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(54) METHOD OF DETECTING PRESSURE DIFFERENCES IN AN APPARATUS FOR THE PREPARATION AND COOLING OF SYNTHESIS GAS

(71) We, SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V. formerly SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ N.V., a company organised under the laws of The Netherlands, of 30 Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention is concerned with a method for the automatic watching of an apparatus for the preparation and cooling of a gas mixture comprising hydrogen and carbon monoxide.

In industrial processes for the preparation of gaseous compounds from hydrocarbons, the hot product gas obtained is as a rule cooled. To this end use may be made of a waste-heat boiler. The coolant used vaporizes and generally the conditions are so selected that the vaporized coolant has a superatmospheric pressure. This is especially the case in the production of a synthesis gas by partial combustion of hydrocarbons with oxygen or with oxygen-enriched air, with the optional supply of steam. The partial combustion is effected in a reactor, and the gas mixture leaving the reactor contains soot in the form of solid particles and has a temperature of 1300°C-1500°C, and a superatmospheric pressure. This gas mixture is subsequently indirectly cooled in a waste-heat boiler. A waste-heat boiler particularly suited to this purpose comprises one or more helically wound tubes for passing-through the gases to be cooled, in which waste-heat boiler water is used as a coolant, flowing around the said tubes. The final temperature of the synthesis gas is as a rule 260°C-340°C, at which temperature steam is formed which may have a pressure of 50-150 atm. The steam pressure is generally higher than the gas pressure in the helically wound tubes and if the existing pressure difference exceeds the permissible pressure difference for which the waste-heat boiler is designed, the helical tubes might fail.

The invention provides for the watching of the excess pressure of the steam in relation to the gas pressure. Too high an excess pressure may arise if the steam-pressure control is not functioning properly or if the gas pressure fails owing to defects in the reactor or owing to defects in the lines for the cooled gas mixture. The watching system comprises means for reducing the steam pressure if the said superatmospheric pressure rises excessively.

The present invention provides a method for the automatic watching of an apparatus for the preparation and cooling of a gas mixture comprising hydrogen and carbon monoxide, which apparatus comprises a reactor for the partial combustion of hydrocarbons with oxygen or with oxygen-enriched air, with the optional supply of steam, at superatmospheric pressure, and a waste-heat boiler having one or more helically wound tubes which, in operation, the gas mixture passes through and water flows around, in which method the excess pressure of the steam in the waste-heat boiler is measured in respect of the gas mixture, or an excess presure varying proportionally therewith, both before and after the cooling of the said gas mixture, with the aid of means for measuring a pressure difference which give a signal, from which means the signals are supplied to threshold-value detectors set at a predetermined value corresponding with a maximum permissable value for the excess steam pressure and which threshold-value detectors give a signal to open or open wider a steam outlet.

The method according to the invention ensures that the steam pressure is immedi-

ately reduced to a pressure lower than that at which the permissible excess pressure is exceeded, both in the event of the gas pressure failing owing to a defect in the combustion or owing to a defect in the oxygen or hydrocarbon supply, and in the case of the gas pressure failing, for example, owing to leakage in the lines for the cooled gases. At the same time it is ensured that the steam pressure is reduced to below this value if the steam pressure rises to above the value at which the permissible excess pressure is exceeded.

If the apparatus for the preparation and cooling of a gas mixture is provided with means with the aid of which the supply of oxygen and/or hydrocarbons to the burner part of the reactor can be interrupted in emergencies, the signal of the threshold-value detectors may also be used for operating these means, so that in the event of the permissible excess pressure of the steam with respect to the gas pressure being exceeded, both the steam outlet is opened and the supply of oxygen and hydrocarbons to the burner part of the reactor is interrupted.

To measure the pressure of the gas mixture prior to cooling it, pressure-measuring means may be placed in the reactor or in the gas outlet of the reactor. Although this is feasible, these locations of the measuring means are not preferred because in that case extremely high temperatures have to be allowed for and the gas mixture contains soot which might deposit on the measuring means. It is, therefore, more preferred to measure a pressure which varies proportionally with the gas pressure, namely the pressure of the oxygen or the oxygen-enriched air which is supplied to the burner part of the reactor.

The pressure of the gas mixture may be measured at the gas outlet side of the waste-heat boiler. Preferably, however, the pressure of the cooled gas mixture is measured after soot has been at least substantially removed with the aid of means for removing soot from the cooled gas mixture, which pressure of the purified gas mixture varies proportionally with the pressure on the gas outlet side of the waste-heat boiler.

The invention also relates to an apparatus suitable for use in the above-defined method, which apparatus comprises a reactor for the partial combustion of hydrocarbons with oxygen or with oxygen-enriched air, with the optional supply of steam, at superatmospheric pressure, and a waste-heat boiler with one or more helically wound tubes which, in operation, the gas mixture which apparatus also comprises means for measuring the excess pressure of the steam in the waste-heat boiler in respect of the pressure of the gas mixture both before and after its cooling, or an excess pressure varying proportionally therewith, and also threshold-value detectors, which means for measuring the excess pressure are connected to the said threshold-value detectors, which are connected to means for regulating the steam pressure in the waste-heat boiler.

The invention will now be further elucidated with reference to the diagram, which represents a preferred embodiment of the invention.

With reference to the drawing, 1 is a reactor for the partial combustion of hydrocarbons with oxygen or with oxygen-enriched air. This reactor also comprises a burner part 2. Hydrocarbons are supplied to the burner part through a line 4. Oxygen or oxygen-enriched air is supplied through a line 3 and steam may be optionally supplied through the line 3 or the line 4. The gas mixture obtained, at superatmospheric pressure, for example, a pressure of 5-80 atm., and a temperature of 1300°C-1500°C, is passed through the connection 5 into the waste-heat boiler 6, which comprises one or more helical tubes (not shown). Cooling water is supplied through a line 26 and flows around the helical tubes, resulting in the formation of steam which is withdrawn through a line 7. The steam pressure is set at a selected value between 50 and 150 atm. by means of a control valve 18 in the line 28. The cooled gas mixture containing soot, at a temperature of 260°C-340°C, leaves the waste-heat boiler through a line 8 and, together with water supplied through a line 9, is passed through a line 10 into a scrubber 11. Water which contains soot is withdrawn through a line 12. The gas which is at least substantially free from soot is supplied through a line 13 to a scrubbing tower 14 and scrubbed with water, removing any soot still present, as well as a portion of the water-soluble components of the gas mixture, such as hydrogen sulphide and ammonia, originating from sulphur and nitrogen in the reactor feed. Water is supplied to the scrubbing tower through a line 15. If desired, the scrubbing water withdrawn through a line 16 may be recycled at least in part to the line 15. The scrubbed gas leaves the scrubbing tower through a line 17 which has a control valve 19. The measuring instrument 21 measures the pressure difference between the pressure existing at a point of measuring 27 in the line 7 and at a point of measuring 24 in the line 3 and gives a signal indicating the magnitude of the pressure difference measured, which signal is supplied to an instrument 23 comprising threshold-value detectors set at a value corresponding with the permissible value

of the excess pressure of the steam in the waste-heat boiler. If this permissible value is exceeded, the instrument 23 gives a signal to open the steam outlet 20 of a steam-discharge line 29. A measuring instrument 22 measures the pressure difference between the pressure existing at the point of measuring 27 in the line 7 and at a point of measuring 25 in the line 17 and gives a signal indicating the magnitude of the pressure difference measured to the above-mentioned instrument 23 and if the permissible value for the pressure difference is exceeded, a signal is given to open the steam outlet 20.

If desired, the point of measuring 25 may be located in the line 13 instead of in the line 17, since the soot content of the gases in the line 13 is very low and has no adverse effect.

The principle of the method according to the invention may be used in any apparatus in which a gas mixture is formed which is subsequently indirectly cooled and where it is desired to watch the pressure difference between coolant and gas mixture.

WHAT WE CLAIM IS:—

1. Method for the automatic watching of an apparatus for the preparation and cooling of a gas mixture comprising hydrogen and carbon monoxide, which apparatus comprises a reactor for the partial combustion of hydrocarbons with oxygen or with oxygen-enriched air, with the optional supply of steam, at superatmospheric pressure, and a waste-heat boiler having one or more helically wound tubes which, in operation, the gas mixture passes through and water flows around, in which method the excess pressure of the steam in the waste-heat boiler is measured in respect of the gas mixture, or an excess pressure varying proportionally therewith, both before and after the cooling of the said gas mixture, with the aid of means for measuring a pressure difference which give a signal, from which means the signals are supplied to threshold-value detectors set at a predetermined value corresponding with a maximum permissible value for the excess steam presure and which threshold-value detectors give a signal to open or open wider a steam outlet.

2. Method as claimed in claim 1, in which the threshold-value detector also give a signal to interrupt the supply of the oxygen or oxygen-enriched air and/or the supply of the hydrocarbons.

3. Method as claimed in claim 1 or 2, in which the excess pressure of the steam is measured in respect of a pressure proportional to that of the non-cooled gas mixture by comparison of the steam pressure with the pressure at which the oxygen or the oxygen-enriched air is supplied to the reactor.

4. Method as claimed in any one of claims 1-3, in which the apparatus also comprises means for removing soot from the cooled gas mixture, and in which the excess presure of the steam is measured in respect of the pressure of the cooled gas mixture after this has been substantially freed from soot.

5. Method as claimed in claim 1, substantially as hereinbefore described with special reference to the drawing.

6. Apparatus suitable for the use in a method as claimed in claim 1, which apparatus comprises a reactor for the partial combustion of hydrocarbons with oxygen or with oxygen-enriched air, with the optional supply of steam, at superatmospheric pressure, and a waste-heat boiler with one or more helically wound tubes which, in operation, the gas mixture passes through and water flows around, which apparatus also comprises means for measuring the excess steam pressure in the waste-heat boiler in respect of the pressure of the gas mixture both before and after its cooling, or an excess pressure varying proportionally therewith, and also threshold-value detectors, which means for measuring the excess pressure are connected to the said threshold-value detectors, which are connected to means for regulating the steam pressure in the waste-heat boiler.

7. Apparatus as claimed in claim 6, in which the threshold-value detectors are also connected to means for interrupting the oxygen or oxygen-enriched air and/or to means for shutting the hydrocarbons.

8. Apparatus as claimed in claim 6 or 7, which also comprises means for the removal of soot from the cooled gas mixture and means for measuring the pressure of the oxygen or oxygen-enriched air supplied to the reactor, and means for measuring the pressure of the cooled gas mixture at least substantially freed from soot.

9. Apparatus as claimed in claim 6, substantially as hereinbefore described with special reference to the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*