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MIXING NOZZLES FOR CARBONIZING FINE GRAIN
FUELS IN A FLUIDIZED BED
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Fig.1

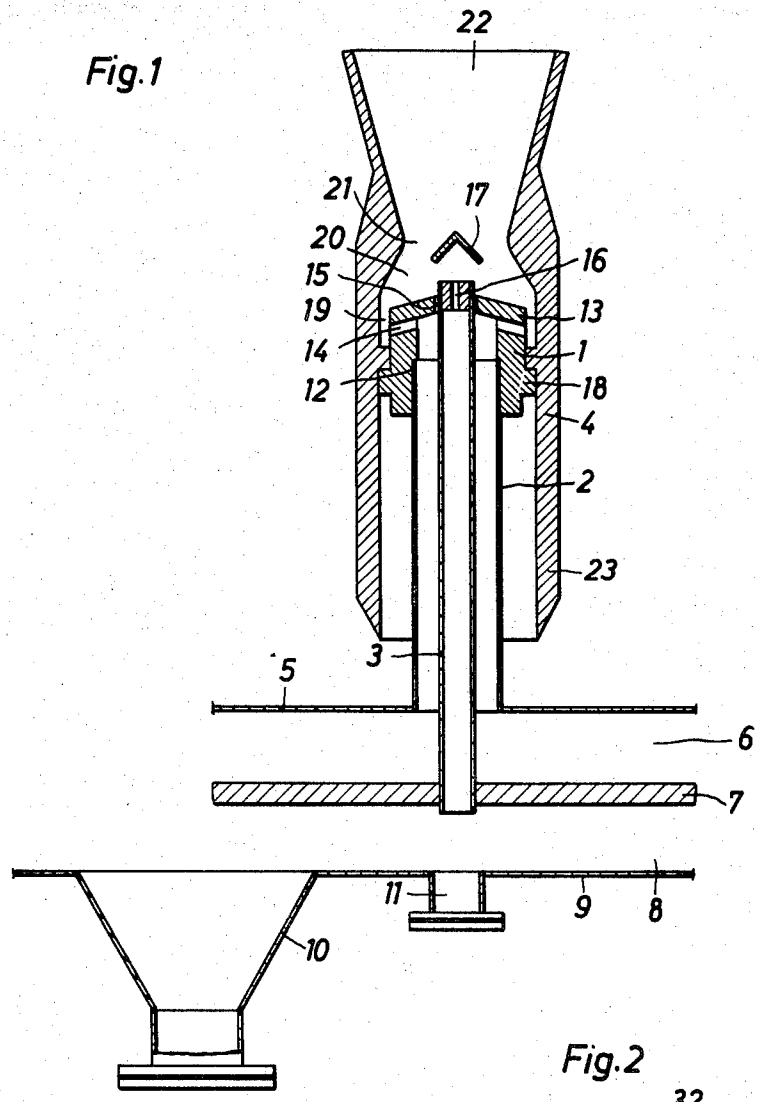
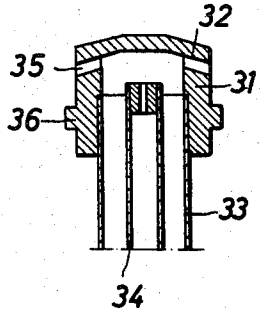


Fig.2



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MIXING NOZZLES FOR CARBONIZING FINE GRAIN FUELS IN A FLUIDIZED BED

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Claims priority, application Germany, Aug. 28, 1969, P 19 43 752.6

Int. Cl. C10b *1/04, 49/22*

U.S. Cl. 202—121 5 Claims

ABSTRACT OF THE DISCLOSURE

Mixing nozzle for fluidized bed reactors having a nozzle shaft through which air and fluid fuel are introduced, a nozzle body over the nozzle shaft having radial openings and a nozzle top having a cup-like shape over the nozzle body and extending upwards therefrom. The process is also disclosed wherein air and fuel are mixed in the nozzle and combusted in close proximity thereto in such a way that combustion gases flow upward through the fluidized bed at high velocity.

RELATED APPLICATION

This application is a division of copending application, Ser. No. 43,091, filed June 3, 1970.

This invention relates to mixing nozzles for carbonizing fine grain fuels such as coal and a process therefor.

BACKGROUND

It is known to carbonize fine-grained coal in a fluidized bed by introducing cold or preheated combustion air through the reactor grate into the fluidized bed. The feed coal, the coke produced by carbonization, and the volatile constituents are partly burnt to heat the fluidized bed to carbonize the feed coal. Experience has shown that the partial combustion involves preferentially the resulting coke and that this is undesirable in view of the yield and ash content. In most cases, the coke is the main product of the carbonization and is considered more valuable, e.g., as fuel for sintering plants, as a leaning material for coking plants, as material for producing shaped coke or the like, than the volatile constituents tar and gas, for which it has become difficult to find an economical utilization.

Carbonization in a fluidized bed cannot be carried out in the same manner as carbonization of briquettes or lump fuels carried out in a shaft furnace with the aid of a scavenging gas. In the latter process, hot burnt gases having only a low oxygen content or no oxygen content at all are passed through the shaft furnace countercurrent to the fuel so as to heat and carbonize the latter. To enable the use of that process in a fluidized bed reactor, the latter would require a grate which resists the high temperatures of about 1000° C. to above 1200° C. at which the combustion gases are introduced. Compared to the internal heating by a partial combustion of the coke with air, hot combustion gases are required at a rate which is four times higher, based on standard conditions. For a given throughput of coal, this means that the diameter of the fluidized bed must be doubled or, where the fluidized bed reactor has a diameter that cannot be exceeded, the number of reactors must be increased four times. To control the gas temperature before the grate of the reactor, a fairly high proportion of the exhaust gases from the reactor must be recirculated to a point preceding the reactor grate. These disadvantages are eliminated when heating is effected by an internal combustion in the fluidized bed reactor. For this reason, it is desirable to find out how the heat required for the carbonization can be generated by a combustion carried out in the fluidized bed reactor but without a combustion of coke.

SUMMARY

According to the invention, combustion air and fluid fuel, that is gaseous, vaporous or liquid fuel, are introduced into a fluidized bed reactor through mixing nozzles and the fuel is added at a rate which corresponds to the oxygen which is available to the combustion air in each nozzle. As a result, the combustion can begin immediately and close to the nozzle. If the mixing nozzle merges first into an enlarged cup-like portion, in which the combustion gases flow at a high velocity, the coke particles from the fluidized bed cannot easily enter that enlarged portion so that the undesired combustion of coke is suppressed. The combustion rate can be increased further if preheated combustion air is supplied. The combustion air may be preheated, e.g., indirectly by a heat exchange with the hot exhaust gases from the fluidized bed reactor. Alternatively, the combustion air may be heated to, e.g., 400–700° C. mixing it with combustion gases from a combustion chamber in which gaseous or vaporous or liquid fuels or fine pulverized coal are burnt.

THE DRAWING

The drawings show diagrammatically and by way of example two nozzle body members for fluidized bed reactors for a coking of coal, which nozzle body members are provided with an enlarged cup-like tip member.

FIG. 1 is a vertical sectional view taken through a nozzle which comprises a tip member and through the adjacent portion of the bottom of the reactor.

FIG. 2 is a vertical sectional view taken through another embodiment of the nozzle body.

DESCRIPTION

The fuel supplied to the mixing nozzles consists suitably of the volatile constituents which are released as a result of the carbonizing process in the fluidized bed and which leave the fluidized bed reactor in a hot mixture with the combustion gas delivered by the mixing nozzles. The vapor-gas mixture which leaves the fluidized bed reactor is suitably passed through a cyclone for a collection of dust and is then cooled, e.g., by being sprayed with water and by the evaporation of said water. The resulting condensed tar is separated in a tar-removing scrubber, where the final residues of dust are also bonded by the tar. The resulting exhaust gas is at a temperature of about 120–150° C. and still contains oil vapors and water vapor and may be supplied as a fuel to the mixing nozzles. Alternatively, the gases may be cooled further to condense the oil and water vapor and the gases may then be used when they have been cooled to, e.g., 30° C.; the tar recovered in the tar-removing scrubber may also be used as a fuel.

Only that portion of the exhaust gases from the fluidized bed reactor must be cooled which is required as a fuel for heating the fluidized bed. The remainder may be supplied directly to a boiler furnace without being cooled.

It is undesirable to compress in a hot or moderately cooled state the exhaust gas which has been discharged from the fluidized bed reactor and passed through a cyclone for dust collection and supply the compressed exhaust gas to the mixing nozzles. In such case, the tar constituents which are highly unsaturated and highly reactive result only in deposits consisting of polymerization and condensation products of the tar in a mixture with small amounts of fine dust in the compressor, in the fuel supply conduits leading to the reactor and in the mixing nozzles.

Because the gases, oils and tars which are formed by the carbonizing process in the fluidized bed do not have a particularly high purity and tend to form deposits with-

in a prolonged time, the fuel supply conduits leading to the mixing nozzles must be simple and easily accessible so that they may be cleaned at proper times and may be burnt out when this is required.

Binary nozzles which have an inlet for combustion air and an inlet for a gaseous or liquid fuel and which are used for a direct heating of fluidized beds are known in various types. They serve particularly to supply the heat required for an endothermic reaction of incombustibles in a fluidized bed reactor. These binary nozzles are so designed that the streams of combustion air and fuel meet immediately after leaving the nozzle and as an intimate mixture burn quickly within the fluidized bed whereas there is no afterburning in the gas space above the fluidized bed.

In a binary nozzle such as that shown in French Pat. 1,504,435, the exit velocity of the air and fuel is selected to be initially higher than the flame velocity of the burning gas mixture and is reduced to the flame velocity only at some distance from the outlet orifices. As a result, the combustion process is spread throughout the volume of the fluidized bed but does not rise above the level thereof.

Binary nozzles for a direct heating of the fluidized bed with liquid or gaseous fuels, which are burnt together with air within the fluidized bed, have been described in German patent applications P 17 58 244.4; P 18 13 286.0 and P 19 06 895.2. In these nozzles too, fuel and combustion air are mixed immediately before or after they are discharged from the nozzle so that the combustion can take place within the fluidized bed and there will be no afterburning above the fluidized bed.

For use in the process according to the invention, the binary nozzles distributed over the bottom of the reactor must be designed so that the combustion is effected very close to the nozzle so quickly and completely that only combustion gases rather than free oxygen will enter the fluidized bed consisting mainly of coke.

In a reactor for carrying out the process according to the invention, a plurality of binary nozzles are distributed throughout the bottom of the reactor.

Each binary nozzle has a nozzle shaft, which is formed by two concentric tubes, and a nozzle body.

One of the two concentric tubes, in most cases the outer one, serves to supply the combustion air to the nozzle body and extends through the bottom of the reactor to an air supply manifold.

The other of the concentric tubes, preferably the inner one, extends to a fuel supply manifold, which is disposed within or below the air supply manifold. The air supply manifold and the fuel supply manifold consist preferably of chambers which are so arranged below the bottom of the reactor that the bottom of the reactor forms the top of the air supply manifold and the bottom of the air supply manifold forms the top of the fuel supply manifold. The bottom of the fuel supply manifold chamber is suitably provided with connecting pipes which have blind flanges and through which the chamber is also accessible for cleaning purposes.

The fuel supply manifold chamber will be omitted if the process according to the invention is carried out with liquid fuel. In that case the inner tube of the nozzle shaft extends through the bottom of the air supply manifold chamber and terminates in a fitting which serves to connect said tube by a hose or pipe to a main fuel conduit.

The nozzle body consists of a nozzle body member and a tip member which has an enlarged cup-like portion in which the supplied fuel is almost completely burnt.

The nozzle body member is a cylindrical hollow body, which is closed at one end by a surface which is flat or oblique in frustoconical shape. The nozzle body member is fitted at its open end on the other tube of the nozzle shaft. The shell of the nozzle body member is formed closely below the end with radial openings, such as bores or slots. The fuel-conducting inner tube of the nozzle shaft terminates in an outlet orifice of controlled size. This tube may terminate within the nozzle body member below the closed end or may extend slightly above the nozzle body member through a central opening in that end and terminate there under a deflecting hood. The shell of the nozzle body member is provided with a peripheral supporting ring, which supports the enlarged cup-like portion of the tip member.

Below the throat of the enlarged cup-like portion, the tip member defines a mixing chamber, which communicates with the outlet orifices of the nozzle body member and in which the combustion begins. The burning mixture enters the enlarged cup-like portion at a high velocity, in which the combustion is almost completed. The hot combustion gas leaves the enlarged cup-like portion at such a high velocity that coke particles from the overlying fluidized bed cannot fall into the cups so that they cannot be contacted with free oxygen. The nozzle body member and the tip member are so heavy that they cannot be lifted by the gas stream passing therethrough.

These heavy binary combustion nozzles eliminate two difficulties which have arisen in the carbonization of coal in a fluidized bed. The expensive and complicated separation of the volatile products of the carbonizing process, which products can be utilized only with difficulty, from the exhaust gas from the fluidized bed reactor is much simplified and the volatile products of the carbonizing process may be used for a direct heating of the reactor. The combustion is controlled to take place in the reactor itself whereas the coke in the fluidized bed is not contacted with free oxygen.

FIG. 1 shows a portion of the bottom of the reactor and a mixing nozzle in accordance with the present invention. The nozzle consists of a nozzle body member **1**, a nozzle shaft comprising an outer tube **2** and an inner tube **3**, which is disposed within and concentric with the tube **2**, and a tip member **4**. The outer tube **2** of the nozzle shaft is sealed in an opening of the bottom **5** of the reactor and terminates in an air supply manifold **6**. The bottom **7** of the air supply manifold **6** constitutes the top of the fuel supply manifold **8**, which is sealed underneath by the bottom **9** formed with the bin pockets **10** and with cleaning pipes **11** provided with blind flanges. The inner tube **3** of the nozzle shaft is concentric with the outer tube **2** and extends through bottom **5** and is sealed in an opening in bottom **7**.

The nozzle body member **1** is fitted on the outer tube **2** of the nozzle shaft and is seated on a defined level at the recessed shoulder **12**. The shell of the nozzle body member is formed closely below the cover **13** with radial outlet openings **14** in the form of bores or slots. The inner tube **3** of the nozzle shaft extends beyond the nozzle body member **1** through central opening **15** in the cover **13** of the nozzle body member **1** and terminates in a sized coaxial outlet orifice **16** under a deflecting member **17**. The outlet orifice **16** may be replaced by horizontal, tangentially discharging outlet orifices formed in the end portion of tube **3**.

The nozzle body member **1** is formed with an outer shoulder **18** below the outlet orifices **14** which carries the tip member **4**. This tip member has such an internal shape that it forms together with the nozzle body member **1** adjacent to the outlet orifices **14** an annular duct **19**, which merges into the mixing chamber **20**, which is constricted over the nozzle body member. The enlarged cup-like portion **22** in which the combustion takes place begins over the throat **21**.

The tip member **4** comprises a tubular extension **23**, which extends below supporting shoulder **18** and is spaced around the nozzle shaft **2**, **3**. This extension preferably increases the combined weight of the nozzle body member **1** and the tip member **4** sufficiently to prevent the lifting of these two members by the inflowing gas. The extension also shields the outside of the outer tube of the nozzle shaft **2**, **3** from the hot material from the fluidized bed. The increased weight of the nozzle body member

and tip member is of special significance in the embodiment of the nozzle body shown in FIG. 2.

In that embodiment, the nozzle body member **31** is closed at the top by the cover **32**. As is the embodiment of FIG. 1, the nozzle body member **31** is mounted on the outer tube **33** of the nozzle shaft.

The inner tube **34** of the nozzle shaft terminates below the cover **32** and the radial outlet orifices **35** in the nozzle body member so that air and fuel are mixed prior to said orifices.

The tip member **4** is fitted on the ring **36** of the nozzle body member in the manner shown in FIG. 1. The combustible mixture formed within the nozzle body member enters the mixing chamber (20 in FIG. 1) disposed over the nozzle body member through outlet orifices **35** and flows from there into the combustion zone proper in the enlarged cup-like portion of the tip member (22 in FIG. 1). This embodiment is particularly suitable for a combustion of liquid fuel, such as the tar from the tar-removing scrubber.

In both embodiments of the mixing nozzle, the inner tube of the nozzle shaft (**3, 34**) is secured only in the bottom of the air supply manifold. The end provided with the outlet opening is freely movable so that the tube is free for thermal expansion.

The following example will further illustrate the invention.

A fluidized bed reactor having an inside diameter of 2000 millimeters and a bed height of 1000 millimeters of mainly coke is provided with 50 mixing nozzles of the type shown in FIG. 1, which are evenly distributed throughout the cross-section of the bed. Combustion gases and gases formed by a degasification of coal are exhausted from the fluidized bed reactor at a total rate of 28,000 cubic meters per hour and at a temperature of 800° C. at the outlet of the fluidized bed reactor. 4000 standard cubic meters of air and 2000 standard cubic meters fuel gas having a calorific value of 2000 kilocalories per standard cubic meter are supplied per hour to the 50 mixing nozzles. The fuel gas consists of part of the gas which has been discharged from the fluidized bed reactor and which has been cooled and from which the condensed tar oil has been separated.

Each mixing nozzle is fed with 80 standard cubic meters of air and 40 standard cubic meters of fuel gas per hour. For this purpose, the cup **22** of each mixing nozzle is 50 millimeters in diameter in its lower portion and has a height of 120 millimeters. The combustion gases flow in the upper outlet opening at a velocity of about 10 meters per second. In this manner combustion takes place very close to the nozzles so quickly and completely that only combustion gases (rather than free oxygen) enter the fluidized bed consisting mainly of coke and because the combustion gases flow upward at a high velocity, coke particles from the bed cannot enter the cups **22** of each nozzle and undesirable coke combustion does not take place.

What is claimed is:

1. Fluidized bed apparatus for carbonizing fine grained fuel without combusting same which comprises a reactor having a plurality of binary mixing nozzles distributed throughout the bottom thereof, each of said nozzles having an outer tube and an inner concentric tube having an outlet orifice at its upper end, the outer one of said tubes being joined to an air supply chamber and the inner tubes being joined to a fluid fuel supply manifold, the improvement which comprises a nozzle body disposed over the upper end of said outer tube having a cover member and radial outlet openings and a nozzle tip resting on said nozzle body, said nozzle tip forming an annular duct around the radial outlet openings of the cover member, said nozzle tip having a throat above said cover member and an increasing inner diameter from said throat to the outlet of the nozzle tip.

2. Fluidized bed apparatus of claim **1** wherein the cover member of said nozzle body has a central opening through which the upper end of the inner tube of said nozzle shaft extends.

3. Fluidized bed apparatus of claim **1** wherein the inner tube of said nozzle shaft terminates within said nozzle body below said cover.

4. Fluidized bed apparatus of claim **1** wherein said nozzle body has an inner shoulder which rests on the upper end of the outer tube of said nozzle shaft and an outer shoulder upon which rests said nozzle tip.

5. Fluidized bed apparatus of claim **4** wherein said nozzle tip is provided with a tubular extension extending below said outer shoulder whereby the combined weight of said nozzle body and said nozzle tip is such that said body and said tip are not lifted by in-flowing air and fuel.

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