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.

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, and a reaction formula of $CO + 3H_2 = CH_4 + H_2O$, $\Delta H_0^{\theta} =$ -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%.