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10 **Process and Plant for the Production of Synthesis Gas by means of
 Catalytic Steam Reformation of a Hydrocarbonaceous Feed Gas**

Field of the Invention

15 The invention relates to a process for producing a synthesis gas chiefly consisting
 of hydrogen and carbon monoxide by catalytic steam reformation of a
 hydrocarbonaceous feed gas, wherein the heat of burners required for the
 chemical reforming reactions to take place is generated by producing a flue gas,
 and wherein, by utilizing the heat contained in the synthesis gas and in the flue
20 gas, a pure steam is generated from boiler feed water and a process steam is
 generated from process condensate.

The invention furthermore relates to a plant for carrying out this process.

25 **Prior art**

 Such processes and plants are known. The underlying process for the catalytic
 steam reformation of a hydrocarbonaceous feed gas is described for example in
 Ullmann's Encyclopedia of Industrial Chemistry, Sixth Edition, Vol. 15, Gas
 Production, Chapter 2. The feed gases, a hydrocarbonaceous gas, such as e.g.
30 natural gas and steam, are passed through externally heated reactor tubes filled
 with catalyst at elevated pressure, e.g. at 20 to 35 bar, and high temperature, e.g.
 800 to 950 °C. The feed gases are converted into synthesis gas rich in hydrogen

and carbon monoxide. Such tubular reactor frequently is referred to as SMR, and the process is referred to as SMR process, an abbreviation for Steam-Methane-Reformer. For the separation of the hydrogen fraction from the synthesis gas the pressure swing adsorption process frequently is employed, which is described in chapter 5.5.3 of the same Ullmann volume.

For the economy of the process it is very important to use the heating energy expended for heating the feed gases and for carrying out the, in total, endothermal reforming reactions as far as possible for steam generation. The steam used together with the hydrocarbonaceous feed gas is referred to as process steam. It is obtained by re-evaporating the condensate formed and deposited from the synthesis gas upon cooling thereof. The heat content of the synthesis gas and of the flue gas however exceeds the heat quantity required for generating the process steam. To make good use of this excess heat, the same is utilized for generating so-called export steam, which chiefly is used outside the SMR process. In order not to load the export steam with impurities from the SMR process, fresh boiler feed water is used for its generation. A part of the export steam is utilized to compensate elutriation losses during the generation of process steam.

The utilization of the heat contained in the synthesis gas and in the flue gas for steam generation in many cases is effected by carrying out an indirect heat exchange between these gases and the process condensate and the boiler feed water. The German patent DE 10 2010 044 939 B3 describes a process carried out in this way.

The object of the invention consists in providing a process and a plant in which the heat transfer from the synthesis gas and from the flue gas for generating the vapors is solved in an alternative way.

Description of the Invention

The object is solved by the process according to claim 1 and by a plant according to the invention with the features of claim 3.

5 Process according to the invention:

A process for producing a synthesis gas chiefly consisting of hydrogen and carbon monoxide by catalytic steam reformation of a hydrocarbonaceous feed gas, wherein the heat of burners required for the chemical reforming reactions to take place is generated by producing a flue gas and wherein, by utilizing the heat
10 contained in the synthesis gas and in the flue gas, a pure steam is generated from boiler feed water and a process steam is generated from process condensate, characterized in that for the generation of the pure steam synthesis gas and flue gas are used and for the generation of the process steam a part of the pure steam is used as heat-transfer medium and the remaining part of the pure steam is
15 discharged from the process as export steam.

A preferred aspect of the process is characterized in that the respective pressures of that part of the pure steam which is used as heat-transfer medium for the generation of process steam and that part which is discharged from the process
20 as export steam are adjusted independent of each other. A pressure for the export steam, which frequently is required by a consumer external to the process, amounts to 52 bar. However, this pressure is not optimal for the process-internal use of the steam as heat-transfer medium. This aspect provides for lowering the pressure for this internal use to e.g. 39 bar. By this decrease in pressure the
25 condensation enthalpy of the steam is increased by 5.8 %, which leads to a reduction of the amount of pure steam required for the generation of process steam. In addition, the parts used for the generation of process steam can be designed for this lower pressure and hence less expensive.

30 Plant according to the invention:

A plant for carrying out the process according to the invention, comprising:

- At least one tubular furnace for carrying out the catalytic steam reformation,

- A boiler for the thermal degasification of boiler feed water,
 - A steam boiler for the generation of pure steam from boiler feed water,
 - At least one heat exchanger each for heating and evaporating the boiler feed water by synthesis gas and by flue gas,
- 5 - At least one apparatus for the mechanical separation of condensate from the synthesis gas,
- A steam boiler for the generation of process steam, equipped with a heat exchanger suitable for the use of pure steam as heat-transfer medium.
- 10 A preferred aspect of the plant according to the invention is characterized in that separate control devices are present for adjusting and regulating the pressures of that part of the pure steam which is used as heat-transfer medium for the generation of process steam and of that part which is discharged from the process as export steam. By means of this equipment the steam pressure can be adjusted
- 15 separately to the requirements of the export steam consumer and also of the internal process steam generation.

Another preferred aspect of the plant according to the invention is characterized in that the steam boiler for the generation of process steam is equipped with an

20 internal plate heat exchanger. Plate heat exchangers provide so much heat exchanger surface relative to the outside dimensions of the heat exchanger that the heat exchanger can be integrated in the steam boiler and an external heat exchanger thus can be omitted. Due to this construction the space requirement for the plant sections of the process steam generation is reduced.

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Another preferred aspect of the plant according to the invention is characterized in that the plant sections getting in contact with process condensate and process steam are made of stainless steel. Due to this construction it is possible to leave impurities, such as CO and CO₂, in the process condensate, i.e. the environment

30 is not burdened by a degasification of the process condensate and these constituents are again supplied to the reforming process via the process steam.

Due to the use of stainless steel, the addition of chemicals for binding oxygen and for pH adjustment can be omitted.

5 Exemplary embodiment

Further features, advantages and possible applications of the invention can also be taken from the following description of an exemplary embodiment and numerical example as well as the drawing. All features described and/or illustrated form the subject-matter of the invention per se or in any combination,
10 independent of their inclusion in the claims or their back-reference.

The process according to the invention will be explained below with reference to Fig. 1 of the drawing, in which:

15 Fig. 1 shows a flow diagram of an exemplary embodiment of the plant according to the invention.

Fig. 1:

20 The flow diagram shows an exemplary embodiment of the plant 1 according to the invention, which in this example serves the production of hydrogen from a hydrocarbonaceous feed gas, such as e.g. natural gas and steam. There are only shown the parts of the plant or the process which are essential for an understanding of the invention.

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In the SMR reformer 2 designed as tubular furnace the feed gas consisting of natural gas 3 and process steam 4 is converted into synthesis gas 5 chiefly consisting of carbon monoxide and hydrogen. The SMR reformer 2 is heated by means of burners 6, of which only one is shown here, which are operated with air
30 7 and fuel gas 8, wherein a flue gas 9 is produced. To utilize the heat contained in the synthesis gas 5 and in the flue gas 9, the same are used as heat-transfer medium for heating the steam boiler 10, by means of the heat exchangers 10a

and 10b, and the synthesis gas 5 in addition is also used for heating the natural gas 3, by means of the heat exchanger 20, and of the degassing boiler 11, by means of the heat exchanger 11a. In the degassing boiler 11 boiler feed water 12 is thermally degassed, the expelled gas 21 is discharged from the plant. Via
5 conduit 13 the degassed and heated boiler feed water is passed into the steam boiler 10, in which it is evaporated to pure steam 14. A part of the pure steam 14 is discharged from the process or the plant as export steam 14a, the other part 14b is used as heating steam for heating the steam boiler 17 which is equipped with the internal plate heat exchanger 17a. The condensate obtained in the heat
10 exchanger 17a is recirculated into the degassing boiler 11 via conduit 22.

The pressures of the steams 14a and 14b each are adjusted by means of the valves 23a and 23b.

15 After the heat exchange with boiler feed water in the heat exchanger 10b, the flue gas 9 is discharged from the process for the further treatment.

In the condensate separator 15 aqueous condensate 16 formed in the synthesis gas is separated and introduced into steam boilers 17. It is evaporated there to
20 process steam 4 by means of the heat exchanger 17a, wherein a partial stream of the pure steam 14 is used as heating steam 14a, heat-transfer medium, and subsequently introduced into the degassing boiler 11. After the condensate separation, the synthesis gas 5 is treated in the pressure swing adsorption plant 18, wherein the hydrogen fraction 19 is separated from the synthesis gas and
25 discharged from the plant or from the process for the further treatment. The residual gas 8 remaining after the hydrogen separation is supplied to the burners 6 of the SMR reformer 2 as fuel gas 8.

Industrial Applicability

30 The invention provides an alternative process and an alternative plant for the production of synthesis gas by steam reformation of a hydrocarbonaceous gas. The system for the production of process steam was redesigned, whereby

energetic and constructive advantages are achieved. The invention therefore is industrially applicable.

List of Reference Numerals

- 1 plant according to the invention:
- 2 SMR reformer
- 3 natural gas stream
- 5 4 process steam
- 5 synthesis gas
- 6 burner
- 7 air for combustion
- 8 residual/fuel gas
- 10 9 flue gas
- 10 steam boiler for export steam, with heat exchangers 10a, b
- 11 degassing boiler with heat exchanger 11a
- 12 boiler feed water, fresh
- 13 boiler feed water, degassed
- 15 14 pure steam
- 14a export steam
- 14b heating steam
- 15 condensate separator
- 16 condensate
- 20 17 steam boiler for process steam, with heat exchanger 17a
- 18 pressure swing adsorption plant
- 19 hydrogen
- 20 heat exchanger
- 21 gas, expelled from boiler feed water
- 25 22 conduit for condensate recirculation
- 23 a, b valve for regulating the steam pressure

Claims:

1. A process for producing a synthesis gas chiefly consisting of hydrogen and carbon monoxide by catalytic steam reformation of a hydrocarbonaceous feed gas in at least one tubular furnace, wherein the catalytic steam reformation uses burners to provide heat for a catalytic reforming reaction, wherein the burners produce a flue gas, wherein the process comprises the steps of:
 - utilizing the heat from the synthesis gas and the flue gas to generate a pure steam from boiler feed water;
 - using a first portion of the pure steam for providing heat to process condensate to produce a process steam in a steam boiler equipped with a heat exchanger, wherein a second part of the pure steam is discharged from the process as export steam, and
 - adjusting a first pressure value for the first portion of the pure steam and a second pressure value for the second pure steam, wherein the first pressure value and the second pressure value are adjusted independent of each other.
2. A plant for carrying out the process according to claim 1, comprising:
 - At least one tubular furnace for carrying out the catalytic steam reformation,
 - A degassing boiler for the thermal degasification of boiler feed water,
 - A steam boiler for the generation of pure steam from boiler feed water,
 - At least one heat exchanger each for heating and evaporating the boiler feed water by synthesis gas and by flue gas,
 - At least one apparatus for the mechanical separation of condensate from the synthesis gas,
 - A steam boiler for the generation of process steam, equipped with a heat exchanger suitable for the use of pure steam as heat-transfer medium.
 - Separate control devices for adjusting and regulating the respective pressures of that part of the pure steam which is used as heat-transfer medium for the generation of process steam and of that part which is discharged from the process as export steam
3. The plant according to claim 2, characterized in that the steam boiler for the generation of process steam is equipped with an internal plate heat exchanger.
4. The plant according to any of claims 2 to 3, characterized in that the plant sections getting in contact with process condensate and process steam are made of stainless steel.