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(54) Process and apparatus for the production of synthesis gas.

(57) Process and apparatus for producing a gas mixture containing hydrogen and carbon monoxide by partially combusting a carbon-containing fuel with an oxygen-containing gas in a reactor in which the product is quenched, the gas produced is separated from ash and slag and passed through a waste heat boiler, which is vertically positioned immediately below the reactor.

The ash and slag are discharged through a vertical discharge means, which extends inside or alongside the waste heat boiler, into a slag bath.

EP 0 257 722 A2

PROCESS AND APPARATUS FOR THE PRODUCTION OF SYNTHESIS GAS

The invention relates to a process and apparatus for producing a gas mixture containing hydrogen and carbon monoxide by partial combusting a carbon-containing fuel with an oxygen-containing gas.

When the oxygen-containing gas is air or oxygen-enriched air, the gas mixture containing hydrogen and carbon monoxide formed also contains a substantial quantity of nitrogen. By carbon-containing fuel is generally meant coal or another solid fuel, such as brown coal, peat, wood, coke, soot etc., but liquid fuels such as tar sand oil or shale oil, mixtures of liquid and/or particulate solid fuels, and hydrocarbon gases are also possible.

Sometimes, a moderator is also introduced into the reactor or gasifier to exercise a moderating effect on the temperature of the gasifier, due to an endothermic reaction between the moderator and the reactants and/or products of the gas mixture containing hydrogen and carbon monoxide preparation. Suitable moderators are steam and carbon dioxide.

The gasification process is suitably carried out at a temperature in the range of from 1200 to 1700 °C and at a pressure in the range of from 1 to 200 bar.

The gasifier in which the production of a gas mixture containing hydrogen and carbon monoxide takes place may have the shape of a sphere, cone block or a cylinder, the shape of a circular cylinder being advantageous.

From German Patent Application 24e, 3/06, S20692 (filed 27-10-1950 in the name of F. Sabel, published 25-10-1951) a process is known wherein ash and slag formed in the gasifier are initially separated from the gaseous products by centrifugal forces resulting from a sharp bend in the passage of the products. Thus ash and slag separate out in substantially liquid form, which on cooling may give rise to the formation of agglomerations of solid material, which cannot be easily removed. Further separation is performed by cooling, which is done in a separate vessel.

It is an object of the present invention to solve the problem of the formation of solid agglomerations by providing a method wherein the gasification is followed immediately by quenching and instantaneous removal of the major part of ash and slag. It is another object of the present invention to provide a compact apparatus for carrying out the said method.

The present invention therefore provides a process for producing a gas mixture containing hydrogen and carbon monoxide by partially combusting a carbon-containing fuel with an oxygen-containing gas, said process comprising the steps of:

(a) supplying said fuel and said oxygen-containing gas to a gasifier at a temperature and a pressure suitable to cause partial combustion;

(b) quenching the product obtained from step (a) in a quench zone provided near the outlet of the gasifier;

(c) separating ash and slag from the gas mixture obtained;

(d) discharging the ash and slag to a slag bath;

(e) passing the gas mixture obtained through a waste heat boiler; characterized in that the waste heat boiler is positioned essentially vertically immediately below the gasifier and the quench zone and wherein the ash and slag are discharged through a discharge means extending essentially vertically inside or alongside the waste heat boiler.

The invention also provides an apparatus for producing a gas mixture containing hydrogen and carbon monoxide by partially combusting a carbon-containing fuel with an oxygen-containing gas, comprising:

(a) a gasifier provided with means for supplying carbon-containing fuel and oxygen-containing gas and further provided with an outlet for product gas;

(b) a quench zone provided near the outlet of the gasifier;

(c) a means for discharging slag and ash from the gasifier;

(d) a waste heat boiler; characterized in that the waste heat boiler is positioned essentially vertically immediately below the gasifier and wherein the slag and ash discharging means is extending essentially vertically inside or alongside the waste heat boiler.

Advantageously, such a process makes use of a downflow gasifier, into whose upper part the carbon-containing fuel and the oxygen-containing gas are simultaneously injected. These components may be injected in the form of one or more jets, which are directed horizontally or vertically downwards or obliquely downwards.

The combustion products formed enter into a quench zone, positioned below the gasifier, and are subjected to one or more streams of cooling medium. Thus, the temperature of the combustion

products is reduced to such a level as to make the ash and the slag solidify, but remains high enough to permit downstream recovery of a substantial portion of the heat of the combustion products.

The invention will now be described by way of example in more detail with reference to the drawing, in which the Figure shows a diagrammatic representation of a longitudinal section of an apparatus according to the invention for the production of a gas mixture containing hydrogen and carbon monoxide by partial combustion of a carbon-containing fuel with an oxygen-containing gas. Referring to the Figure, a gasifier 1 has been shown. Via supply means 2 in the top of the gasifier 1 carbon-containing fuel, an oxygen-containing gas and optionally a moderator are injected into the gasifier. Partial combustion under appropriate conditions produces a gas mixture containing hydrogen and carbon monoxide and ash and slag, which leave the gasifier through an outlet 3 in the bottom of the gasifier. Here the product gas is quenched by a cooling medium, which enters a quench zone through inlets 4. The major part of ash and slag, which are cooled, fall into a slag discharge means 5, which is advantageously surrounded by the outer shell of a waste heat boiler 6 and discharges into a slag bath 7. This slag bath can be a water bath. The waste heat boiler comprises cooling means such as coils or panels which have not been represented for reasons of clarity. From the slag bath 7 the slag is discharged to a suitable disposal means, e.g. a slag lock hopper (not shown). The gas mixture obtained, which may still contain some ash and slag contaminants, is cooled in the waste heat boiler 6 and leaves the latter through an outlet 8 to undergo further treatment, if necessary, such as removal of contaminants.

It will be appreciated that the slag discharge means 5 can be positioned immediately below the outlet of the gasifier and may have its upper end in the quench zone. Advantageously, the slag discharge means 5 may extend alongside the waste heat boiler.

The pressures prevailing in the gasifier, waste heat boiler and slag discharge means are such that the discharge of product gas from the gasifier into the slag discharge means 5 is prevented and substantially all product gas is passed into the waste heat boiler. Such process features as well as constructional features are not part of the invention and will not be described or shown in the Figure for reasons of clarity.

The operation of the method and the apparatus of the invention is as follows:

In the quench zone the products leaving the gasifier are quickly cooled down to about 700-900°C. The cooling medium used therefore may be gas (for example cold recycled product gas) and/or steam generated in situ by the injection of liquid water. But more economically, at least part of the cooling medium may be made up by steam generated during any cooling operation applied in the process. For example, steam formed during the water bath cooling of ash and slag as described below may be suitably applied for this purpose. Another suitable source of steam is present in a particular embodiment of the invention, which will be discussed later.

The transition from gasifier to quench zone takes place through an outlet in the bottom of the gasifier. Conveniently, such an outlet has a tapered shape to facilitate collection of ash and slag. The outlet debouches into the slag discharge means, which advantageously is a vertical tube, which is open at its top and which empties itself into a water bath, in which ash and slag are further cooled.

Advantageously, the slag discharge means is placed inside the waste heat boiler. Thus a greater portion of the heat of the ash and slag is recovered, which improves the efficiency of the process.

The temperature in the gasifier, among other factors, influences the composition of the gas mixture formed. This temperature can be controlled by various methods, one of which being the degree of preheating the reactants prior to their being injected into the gasifier.

In a particular embodiment of the invention the gasifier is surrounded by a water jacket. If inside the water jacket steam is formed, this can be used as cooling medium in the quench zone or at least as part of the cooling medium needed.

The gas mixture containing hydrogen and carbon monoxide entering the waste heat boiler has a temperature between 700 and 900°C. In the waste heat boiler indirect heat transfer takes place from the gas to for example cooling panels, causing the temperature of the gas to drop to about 200-250°C. As cooling medium usually water is used, which is partly or wholly converted into steam, which may suitably used in the process or elsewhere.

The wall between the slag discharge means and the waste heat boiler can be constructed in any way suitable for the purpose, for example as a cylindrical cooling panel (tubes welded on a metal sheet) which can be rapped in order to avoid fouling. The diameter of such tubes can for example be in the range of 1-4 cm.

It is inevitable that part of the ash and slag is entrained by the gas mixture as small droplets or particles. Therefore, these contaminating components should be removed from the gas mixture

after the latter has left the waste heat boiler. For this purpose the gas mixture with entrained contaminating components is passed through a cyclone or other suitable apparatus.

At this stage of the process the gas mixture has still a temperature of about 200-250°C. A convenient way of further cooling is by the injection of water or steam into the gas. This raises the water content of the gas, which can be advantageous if the gas mixture is used as starting material for CO shift. Also, the water present can be of use to control NO_x emission when the gas mixture is combusted.

The present invention can further be illustrated by reference to the following data, showing by way of example the sizing of the configuration according to the invention:

Unit capacity: 1000 t/d Illinois No. 6 coal;

Process conditions of gas ex gasifier: 5.40 m^3/s, 25 bar, 1450 °C;

Process conditions of recycle gas used as quench medium:

1.75 m^3/s, 26 bar, 200 °C;

Diameter of gasifier : 2.5-3.0 m

Length of gasifier : 5-8 m

Diameter of gasifier exit : 0.8-1.2 m

Diameter of slag discharge means : 0.8-1.2 m

Diameter of waste heat boiler : 1.5-1.8 m

Length of waste heat boiler : 15-25 m.

Various modifications of the present invention will become apparent to those skilled in the art from the foregoing description and accompanying drawing. Such modifications are intended to fall within the scope of the appended claims.

Claims

1. A process for producing a gas mixture containing hydrogen and carbon monoxide by partially combusting a carbon-containing fuel with an oxygen-containing gas, said process comprising the steps of:

(a) supplying said fuel and said oxygen-containing gas to a gasifier at a temperature and a pressure suitable to cause partial combustion;

(b) quenching the product obtained from step (a) in a quench zone provided near the outlet of the gasifier;

(c) separating ash and slag from the gas mixture obtained;

(d) discharging the ash and slag to a slag bath;

(e) passing the gas mixture obtained through a waste heat boiler;

characterized in that the waste heat boiler is positioned essentially vertically immediately below the gasifier and the quench zone and wherein the ash and slag are discharged through a discharge means extending essentially vertically inside or alongside the waste heat boiler.

2. The process as claimed in claim 1, characterized in that steam is used as quench medium, which steam is generated in a water jacket, placed round the gasifier.

3. The process as claimed in any one of claims 1-2, characterized in that, in addition to being cooled in the waste heat boiler, the gas mixture obtained is cooled further by direct injection of water or steam.

4. The process as claimed in any one of claims 1-3, characterized in that contaminating components are removed from the gas mixture obtained as said gas mixture leaves the waste heat boiler.

5. An apparatus for producing a gas mixture containing hydrogen and carbon monoxide by partially combusting a carbon-containing fuel with an oxygen-containing gas, comprising:

(a) a gasifier provided with means for supplying carbon-containing fuel and oxygen-containing gas and further provided with an outlet for product gas;

(b) a quench zone provided near the outlet of the gasifier;

(c) a means for discharging slag and ash from the gasifier;

(d) a waste heat boiler;

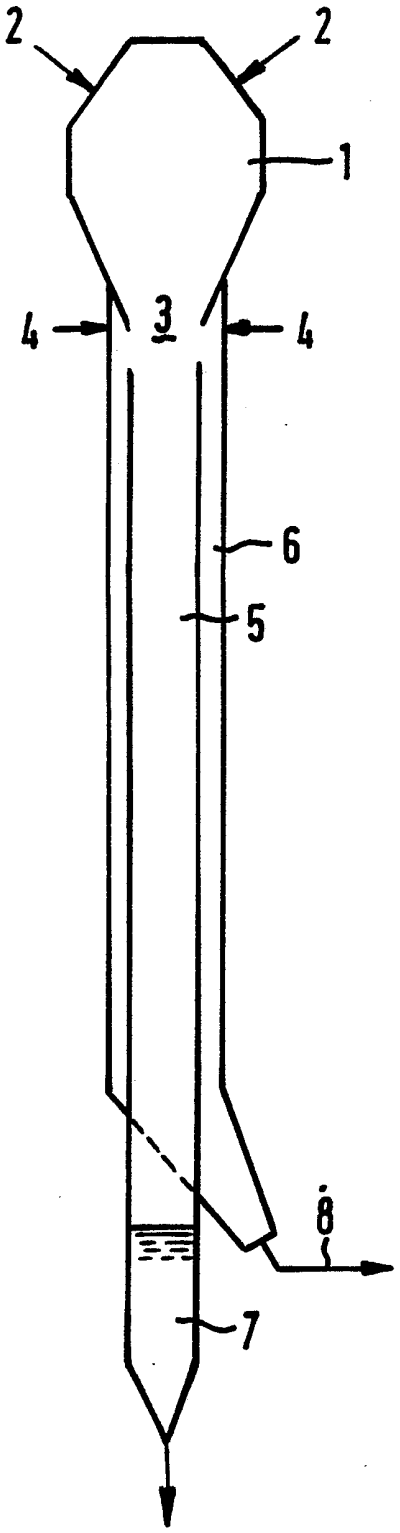
characterized in that the waste heat boiler is positioned essentially vertically immediately below the gasifier and wherein the slag and ash discharging means is extending essentially vertically inside or alongside the waste heat boiler.

6. The apparatus as claimed in claim 5, characterized in that a water jacket is positioned round the gasifier.

7. The apparatus as claimed in claim 5 or 6, characterized by means to remove contaminants from a gas mixture leaving the waste heat boiler.

8. The apparatus as claimed in any one of claims 5-7, characterized in that the essentially vertical slag and ash discharging means is positioned below the outlet of the gasifier and has its upper end in the quench zone.

9. Product gas whenever obtained by the process as claimed in any one of claims 1-4.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