SUMMARY OF THE INVENTION

[0009] On the basis of comprehensive utilization of gasification of biomass at high temperature and high pressure and methanation in a circulating adiabatic fixed bed, the invention provides a method and system for cogenerating gas-steam. Meanwhile, the method can generate a large amount of superheated steam and substitute natural gas with high efficiency.

[0010] The technical scheme of the invention is that: a method for cogenerating gas-steam based on gasification and methanation of biomass comprises the following steps:

[0011] 1) biomass gasification: mixing oxygen and water vapor produced from an air separation plant with biomass, transporting a resulting mixture via a nozzle to a gasifier, gasifying the biomass at a temperature of 1,500-1,800°C and a pressure of 1-3 ~~mPa~~MPa to yield crude gasified gas, and transporting superheated steam having a pressure of 5-6 ~~mPa~~MPa resulting from sensible heat recovery to a steam turbine;

[0012] 2) shift and purification: according to demand for a methanation reaction, adjusting a hydrogen/carbon ratio of the crude gasified gas generated from step 1) to 3: 1 using a shift reaction, and eluting the crude gasified gas using low-temperature methanol for desulfurization and decarburization, whereby yield purified syngas;

primary methanation reactor via a recycle compressor; another stream accounts for 60-70%, and enters the first secondary methanation reactor; the process gas is cooled to 270-290°C and enters the first secondary methanation reactor for further methanation reaction; an outlet temperature of mixed gas of the first secondary methanation reactor is 440-460°C, and an inlet temperature of a feed gas of the second secondary methanation reactor is 270-290°C; and the intermediate pressure superheated steam generated from the methanation reaction is transported to the steam turbine.

[0018] A pressure of the intermediate pressure superheated steam that is generated by the first/second waste heat boiler and the first/second steam superheater in the primary methanation unit is 4.5-5 ~~mPa~~MPa.

[0019] The methanation reaction in step 3) employs high-load nickel as a catalyst, with a reaction temperature of 270-630°C, a pressure of 1-3 ~~mPa~~MPa, and a reaction formula of $CO + 3H_2 = CH_4 + H_2O$, $\Delta H_0^{\theta} = -206$ kJ/mol.

[0020] After the process gas from the second primary methanation reactor is cooled through the second waste heat boiler and the second steam superheater, a first stream flowing to the first primary methanation reactor through the recycle compressor accounts for 60-70%; and a second stream entering the first secondary methanation reactor accounts for 30-40%.

[0021] The system for cogenerating gas-steam based on gasification and methanation of biomass comprises: a gasification unit, a shift unit, a purification unit, a methanation unit,

[0027] FIG. 3 is a schematic diagram of a methanation unit of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0028] The invention is further illustrated in more detail in the light of the drawings and embodiments, which are not intended to define the protection scope of the invention.

[0029] As shown in FIG. 1, FIG. 2 and FIG. 3:

[0030] Step 1): Rice straw, crop stalk and other biomass were dried, crushed and sorted. Biomass raw material with the diameter or maximum length below 2 mm was directly transported to the gasifier of the high-temperature airflow bed through a screw feeder. The pressure in the gasifier was 1-3 ~~mPa~~MPa. An external thermostatic high-temperature heater was provided in the outlet segment of the gasified gas of the biomass gasifier to keep the gasification temperature within the gasifier at 1,500-1,800°C, and guarantee the gasification intensity, gasified gas quality and strengthened heat transfer process. As the gasification agent, superheated water vapor and oxygen were premixed, and then fully mixed with the treated biomass. The mixture was injected into the gasifier with a special nozzle at a rate of 100-120 m/s for gasification by way of parallel flow. Due to small particle size and strong heat transfer ability of the airflow bed, raw material was heated to the furnace temperature as soon as it entered the furnace. Almost at the same time, there was moisture evaporation, volatile matter decomposition, tar cracking, carbon combustion and gasification. Alkali-containing metal ash was converted to liquid slag,

[0035] Pressure of the intermediate pressure superheated steam that was generated by the waste heat boiler and steam superheater using the recycling reaction heat in the primary methanation reaction stage was 4.5-5 ~~mPa~~MPa.

[0036] The methanation was carried out with high-load nickel as the catalyst, at the reaction temperature of 270-630°C, under the pressure of 1-3 ~~mPa~~MPa, and following $CO + 3H_2 = CH_4 + H_2O$ ΔH_0^θ = -206 kJ/mol.

[0037] Step 4) Methane concentration: After methane was concentrated through pressure swing adsorption of crude natural gas, substituent natural gas following national standard was obtained. In general, the natural gas enters the urban gas pipeline as domestic gas, and may also enter the gas turbine to generate electricity in case of power shortage.

[0038] As shown in FIG. 1, a method and system for cogenerating gas-steam based on gasification and methanation of biomass comprises a gasification unit, a shift unit, a purification unit, a methanation unit and a methane concentration unit.

[0039] As shown in FIG. 2, a waste heat boiler is provided in the upper part of the gasifier of the gasification unit. Intermediate pressure superheated steam is generated by the waste heat boiler using the recycling waste heat of the crude gasified gas from the gasifier, and is transported to the steam turbine. An external thermostatic high-temperature heater is provided in the outlet segment of the gasified gas of the biomass gasifier to keep the gasification temperature within the gasifier at 1,500-1,800°C. Crude gasified gas from the gasifier is controlled at a temperature of 1,200-1,500°C.

Rate of flow Nm^3/h	43960	53320	29300	7350
Percentage vol. %				
CO	43.41%	12.03%	20.36%	0.01
H_2	16.42%	37.30%	67.53%	0.30
N_2	5.77%	4.76%	8.04%	1.17
CO_2	21.19%	41.23%	1.88%	1.13
CH_4	1.92%	1.59%	2.16%	96.13
H_2O	9.29%	1.45%	0.03%	1.26
C_2-C_4	1.92%	1.59%	0.00%	0.00
Caloric value of syngas kcal/m^3			2579	8227
Yield of syngas m^3/d				176400
Chemical synthesis efficiency from biomass to syngas (chemical energy of SNG/biomass chemical energy of biomass)				47%
Steam from methanation 450°C, 4.7 ~~mPa~~MPa (t/h)				21.45

Example 2

[0045] Biomass 1000 tons/day, and the gasification agent comprising 98 vol. % of oxygen is employed for gasification.

Table 2 Material balance and performance parameters of gas product

	Example 1			
	Gasified as	Shift gas	Syngas	Gas product
Rate of flow Nm^3/h	51140	64640	39670	10190
Percentage vol. %				
CO	52.10%	14.46%	21.91%	0.01%
H_2	22.81%	44.81%	72.66%	0.20
N_2	2.02%	1.60%	2.48%	2.00%

CO_2	12.55%	36.70%	1.79%	0.28%
CH_4	1.17%	0.92%	1.13%	96.47%
H_2O	9.27%	1.45%	0.02%	1.03%
C_2-C_4	0.02%	0.01%	0.00%	0.00%
Caloric value of syngas kcal/m^3			8256	8227
Yield of syngas m^3/d				244560
Chemical synthesis efficiency from biomass to syngas (chemical energy of SNG/biomass chemical energy of biomass)				64%
Steam from methanation 450°C, 4.7 ~~mPa~~MPa (t/h)				30.90

CLAIM

1. A method for cogenerating gas-steam based on gasification and methanation of biomass, the method comprising:

1) biomass gasification: mixing oxygen and water vapor produced from an air separation plant with biomass, transporting a resulting mixture via a nozzle to a gasifier, gasifying the biomass at a temperature of 1,500-1,800°C and a pressure of 1-3 ~~mPa~~MPa to yield crude gasified gas, and transporting superheated steam having a pressure of 5-6 ~~mPa~~MPa resulting from sensible heat recovery to a steam turbine;

2) shift and purification: according to demand for a methanation reaction, adjusting a hydrogen/carbon ratio of the crude gasified gas generated from step 1) to 3: 1 using a shift reaction, and eluting the crude gasified gas using low-temperature methanol for desulfurization and decarburization, whereby yield purified syngas;

3) methanation: introducing the purified syngas in step 2) to a methanation unit comprising a primary methanation unit and a secondary methanation unit, the primary methanation unit comprising a first primary methanation reactor and a second primary methanation reactor connected in series; allowing part of process gas from the second primary methanation reactor to return to an inlet of the first

a recycle compressor; another stream accounts for 60-70%, and enters the first secondary methanation reactor; the process gas is cooled to 270-290°C and enters the first secondary methanation reactor for further methanation reaction; an outlet temperature of mixed gas of the first secondary methanation reactor is 440-460°C, and an inlet temperature of a feed gas of the second secondary methanation reactor is 270-290°C; and the intermediate pressure superheated steam generated from the methanation reaction is transported to the steam turbine.

5. The method of claim 4, characterized in that a pressure of the intermediate pressure superheated steam that is generated by the first/second waste heat boiler and the first/second steam superheater in the primary methanation unit is 4.5-5 ~~mPa~~MPa.

6. The method of claim 1 or 2, characterized in that the methanation reaction in step 3) employs high-load nickel as a catalyst, with a reaction temperature of 270-630°C, a pressure of 1-3 ~~mPa~~MPa, and a reaction formula of $CO + 3H_2 = CH_4 + H_2O$, ΔH_0^{θ} = -206 kJ/mol.

7. The method of claim 4, characterized in that after the process gas from the second primary methanation reactor is cooled through the second waste heat boiler and the second steam superheater, a first stream flowing to the first primary methanation reactor through the recycle compressor accounts for 60-70%; and a second stream entering the first secondary methanation reactor accounts for 30-40%.

8. A system for cogenerating gas-steam based on gasification and methanation of