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NL-6812 AR Arnhem(NL)(54) **Steam and gas turbine power plant using moistened natural gas.**

(57) The invention relates to a steam and gas turbine installation for generating electricity and/or heat from natural gas, comprising:

- i) a combustion unit for combusting a mixture of moistened natural gas and air, and provided with a flue gas duct which ends in a chimney, to which flue gas duct are connected for heat exchanging:
- ii) a heating unit (6) for heating high pressure steam respectively medium pressure steam;
- iii) an evaporator unit (7) for forming high pres-

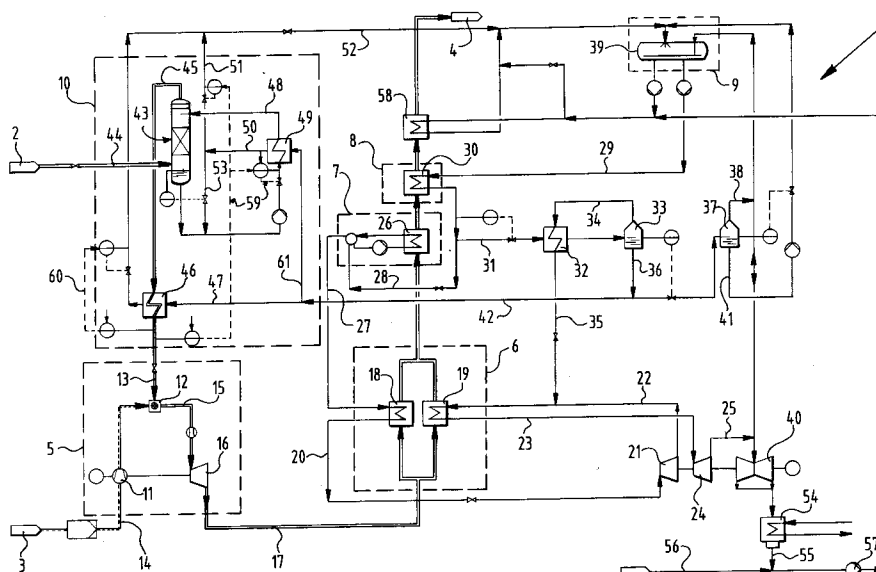
sure steam;

iv) an economizer unit;

v) a degassing unit (9) for degassing condensate;

vi) turbines for generating electricity with steam; and

vii) a moistening unit (10) for moistening natural gas for supplying to the combustion unit, wherein an independent steam unit for high pressure and/or low pressure steam is preferably present.

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The present invention relates to a STEG installation for generating electricity and/or heat using moistened natural gas.

The use of STEG installations for generating electricity and/or heat has increased greatly in recent years. However, the combustion of natural gas in a gas turbine of a STEG installation has an undesired effect, namely an NO_x emission which is approximately twice as high compared to the combustion of natural gas with atmospheric burners in conventional natural gas-fired boilers. The increase in the NO_x emission is the result of the higher flame temperature and the higher combustion pressure in the gas turbine.

The combusting of synthesis gas coming from coal gasifying installations in a KV-STEG installation, likewise leads to higher NO_x emissions, mainly as a result of the relatively high CO and H₂ content in the synthesis gas.

An important method of lowering the NO_x emission is lowering the flame temperature in the combustion chambers of the gas turbine.

Compared with a STEG installation, the amount of surplus heat in the economizer unit in the case of a KV-STEG installation is lower because more steam is generated in the evaporator unit. In a KV-STEG installation the residual heat from the economizer is thus used to heat the synthesis gas.

The present invention has for its object to improve the efficiency in a STEG installation, to lower the NO_x emission, but above all to enable provision of a much smaller installation relative to a KV-STEG installation.

It is moreover the object to realize a considerably simplified embodiment of the degasification boiler relative to a three-pressure STEG installation.

This is achieved according to the invention with a STEG installation for generating electricity and/or heat from natural gas, which comprises

- i) a combustion unit for combusting a mixture of moistened natural gas and air, and provided with a flue gas duct which ends in a chimney, to which flue gas duct are connected for heat exchanging;
- ii) a heating unit for heating high pressure steam, respectively medium pressure steam;
- iii) an evaporator unit for forming high pressure steam;
- iv) an economizer unit;
- v) a degassing unit for degassing condensate;
- vi) turbines for generating electricity with steam; and
- vii) a moistening unit for moistening natural gas to be supplied to the combustion unit.

Because for moistening the natural gas hot water is used with which only low pressure steam of for example approximately 3.5 bar could be generated, the improvement in efficiency is sub-

stantially equal to the work which can be obtained by the expansion of medium pressure steam of for instance about 20 bar to low pressure steam. With the STEG installation according to the invention the efficiency improvement amounts to approximately 1.5% point. When the water/natural gas ratio amounts to roughly 0.8, a lowering of the NO_x emission of 70% can be achieved with the application of conventional diffusion burners. Pre-mix burners that are difficult to adjust do not therefore have to be used in combination with the gas turbine. It is even possible to use gas turbines of older type with conventional burners, which combinations cannot attain the currently applicable values for NO_x emission.

According to a first embodiment the moistening water comes directly from the economizer unit.

For optimum control of the moistening of the natural gas at fluctuating loads of the STEG installation according to the invention, it is however recommended that the moistening unit comprises a recirculation circuit for moistening water. Supplementary water and extra heat can be added to this recirculation circuit, for which purpose the recirculation circuit preferably comprises a recirculation heat exchanger for the heat exchange with water coming from the economizer unit.

For optimal moistening of the natural gas it is further recommended that the moistening unit comprises a control unit for controlling the recirculation ratio in the recirculation circuit.

If a part of the water coming from the economizer unit is not used for heating of or inclusion in the recirculation circuit, the residual heat of the water can be used for heating the moistened natural gas for adding to the combustion unit. The natural gas is herein superheated, 10-40 °C, in order to avoid condensation in a gas pipe to the diffusion burner of the combustion unit.

It is further recommended that the moistening unit comprises a control unit for controlling the ratio between moistened natural gas and the water supply to the gas preheater, and that the moistening unit comprises a control unit for controlling the ratio of the recirculation flow and the water supplied to the recirculation heat exchanger.

The water coming from the economizer unit that is not supplied to the moistening unit according to the invention can still be used for generating low pressure steam. It is hereby recommended that the economizer unit is connected on the steam side to a degassing unit via a low pressure steam unit.

It will be apparent that the amount of heat which can be extracted from the flue gas by the economizer unit becomes greater as the ratio between the heat which is used for super- and reheating and the heat which is used for evaporation

becomes greater. This ratio becomes greater when an additional, independent heat source is present which produces steam for this purpose. Such a heat source is for example a refuse burning installation. The STEG installation according to the invention can therefore be employed to very great advantage in combination with such an additional, independent heat source.

Mentioned and other features of the STEG installation according to the invention will be elucidated hereinafter in the light of a schematic process description of a STEG installation according to the invention in which moistened natural gas is used, without the STEG installation according to the invention being deemed limited thereto. This process description is only given by way of example while reference is made to the annexed drawing.

In the drawing:

figure 1 shows a flow diagram of a STEG installation according to the invention.

Figure 1 shows a STEG installation 1 according to the invention in which natural gas 2 is combusted with air 3 with formation of flue gas 4 in addition to electricity and/or heat respectively generated with the turbines and/or extracted from the liquid or gas flows.

The STEG installation 1 comprises a combustion unit 5 for combusting a mixture of moistened natural gas and air.

On the flue gas side the combustion unit 5 connects onto a heating unit 6, an evaporator unit 7 and an economizer unit 8, to which feedwater is supplied from a degasser 9.

The STEG installation 1 according to the invention is characterized by a moistening unit 10 for moistening natural gas 2 for supplying to combustion unit 5. Finally, the STEG unit comprises a number of turbines for generating electricity with steam.

The combustion unit 5 comprises an inlet 14 for air which supplies the air via a compressor 11 to a diffusion burner 12 which is also provided with an inlet 13 for moistened natural gas coming from moistening unit 10.

An outlet 15 of burner 12 is connected to a gas turbine 16 which at full load produces flue gas with a temperature of 500 to 600 °C. The flue gas is discharged via a flue gas duct 17 to the heating unit 6.

The heating unit 6 comprises a superheater 18 and a reheater 19. In the superheater 18 high pressure steam is superheated to approximately 541 °C and fed via the pipe 20 to a steam turbine 21. The steam expands to medium pressure level and is fed via the pipe 22 to the re-heater 19, in which the medium pressure steam is reheated to approximately 541 °C and supplied via a pipe 23 to

a steam turbine 24 which delivers low pressure steam via a pipe 25.

The evaporator unit 7 comprises an evaporator 26 with which saturated steam is generated which is supplied to superheater 18 via a pipe 27. The feed pipe 28 of evaporator 26 is connected to the economizer unit 8 in which feedwater under high pressure coming from the degassing unit 9 supplied via the pipe 29 is pre-heated in an economizer 30 to several degrees under the evaporation temperature (for example 319 °C). This difference in temperature can be controlled by regulating the amount of feedwater supplied via the pipe 29. Surplus feedwater is fed via a pipe 31 and a heat exchanger 32 to an expansion tank 33. A top pipe 34 supplies medium pressure steam which is superheated in the heat exchanger 32 and fed via pipe 35 to pipe 22.

A bottom pipe 36 from the expansion tank 33 carries medium pressure feedwater with a temperature of about 240 °C. This feedwater can, if necessary, be used for generating low pressure steam in an expansion tank 37 and can be drained via a pipe 38 from where the low pressure steam can be supplied as desired to a degasser boiler 39 or to the steam turbine 40. A lower pipe 41 of the expansion tank 37 leads water for degassing to the degasser boiler 39.

According to the invention, however, the feedwater coming indirectly out of the economizer unit 8 is fed via a pipe 42 to the moistening unit 10.

The moistening unit 10 comprises a moistening column 43 with a natural gas inlet 44 on the bottom side. The moistened natural gas leaves the moistening column via the pipe 45 and is preheated in a gas pre-heater 46 which connects onto the inlet 13. In the gas pre-heater 46 the moistened natural gas is pre-heated with a portion of the water coming out of the economiser unit that is supplied via the pipe 42 and the branch pipe 47.

The moistening column 43 further comprises a circuit pipe 48 for water with which the natural gas 2 is moistened. The circuit pipe 48 comprises a heat exchanger 49 with which the water present in the circuit can be heated with water supplied from the economizer unit 8 via pipe 42 and pipe 61. The moistening water is for instance heated from a temperature of about 105 °C to a temperature of about 210 °C, wherein the economizer water cools from 240 °C to about 118 °C. The economizer water can be drained via pipe 50 and pipe 51 which debouches into a collection pipe 52 which is connected to the degasser boiler 39. From pipe 50 extra economizer water can be supplied to the circuit pipe 48 via the supplementary supply line 53. It is optionally possible to supply fresh water to the circuit pipe 48 via a non-shown supplementary supply line.

Finally, the STEG installation 1 according to the invention comprises a heat exchanger 54 which connects onto the turbine 40 and in which steam under vacuum is condensed. An outlet 55 is connected to a supplementary pipe 56 for demineralised water. This feedwater is brought to pressure with a pump 57 and, after pre-heating in a low pressure heat exchanger 58, supplied to the collection pipe 52.

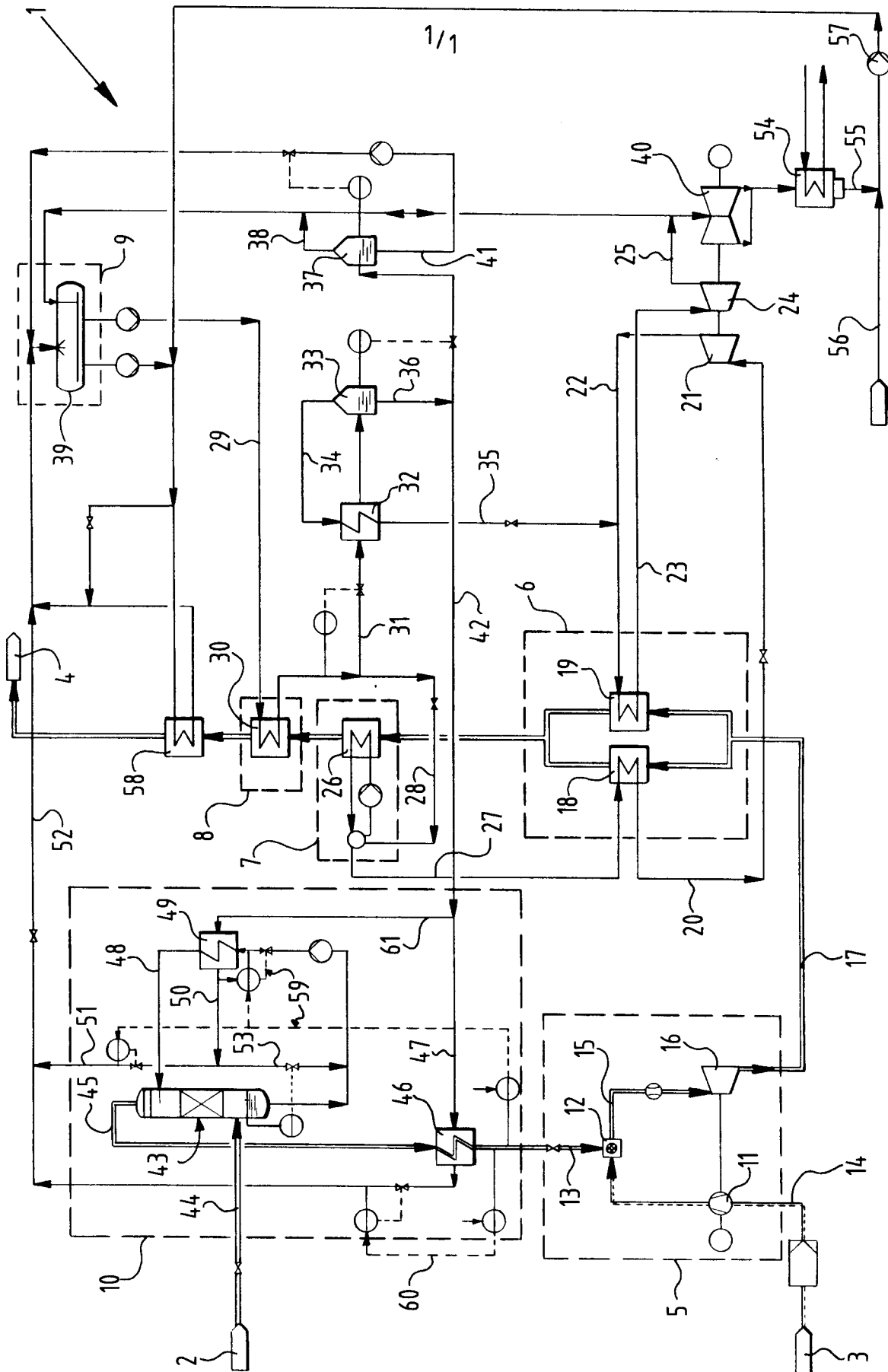
The moistening unit 10 comprises a control unit 59 with which the recirculation over the moistening column 43 can be varied so that the so-called Wobbe index can be held constant.

With the control unit 60 the ratio between the amount of hot water supplied to the gas pre-heater 46 and the amount of moistened natural gas can be kept constant. The ratio between the recirculation flow in the circuit pipe 48 and the amount of water supplied via the pipe 61 can also be regulated. This means that, subject to the optimal moistening of the natural gas, only a part of the lower circuit of the expansion tank 33 is supplied to expansion tank 37 for generating low pressure steam. Thus possible is optimal use of the hot water from the economizer unit 8 in the moistening unit 10 for moistening the natural gas. Obtained herewith is not only a considerable reduction in the NO_x emission but also an increase in efficiency of approximately 1.5% point.

Claims

1. STEG installation for generating electricity and/or heat from natural gas, comprising:
 - i) a combustion unit for combusting a mixture of moistened natural gas and air, and provided with a flue gas duct which ends in a chimney, to which flue gas duct are connected for heat exchanging;
 - ii) a heating unit for heating high pressure steam respectively medium pressure steam;
 - iii) an evaporator unit for forming high pressure steam;
 - iv) an economiser unit;
 - v) a degassing unit for degassing condensate;
 - vi) turbines for generating electricity with steam; and
 - vii) a moistening unit for moistening natural gas for supplying to the combustion unit.
2. Installation as claimed in claim 1, wherein the moistening water comes from the economizer unit.
3. Installation as claimed in claim 1 or 2, wherein the moistening unit comprises a recirculation circuit for moistening water.

4. Installation as claimed in claims 2 and 3, wherein the recirculation circuit comprises a recirculation heat exchanger for heat exchange with water coming from the economizer unit.
5. Installation as claimed in claim 3 or 4, wherein the moistening unit comprises a control unit for controlling the recirculation ratio in the recirculation circuit.
6. Installation as claimed in claims 1-5, wherein the moistening unit comprises a gas pre-heater for heat exchange with water coming from the economizer unit.
7. Installation as claimed in claim 6, wherein the moistening unit comprises a control unit for controlling the ratio between moistened natural gas and the water supply to the gas pre-heater.
8. Installation as claimed in claims 4-7, wherein the moistening unit comprises a control unit for controlling the ratio of the recirculation flow and the water supplied to the recirculation heat exchanger.
9. Installation as claimed in claims 1-8, wherein the economizer unit is connected on the steam side via a low pressure steam unit to a degasser unit.
10. Installation as claimed in claims 1-9, with an independent steam unit for high pressure and/or low pressure steam.





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EUROPEAN SEARCH REPORT

Application Number
EP 93 20 1893

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	DE-A-20 05 656 (METALLGESELLSCHAFT) * page 9, paragraph 2 * * page 11, line 19 - page 12, line 21; figures * ---	1-3	F01K21/04 F01K23/10
X	EP-A-0 086 504 (SHELL) * page 2, line 24 - line 25 * * page 5, line 7 - page 6, line 9; figures * ---	1-3	
A	EP-A-0 207 620 (IMPERIAL CHEMICAL) * page 3, line 7 - page 6, column 9; figures * ---	1-3	
A	EP-A-0 081 996 (MITSUBISHI GAS) * page 8, line 13 - line 23; figures * ---	1-3	
A	WO-A-83 01812 (GENERAL ELECTRIC) * page 5, line 11 - page 6, line 13; figure 1 * ---	1,9	
A	EP-A-0 036 998 (KRAFTWERK UNION) -----		TECHNICAL FIELDS SEARCHED (Int.Cl.5) F01K
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 23 December 1993	Examiner Van Gheel, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			