A ceramic heat exchanger 3 is provided for heat-exchanging of a gasification gas (600-900°C) containing tar and produced in a gasification furnace 1 with a reformed gasification gas (1100-1500°C) from a reforming furnace 2 for temperature raising before introduction of the gasification gas into the reforming furnace.
FIG. 1

GAS REFINEMENT REFORMING FURNACE

GASIFICATION GAS

GASIFICATION FURNACE

GASIFICATION AGENT (WATER VAPOR, AIR, OXYGEN OR THE LIKE)

OXYGEN OR AIR

FUEL

600 ~ 900°C

1

2

REFORMING FURNACE

1100 ~ 1500°C

GAS REFINEMENT
FIG. 4

[Graph showing comparison of oxygen input/gasification gas (dry) and outlet temperature of reforming furnace]
METHOD AND APPARATUS FOR
REFORMING TAR IN GASIFICATION
EQUIPMENT

TECHNICAL FIELD

[0001] The present invention relates to a method and an apparatus for reforming tar in a gasification equipment.

BACKGROUND ART

[0002] Conventionally, a fuel gasification equipment for production of a gasification gas has been developed, using solid fuel such as coal, biomass, waste plastic or various wet wastes as fuel.

[0003] In general, when the solid fuel is gasified at low temperature (600-900°C) in a gasification furnace, a resultant gasification gas contains tar. Since the tar contained is condensed into mist as the gasification gas is lowered in temperature, utilization of the gasification gas as, for example, a raw material for chemical synthesis may cause problems such as pipe clogging and other troubles in devices due to tar and poisoning of synthetic catalysts due to adherence of tar in a downstream refinery or chemical synthesis process.

[0004] Tar reforming at high temperature is a conventional technique for removal of the tar component in the gasification gas. In this technique, as shown in FIG. 1, fuel is gasified with a gasification agent (water vapor, air, oxygen or the like) in a gasification furnace 1 to produce a gasification gas which is introduced into a reforming furnace 2 where the gasification gas is burned by addition of oxygen or air for temperature raising into about 1100-1500°C, while the tar component is reformed by oxidation or water vapor reforming.

[0005] A general technical level pertinent is disclosed, for example, in Patent Literature 1 where a fuel gas containing a tar component is raised in temperature, using a heat storage body and a combustion assist gas, into a high temperature of 1100°C or more to thermally decompose and remove the tar component.

Patent Literature 1: JP 2005-60533A

SUMMARY OF INVENTION

Technical Problems

[0006] However, such reforming of the tar component with the temperature raising to about 1100-1500°C by combustion of the gasification gas in the reforming furnace 2 with addition of oxygen or air necessitates the combustion of the gasification gas in large quantity for temperature raising up to the reaction temperature, with a disadvantageous result that the gasification gas to be provided as a product has a substantially lowered calorific value.

[0007] The invention was made in view of the above and has its object to provide a method and an apparatus for reforming tar in a gasification equipment capable of reforming tar by temperature raising of a gasification gas by means of very small oxygen and combustion amounts while minimizing the lowering of calorific value in the gasification gas, capable of preventing troubles in downstream devices due to tar and also capable of achieving heat recovery of the gasification gas at a low temperature by a metallic heat exchanger, leading to effective utilization of the thermal energy without waste.

Solution to Problems

[0008] The invention is directed to a method for reforming tar in a gasification equipment wherein fuel is gasified with a gasification agent in a gasification furnace to produce a gasification gas, said gasification gas being introduced into a reforming furnace where a tar component in the gasification gas is reformed.

[0009] characterized in that the gasification gas containing tar and produced in the gasification furnace is heat-exchanged in a ceramic heat exchanger with a reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace.

[0010] As in the method for reforming tar in the gasification equipment according to the invention, when the gasification gas containing tar and produced in the gasification furnace is heat-exchanged in the ceramic heat exchanger with the reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace, the combustion of the gasification gas in large quantity becomes unnecessary for temperature raising to the reaction temperature for reforming of the tar component; oxygen input to the reforming furnace may be suppressed; substantial lowering of a calorific value in the gasification gas to be provided as a product may be prevented; troubles in downstream devices due to tar may be prevented; and heat recovery of the gasification gas at a low temperature may be achieved with a metallic heat exchanger, leading to reduction of waste of thermal energy.

[0011] In the method for reforming tar in the gasification equipment, it is preferable that a portion of fuel to be supplied to the gasification furnace is burned in a combustion furnace to supply a resultant exhaust combustion gas to a ceramic tube disposed in the reforming furnace for temperature raising of the gasification gas in the reforming furnace to thereby reform a tar component in the gasification gas, which brings about the reforming of the tar component without the combustion of the gasification gas at all and prevents dilution of the gasification gas with the exhaust combustion gas.

[0012] In the method for reforming tar in the gasification equipment, it is preferable that air for said combustion furnace is heat-exchanged in metallic and ceramic heat exchangers with the exhaust combustion gas from the ceramic tube in said reforming furnace for temperature raising of the air before introduction thereof into the combustion furnace and for temperature lowering of the exhaust combustion gas from the ceramic tube before discharge thereof, which further enhances the efficiency.

[0013] The invention is also directed to an apparatus for reforming tar in a gasification equipment wherein fuel is gasified with a gasification agent in a gasification furnace to produce a gasification gas, said gasification gas being introduced into a reforming furnace to reform a tar component in the gasification gas,

[0014] characterized by comprising a ceramic heat exchanger for heat-exchanging the gasification gas containing tar and produced in the gasification furnace with a reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace.
As in the apparatus for reforming tar in the gasification equipment according to the invention, when it comprises the ceramic heat exchanger for heat-exchanging the gasification gas containing tar and produced in the gasification furnace with the reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace, the combustion of the gasification gas in large quantity becomes unnecessary for temperature raising to the reaction temperature for reforming of the tar component; oxygen input to the reforming furnace may be suppressed; substantial lowering of a calorific value in the gasification gas to be provided as a product may be prevented; troubles in downstream devices due to tar may be prevented; and heat recovery of the gasification gas at a low temperature may be achieved with a metallic heat exchanger, leading to reduction of waste of thermal energy.

In the apparatus for reforming tar in the gasification equipment, it is preferable that it further comprises a combustion furnace for burning a portion of fuel to be supplied to said gasification furnace, and a ceramic tube disposed in said reforming furnace and supplied with exhaust combustion gas from the combustion furnace for temperature raising of the gasification gas in the reforming furnace to thereby reform a tar component in the gasification gas, which brings about the reformation of the tar component without the combustion of the gasification gas at all and prevents dilution of the gasification gas with the exhaust combustion gas.

In the apparatus for reforming tar in the gasification equipment, preferably it further comprises metallic and ceramic heat exchangers for heat-exchanging air for the combustion furnace with the exhaust combustion gas from the ceramic tube before introduction of said air into the combustion furnace and for temperature lowering of the exhaust combustion gas before discharge thereof, which further enhances the efficiency.

Advantageous Effects of Invention

According to a method and an apparatus for reforming tar in a gasification equipment of the invention, tar can be reformed by temperature raising of a gasification gas by means of very small oxygen and combustion amounts while minimizing the lowering of a calorific value in the gasification gas; troubles in downstream devices due to tar can be prevented; heat recovery of the gasification gas at a low temperature can be also achieved with a metallic heat exchanger, leading to effective utilization of the thermal energy without waste.

In the method for reforming tar in the gasification equipment of the invention, a portion of fuel to be supplied to the gasification furnace may be burned in a combustion furnace to supply a resultant exhaust combustion gas to a ceramic tube disposed in the reforming furnace for temperature raising of the gasification gas in the reforming furnace to thereby reform a tar component in the gasification gas, which brings about the reformation of the tar component without the combustion of the gasification gas at all and prevents dilution of the gasification gas with the exhaust combustion gas. In the apparatus for reforming tar in the gasification equipment of the invention, provision of the ceramic tube supplied with exhaust combustion gas from the combustion furnace for temperature raising of the gasification gas in the reforming furnace to thereby reform the tar component in the gasification gas can bring about temperature raising of the gasification gas without the combustion of the gasification gas at all and without dilution of the gasification gas with the exhaust combustion gas to reform the tar while further reliably suppressing the lowering of a calorific value of the gasification gas.

Furthermore, in the method for reforming tar in the gasification equipment of the invention, heat-exchange of the air for the combustion furnace in metallic and ceramic heat exchangers with the exhaust combustion gas from the ceramic tube in the reforming furnace can bring about temperature raising of the air before introduction thereof into the combustion furnace and temperature lowering of the exhaust combustion gas before discharge thereof, which further enhances the efficiency. In the apparatus for reforming tar in the gasification equipment of the invention, provision of metallic and ceramic heat exchangers for heat-exchange of the air for the combustion furnace with the exhaust combustion gas from the ceramic tube in the reforming furnace can bring about temperature raising of the air before introduction thereof into the combustion furnace and temperature lowering of the exhaust combustion gas before discharge thereof, which further enhances the efficiency.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic general configuration showing a conventional example;
FIG. 2 is a schematic general configuration showing an embodiment of the invention;
FIG. 3 is a schematic section showing a ceramic heat exchanger in the embodiment of the invention;
FIG. 4 is a comparison diagram on a relationship between a ratio of oxygen input to a gasification gas and an outlet temperature of a reforming furnace, with and without a ceramic heat exchanger (invention and the prior art, respectively); and
FIG. 5 is a schematic general configuration showing a further embodiment of the invention.

REFERENCE SIGNS LIST

1 gasification furnace
2 reforming furnace
3 ceramic heat exchanger
3a shell
3b ceramic tube
3c baffle plate
4 combustion furnace
5 ceramic tube
6 metallic heat exchanger
7 ceramic heat exchanger

DESCRIPTION OF EMBODIMENTS

Embodiments of the invention will be described with reference to the drawings.

FIG. 2 shows an embodiment of the invention; in the figure, parts similar to those in FIG. 1 are represented by the same reference numerals. Although its basic configuration is the same as the conventional configuration shown in FIG. 1, the embodiment is characteristic in, as shown in FIG. 2, provision of a ceramic heat exchanger 3 for heat exchange of a gasification gas (600-900° C.) containing tar and produced in a gasification furnace 1 with a reformed gasification gas.
(1100-1500°C.) from a reforming furnace 2 for temperature raising of the gasification gas before introduction thereof into the reforming furnace 2.

[0031] The ceramic heat exchanger 3 is a so-called shell and tube heat exchanger as shown in FIG. 3 constituted by a number of ceramic tubes 36 arranged in a shell 3 together with baffle plates 3c. The gasification gas containing tar and produced in the gasification furnace (see FIG. 2) is passed through the shell 3c while the reforming gasification gas from the reforming furnace 2 (see FIG. 2) is passed through the ceramic tubes 36, so that the gasification gas is raised in temperature before introduction thereof into the reforming furnace 2 while the reforming gasification gas from the reforming furnace 2 is lowered in temperature (700-1000°C.) before supply to a downstream refinery or chemical synthesis process. This can achieve a heat transfer efficiency as high as about 80%.

[0032] The operation of the embodiment will be described.

[0033] Fuel is gasified with a gasification agent in the gasification furnace 1 to produce the gasification gas containing tar which is heat-exchanged in the ceramic heat exchanger 3 with the reforming gasification gas from the reforming furnace 2 for temperature raising of the gasification gas before introduction thereof into the reforming furnace 2.

[0034] In the reforming furnace 2, the gasification gas is mixed with oxygen (or air) and is partly burned while oxidation or water vapor reforming reaction of the tar component proceeds.

[0035] The reforming gasification gas discharged from the reforming furnace 2 is led again to the ceramic heat exchanger 3 where the reforming gasification gas is heat-exchanged with the gasification gas containing tar and produced in the gasification furnace 1 for temperature lowering of the reforming gasification gas before introduction thereof into the downstream refinery or chemical synthesis process.

[0036] As a result, the combustion of the gasification gas in a large quantity becomes unnecessary for temperature raising to the reaction temperature for the reforming of the tar component; oxygen input into the reforming furnace may be suppressed; substantial lowering of a calorific value of the gasification gas to be provided as a product may be prevented; troubles in downstream devices due to tar may be prevented; and heat recovery of the gasification gas at a low temperature may be achieved with a metallic heat exchanger (which may be incorporated in a line leading to the downstream refinery or chemical synthesis process although not particularly illustrated), which reduces the waste of thermal energy. Since the reforming furnace 2 may be controlled in temperature by changing the amount of oxygen, the temperature control is easily performed.

[0037] FIG. 4 is a comparison diagram of relationship between a ratio of oxygen input to gasification gas and an outlet temperature of the reforming furnace 2 with and without the ceramic heat exchanger 3 (the invention and the prior art, respectively). As apparent from FIG. 3, in the prior art without the ceramic heat exchanger 3, oxygen corresponding to about 20% of the gasification gas was required for raising the outlet temperature of the reforming furnace 2 to 1200°C whereas it was confirmed in the embodiment of the invention with the ceramic heat exchanger 3 that the oxygen input amount may be reduced to half, i.e., about 10%.

[0038] Thus, the gasification gas may be raised in temperature with very small oxygen and combustion amounts to reform tar while minimizing the lowering of a calorific value of the gasification gas; troubles due to tar may be prevented in downstream devices; and heat recovery of the gasification gas at a low temperature may be achieved with a metallic heat exchanger, leading to effective utilization of the thermal energy without waste.

[0039] FIG. 5 shows a further embodiment of the invention; in the figure, parts similar to those in FIG. 2 are represented by the same reference numerals. Although its basic configuration is the same as that shown in FIG. 2, this embodiment is characterized, as shown in FIG. 5, by provision of a combustion furnace 4 which burns a portion of fuel to be supplied to the gasification furnace 1.

[0040] a ceramic tube 5 disposed in the reforming furnace 2 and supplied with exhaust combustion gas from the combustion furnace 4 for temperature raising of the gasification gas in the reforming furnace 2 to thereby reform the tar component in the gasification gas, and

[0041] a metallic heat exchanger 6 (a lower temperature range of 800-900°C. or less) and a ceramic heat exchanger (a higher temperature range of 800-900°C. or more) which heat-exchange air for the combustion furnace 4 with the exhaust combustion gas from the ceramic tube in the reforming furnace 2 for temperature raising of the air before introduction thereof into the combustion furnace 4 and for temperature lowering of the exhaust combustion gas before discharge thereof.

[0042] In the embodiment shown in FIG. 5, fuel is gasified with a gasification agent in the gasification furnace 1 to produce a gasification gas containing tar which is heat-exchanged in the ceramic heat exchanger 3 with the reforming gasification gas from the reforming furnace 2 for temperature raising of the gasification gas before introduction thereof into the reforming furnace 2 while air passing through the metallic and ceramic heat exchangers 6 and 7 and raised in temperature is led to the combustion furnace 4, and a portion of fuel to be supplied to the gasification furnace 1 is burned in the combustion furnace 4 to supply the exhaust combustion gas to the ceramic tube 5 in the reforming furnace 2.

[0043] Thus, in the reforming furnace 2, the gasification gas may be raised in temperature by the heat of the exhaust combustion gas from the combustion furnace 4 to the ceramic tube 5 without the combustion of the gasification gas at all and without dilution of the gasification gas with the exhaust combustion gas to thereby reform the tar component in the gasification gas. The reforming gasification gas discharged from the reforming furnace 2 is then led again to the ceramic heat exchanger 3 where the reforming gasification gas is heat-exchanged with the gasification gas containing tar and produced in the gasification furnace 1 for temperature lowering of the reforming gasification gas before introduction thereof into a downstream refinery or chemical synthesis process while the exhaust combustion gas discharged from the ceramic tube 5 in the reforming furnace 2 sequentially passes through the ceramic and metallic heat exchangers 7 and 6 and is heat-exchanged with the air for the combustion furnace 4 for temperature lowering of the exhaust combustion gas before discharge thereof.

[0044] As a result, in the embodiment shown in FIG. 5, the temperature of the gasification gas can be raised to the reaction temperature for reforming of the tar component without the combustion of the gasification gas at all and without dilution of the gasification gas with the exhaust combustion gas; oxygen (or air) may not be input to the reforming furnace; substantial lowering of a calorific value in the gasifica-
tion gas to be provided as a product may be prevented; troubles in downstream devices due to tar may be prevented; and heat recovery of the gasification gas at a low temperature may be achieved with the metallic heat exchanger (which may be incorporated in a line leading to the downstream refinery or chemical synthesis process although not particularly illustrated), which reduces the waste of thermal energy. Since the temperature of the reforming furnace 2 may be controlled by changing amounts of fuel and air supplied to the combustion furnace 4, the temperature control is easily performed.

[0045] Thus, in the embodiment shown in FIG. 5, the tar reforming can be made by raising in temperature the gasification gas without the combustion of the gasification gas at all and without dilution of the gasification gas with the exhaust combustion gas to thereby more reliably suppress the lowering of a calorific value in the gasification gas; troubles in downstream devices due to tar may be prevented; heat recovery of the gasification gas at a low temperature may be achieved with the metallic heat exchanger 6, leading to effective utilization of the thermal energy without waste.

[0046] It is to be understood that a method and an apparatus for reforming tar in a gasification equipment of the invention are not limited to the above embodiments and that various changes and modifications may be made within the scope of the invention.

1. A method for reforming tar in a gasification equipment wherein fuel is gasified with a gasification agent in a gasification furnace to produce a gasification gas, said gasification gas being introduced into a reforming furnace where a tar component in the gasification gas is reformed, characterized in that the gasification gas containing tar and produced in the gasification furnace is heat-exchanged in a ceramic heat exchanger with a reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace.

2. A method for reforming tar in a gasification equipment as claimed in claim 1, wherein a portion of fuel to be supplied to the gasification furnace is burned in a combustion furnace to supply a resultant exhaust combustion gas to a ceramic tube disposed in the reforming furnace for temperature raising of the gasification gas in the reforming furnace to thereby reform a tar component in the gasification gas.

3. A method for reforming tar in a gasification equipment as claimed in claim 2, wherein air for said combustion furnace is heat-exchanged in metallic and ceramic heat exchangers with the exhaust combustion gas from the ceramic tube in said reforming furnace for temperature raising of the air before introduction thereof into the combustion furnace and for temperature lowering of the exhaust combustion gas from the ceramic tube before discharge thereof.

4. An apparatus for reforming tar in a gasification equipment wherein fuel is gasified with a gasification agent in a gasification furnace to produce a gasification gas, said gasification gas being introduced into a reforming furnace to reform a tar component in the gasification gas, characterized by comprising a ceramic heat exchanger for heat-exchanging the gasification gas containing tar and produced in the gasification furnace with a reformed gasification gas from the reforming furnace for temperature raising of said gasification gas before introduction thereof into the reforming furnace.

5. An apparatus for reforming tar in a gasification equipment as claimed in claim 4, further comprising a combustion furnace for burning a portion of fuel to be supplied to said gasification furnace, and a ceramic tube disposed in said reforming furnace and supplied with exhaust combustion gas from said combustion furnace for temperature raising of the gasification gas in said reforming furnace to thereby reform a tar component in the gasification gas.

6. An apparatus for reforming tar in a gasification equipment as claimed in claim 5, further comprising metallic and ceramic heat exchangers for heat-exchanging air for said combustion furnace with the exhaust combustion gas from the ceramic tube before introduction of said air into said combustion furnace and for temperature lowering of the exhaust combustion gas before discharge thereof.

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