said velocity being sufficient to suspend the lighter particles of carbonaceous material in said zone and to carry off generated gases and fine carbonaceous particles,

(e) the rate of delivery of the combustion gases to said zone being sufficient to gasify the carbonaceous material therein and to yield a product gas at the temperatures and reaction conditions in said zone,

(f) separating the ungasified fine solids from the product gas discharged from said gasifying zone, and

(g) delivering the separated fine solids to said cyclone furnace.

2. The process according to claim **1** including the steps of: screening fine carbonaceous material for burning in said cyclone furnace from the relatively coarser carbonaceous material introduced to the lower end of said gasifying zone; and mixing a portion of the product gas partly with the fine solids from said separating means and partly with the screened fine carbonaceous material for promoting the flow thereof to said cyclone furnace.

3. Apparatus for making gas from solid carbonaceous material comprising:

(a) a vertically elongated shell defining a gasifying zone having a restricted inlet at the bottom thereof and an outlet adjacent the top thereof,

(b) a cyclone furnace for burning relatively fine carbonaceous material to produce combustion gases of about 3000° F. temperature,

(c) a throat defining a divergent passageway at the entrance of said gasifying zone above said restricted inlet for conducting 3000° F. combustion gases from said cyclone furnace,

(d) means for delivering relatively coarse, solid carbonaceous material into the restricted inlet to said gasifying zone,

(e) means for separating fine carbonaceous material from the gases discharged from the outlet of said gasifying zone,

(f) and means for conducting the separated fine carbonaceous material from said separating means to said cyclone furnace,

(g) the flow areas of said divergent passageway being such as to provide a decreasing flow velocity of combustion gases therethrough whereby the heavier particles of carbonaceous material in said gasifying zone are suspended in the lower end of said divergent passageway by gas velocities of between 100 and 150 feet per second and lighter coarse particles are suspended in the upper end of said divergent passageway by gas velocities to below 60 feet per second.

4. Apparatus according to claim **3** including a heat exchanger arranged adjacent said outlet in heat transfer relationship with the product gas for absorbing heat therefrom.

5. Apparatus according to claim **3** including a screening device for separating fine solid material from the relatively coarse material to be delivered to the lower end of said gasifying zone, means for conveying fine solid material from said screening device to said cyclone furnace, and means for mixing a portion of said product gas with the fine solid material from said screening device to promote the flow thereof through said conveying means.

6. Apparatus according to claim **3** including a device for screening fine material from the relatively coarse material to be introduced to the lower end of said gasifying means, means for conveying the screened fine material from said device to said cyclone furnace, and means for mixing a portion of the product gas with the separated fine material and the screened material to promote the flow thereof to said cyclone furnace.

References Cited

UNITED STATES PATENTS

2,557,680	6/1951	Odell	48—203 XR
2,582,710	1/1952	Martin	48—203 XR
2,614,069	10/1952	Matheson	48—203 XR
2,743,217	4/1956	Silsby	201—31
2,866,696	12/1958	Godel	48—203
2,879,148	3/1959	Atwell	48—203 XR

MORRIS O. WOLK, *Primary Examiner.*

R. E. SERWIN, *Assistant Examiner.*

U.S. Cl. X.R.

48—203; 201—31