AMENDED SPECIFICATION

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PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in and relating to the Production of Producer Gas

We, MICHAEL HENRY MILLER ARNOLD, DAVID REGINALD PRYDE and RONALD JAMES MORLEY, all British Subjects, of Norton Hall, The Green, Norton-on-Tees, County Durham, and IMPERIAL CHEMICAL INDUSTRIES LIMITED, a British Company, of Imperial Chemical House, Millbank, London, S.W.1, do hereby declare the nature of this invention to be as follows:—

This invention relates to the production of producer gas.

According to the present invention there is provided a process for the production of producer gas in which coal is carbonised and subsequently treated with oxygen-containing gas to produce gas, the steps of carbonisation and of gas production being carried out in separate vessels, the solid material in both steps being maintained in the fluid state, without producing in the carbonisation step, an entrained stream, the significance of the terms "fluid state" and "entrained stream" being as hereinafter defined.

Referring to the accompanying drawing, when a stream of gas is passed in an upward direction through a bed of discrete particles, the pressure drop at first increases linearly with increase in the gas velocity. As the gas velocity is increased a critical point A is reached at which the pressure drop-gas velocity begins to inflect and the volume of the bed of discrete particles increases by approximately 10%. At this point the bed of discrete particles assumes some of the properties of a liquid, for example, the particles can be poured in a manner similar to liquids. Similarly, owing to the fact that the individual particles are cushioned by gas and the internal friction of the bed is thus greatly reduced, the bed can easily be stirred. If the gas velocity is further increased above this critical point, a point B is reached at which a motion similar to that observed on the surface of a boiling liquid is assumed by the particles, and for all gas velocities above this point, the pressure drop is substantially independent of the gas velocity.

As the gas velocity is increased beyond the value denoted by B, the bed continues to expand until it occupies the whole of the reaction vessel. Further increase in the gas velocity causes the bed to expand into the gas exit pipe where by reason of the higher gas velocity, the particles are entrained and carried away by the gas stream. With still further increases in gas velocities, a stage is finally reached when the particles pass through the vessel as a stream entrained in the gas.

Hereinafter the state of the carbonaceous material in a reaction vessel through which gas is passed upwards with a velocity of the value denoted by A or higher, will be referred to as the fluid state; when the gas velocity is between the points A and B the state of the carbonaceous material will be more particularly referred to as an expanded bed; when the gas velocity is of the value denoted by B or higher, but the carbonaceous material is still in the form of a bed, the state of the carbonaceous material will be more particularly referred to as a boiling bed, while when the velocity is so high that the carbonaceous material passes through the reaction vessel as a stream with the gases, the state of the material will be more particularly referred to as an entrained stream.

The coal must be in the form of small particles or powder in order that it may be maintained in the fluid state by the use of practical gas velocities. While a wide variety of coals may be used in the

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process of the present invention, it is advisable not to use alone those varieties which swell and cake when heated; such varieties of coal may be used if they are mixed with coke, or some inert material such as sand, to prevent aggregation of the particles. It should be understood that in the process of the present invention, the coal fed to the carbonisation step may or may not be completely carbonised as desired.

The heat required for the carbonisation step may be applied externally to the vessel in which the coal is being carbonised, or it may be obtained by the combustion, with air, of a portion of the coal fed to the carbonisation vessel. It is advantageous however, in the carbonisation step to utilize the sensible heat of the hot residue leaving the gas producing step, by mixing a suitable quantity of such hot residue with the coal being fed to the carbonisation step.

The material leaving the carbonisation step may be fed to the gas-producing step with or without cooling, as desired, for example, in order to control the temperature in the gas-producing step.

Dated the 2nd day of June, 1944.

J. W. KIDSDALE,
Solicitor for the Applicants.

COMPLETE SPECIFICATION

Improvements in and relating to the Production of Producer Gas

We, MICHAEL HENRY MILLER ARNOLD, DAVID REGINALD PRYDE and RONALD JAMES MORLEY, all British Subjects, of Norton Hall, The Green, Norton-on-Tees, County Durham, and IMPERIAL CHEMICAL INDUSTRIES LIMITED, a British Company, of Imperial Chemical House, Millbank, London, S.W.1, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the production of producer gas.

It has already been proposed, in processes for the gasification of coal in granular or dust form by the upward passage therethrough of a gasifying agent such as air or steam, to provide one or more secondary chambers within which partially consumed fuel carried from the initial gasifying chamber by the gasifying agent and the gas produced can be completely consumed for the production of gas or heat.

It has also been proposed to carbonise particulate coal by indirect heat exchange with hot waste flue gases and to utilise the particulate carbonised material in a gas-producing step.

According to the present invention there is provided a process for the production of producer gas in which coal is carbonised and subsequently treated with an oxygen-containing gas other than air to produce gas, the steps of carbonisation and of gas production being carried out in separate vessels, the solid material in both steps being maintained in the fluid state, without producing in the carbonisation step, an entrained stream, the significance of the terms "fluid state" and "entrained stream" being as hereinafter defined, utilising in the carbonisation step, the sensible heat of hot solid material withdrawn from the gas-producing step.

In the carbonisation step the sensible heat of hot material withdrawn from the gas-producing step may be used, for example, by mixing a suitable quantity of such hot solid residue with the coal being fed to the carbonisation step. Any supplementary heat required in the carbonisation step may be obtained by introducing a suitable proportion of oxygen or an oxygen-containing gas, such as air, with the gas used to maintain the bed of solid material in the fluid state.

Referring to the drawing accompanying the provisional specification, when a stream of gas is passed in an upward direction through a bed of discrete particles, the pressure drop at first increases linearly with increase in the gas velocity. As the gas velocity is increased a critical point A is reached at which the pressure drop-gas velocity curve begins to inflect and the volume of the bed of discrete particles increases by approximately 10%. At this point the bed of discrete particles assumes some of the properties of a liquid, for example, the particles can be poured in a manner similar to liquids. Similarly, owing to the fact that the individual particles are cushioned by gas and the internal friction of the bed is thus greatly reduced, the bed can easily be stirred. If the gas velocity is further increased above this critical point, a point B is reached at which a motion similar to that observed on the surface of a boiling liquid is assumed by the particles, and for all gas velocities above this point, the pressure drop is substantially independent of the gas velocity.

As the gas velocity is increased beyond the value denoted by B, the bed continues to expand until it occupies the whole of the reaction vessel. Further increase in the gas velocity causes the bed to expand into the gas exit pipe where by reason of the higher gas velocity, the particles are entrained and carried away by the gas stream. With still further increases in gas velocities, a stage is finally reached when the particles pass through the vessel as a stream entrained in the gas.

Hereinafter the state of the carbonaceous material in a reaction vessel through which gas is passed upwards with a velocity of the value denoted by A or higher, will be referred to as the fluid state; when the gas velocity is between the points A and B the state of the carbonaceous material will be more particularly referred to as an expanded bed; when the gas velocity is of the value denoted by B or higher, but the carbonaceous material is still in the form of a bed, the state of the carbonaceous material will be more particularly referred to as a boiling bed, while when the velocity is so high that the carbonaceous material passes through the reaction vessel as a stream with the gases, the state of the material will be more particularly referred to as an entrained stream.

In the process of the present invention, the solid material in the carbonisation and gas-producing steps must be in the form of small particles or powder in order that it may be maintained in the fluid state by the use of practical gas velocities. In the carbonisation step the bed of solid material may be maintained in the fluid state by the passage through it of gases which have been collected from the carbonisation step, while in the gas-producing step the bed of solid material may be maintained in the fluid state by the passage through it of oxygen or an oxygen-containing gas, or if desired steam may be mixed with such gases in proportions suitable for obtaining gas of required composition, and/or for controlling the temperature in the bed of solid material. Preferably in the carbonisation step the solid material and the gas used to maintain it in the fluid state flow in counter-current, while in the gas-production step it is preferable to have co-current flow of solid material and of gas or of the mixture of gas and steam used for maintaining the fluid state and for the production of gas.

A wide variety of coals may be fed to the carbonisation step; those varieties which swell and cake excessively when heated may be used satisfactorily if they are mixed with coke, or some inert material such as sand or ash to prevent aggregation of the particles. It should be understood that in the carbonisation step of the present invention, the coal may or may not be completely carbonised as desired. Similarly, in the gas-producing step all the carbonaceous material fed may or may not be completely consumed.

In order to decrease any tendency of particulate or powdered coal to agglomerate in the carbonisation step it is preferable to ensure good intermingling of the hot residue from the gas-producing step and the coal being fed to the carbonisation step before they reach the fluid bed. This intermingling may be attained for example, by feeding suitably directed streams of hot residue and of coal into the top of the carbonisation vessel at a suitable height above the fluid bed.

The material leaving the carbonisation step may be fed to the gas-producing step with or without cooling, as desired, for example, in order to control the temperature in the gas-producing step.

It will be understood that by suitable arrangement of the vessels in which the carbonisation step and the gas-producing step are carried out, the process of the present invention may be operated continuously for the production of producer gas.

The following example illustrates the continuous operation of the process of the present invention.

EXAMPLE.

Referring to the accompanying drawing, powdered coal, the particles of which had a radius of from 0.035 cms. to 0.039 cms., was fed from the hopper 1 through pipeline 2 into the carbonisation vessel 3, from which, carbonisation gases left by the pipeline 4 and were collected in the holder 5. The powdered coal in the carbonisation vessel 3 was maintained in the fluid state by the passage through it, at a velocity of 80 cms. per second, of carbonisation gases taken from the holder 5 by the pump 6 and introduced into the carbonisation vessel by the pipeline 7. Carbonaceous material at a temperature of about 700°C. left the carbonisation vessel by pipeline 8 and was conveyed through pipeline 9 into the gas-producing vessel 10 by introducing into the pipeline 9 through the inlet 11, air saturated at 74°C. with steam, the velocity of the air/steam mixture being 850 cms. per second. The carbonaceous material in the gas-producing vessel 10 was maintained in the fluid state by the passage through it of the stream of air introduced through pipeline 9, the velocity of the air through the gas-producing vessel being 200 cms. per second. Producer gas passed from the gas-producing vessel 10 through the pipeline 12. This producer gas contained 22.0% of carbon monoxide, 24.0% of hydrogen and 44.0% of nitrogen, the remainder being chiefly carbon dioxide and methane: these percentages are by volume. Solid residual material at a temperature of about 1000°C. overflowed from the gas producing vessel 10 through the pipeline 13 and passed into the carbonisation vessel 3, where it intermingled with powdered coal falling from the pipeline 2 before reaching the surface 14 of the fluid bed of carbonisation material. Residual solid material was removed from the system as desired through pipeline 15 and control means 16.

The velocities in the foregoing example were "open tube" velocities, that is they were measured while the carbonisation vessel 3, the pipeline 9 and the gasification vessel 10 were empty.

It should be understood that the sensible heat of the producer gas and of the gases from the carbonisation vessel may be used as desired to preheat the air and steam used in the process or to generate steam in waste heat boilers.

We are aware of Specification No 586,391 which claims an improved process for the production of gaseous fuels from solid carbonaceous material which is passed as a fluidised stream through a reaction system comprising at least two chambers in one of which the carbonaceous material is burnt with air and the remainder raised to high temperatures and another of said chambers comprising a gasification zone in which heat is provided by heated carbonaceous material flowing from the combustion chamber; such a process may include a third chamber comprising a carbonisation zone.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a process for the production of producer gas in which coal is carbonised and subsequently treated with an oxygen-containing gas other than air to produce gas, the steps of carbonisation and of gas production are carried out in separate vessels, the solid material in both steps being maintained in the fluid state, without producing in the carbonisation step, an entrained stream, utilising, in the carbonisation step, the sensible heat of hot solid material withdrawn from the gas-producing step.

2. In a process for the production of producer gas in which coal is carbonised and subsequently treated with oxygen or an oxygen-containing gas to produce gas, the steps of carbonisation and of gas production are carried out in separate vessels, the solid material in both steps being maintained in the fluid state, without producing in the carbonisation step, an entrained stream, utilising, in the carbonisation step, the sensible heat of hot solid material withdrawn from the gas-producing step, the fluid bed in the carbonisation step being maintained by the passage through the solid material of gases collected from the said carbonisation step.

3. A process as claimed in Claim 1 or 2 in which the hot solid residue leaving the gas-producing step is mixed with the coal being fed to the carbonisation step.

4. A process as claimed in Claim 1, 2 or 3 in which in the carbonisation step oxygen or an oxygen-containing gas is added to the gases used for maintaining the fluid bed.

5. A process as claimed in any of Claims 1 to 4 in which the carbonisation step the solid material and the gas used to maintain it in the fluid state are in counter-current flow.

6. A process as claimed in any of Claims 1 to 5 in which in the gas production step the solid material and the gas used to maintain it in the fluid state are in co-current flow.

7. A process as claimed in any of Claims 1 to 6 in which in the gas production step, steam is added to the oxygen or oxygen-containing gas used to maintain the solid material in the fluid state.

8. A process as claimed in any of Claims 1 to 7 in which the coal in the carbonisation step is incompletely carbonised.

9. A process as claimed in any of Claims 1 to 8 in which the temperature of the solid material leaving the carbonisation step is lowered before feeding the said material to the gas-producing step.

10. A process as claimed in any of Claims 1 to 9 which comprises continuously feeding coal to the carbonisation step, continuously feeding carbonaceous material from the carbonisation step to the gas-producing step and continuously removing hot solid residual material from the gas-producing step.

11. A process as claimed in Claim 10 in which hot solid residual material from the gas-producing step is continuously fed to the carbonisation step.

12. A process for the production of producer gas substantially as described in the foregoing Example.

13. Producer gas whenever produced by the process claimed in any of Claims 1 to 12.

Dated the 1st day of June, 1945.
J. W. RIDSDALE,
Solicitor for the Applicants.