

Integration of liquid transportation fuel production into airless injection gas-steam cycle

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Abstract. Mineral fuel combustion negatively impacts on environment. Carbon dioxide (carbonic acid gas) is a danger matter obtained after combustion of such fuel. Deterioration of environment instigates society to invent new effective technologies to minimize anthropogenic emissions. There is an airless injection gas-steam cycle [1] for production of electricity and heat energy. Specific character of this cycle is a complete carbon capture. It is realized by liquid oxygen cooling. Also this cycle is characterized by high effectiveness of heat and electrical energy co-production and opportunity of liquid carbon dioxide production, which is convenient for transportation and usage. This diagram provides with reduction of carbon dioxide emissions, while it is impossible in other technologies. Disadvantage of such diagram is impossibility of using captured carbon dioxide in other fields. In this paper perspective method of airless injection gas-steam cycle modernization is offered for further liquefied carbon dioxide conversion into synthesis gas. Eventually, synthetic liquid transportation fuel (methanol) is obtained. Methanol refers to alternative type of fuel. It is an energy intensive, easily used and safe energy carrier. Minimal value of carbon dioxide emissions per produced energy unit of such plant essentially solves problem of anthropogenic influence on environment.

1 Introduction

In many cases degradation of ecology is connected with anthropogenic emission. Observed climatic changes require immediate solution of this problem. That's why there was a Paris Climate conference in 2015. The aim was to consolidate countries for the fight against global warming and to avoid increasing of a planet average temperature more than 2 °C. Laws related to reducing greenhouse gas emissions are going to be realized to achieve these goals. Firstly, it will affect on industry and energy industry. Nowadays, more than 80% of global energy consumption is fossil fuel, which gives off carbon dioxide during the combustion (it has been increased 30% for the last 50-60 years) [2]. It leads to raise of average annual temperature. So, it's necessary to reorganize manufacture industry and energy industry to reduce greenhouse gas emissions [3].

This time, industry has linear system of «stuff- products-waste products», where waste products are get into

environment. It is necessary to convert industry into an infinite natural-industrial cycle as «stuff- products- waste products- stuff or products». Also, there are accessory methods for reduction of greenhouse emissions: waste utilization, gas emission treatment and using different types of fuel [4, 5, 6].

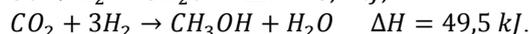
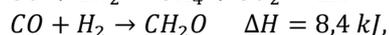
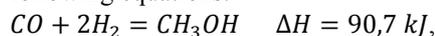
In terms of ecology, today the best decision is consumption change from coal fuel to natural gas. It produces less CO₂ (less than 400 kg/MW per hour) than coal fuel (about 800kg/MW per hour) [7]. Also, direction of effectiveness increasing related to using fuel for electrical and heat energy production is developing. It should be pointed out that feature of Russian energy industry is combined electrical energy and heat energy production and centralized heat supply from electric power station [8].

Besides mentioned decisions about solving ecological situation, there are such methods as CO₂ recovery from combustion products, which are got after the plant, fuel recovery from carbon before its combustion and fuel

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The ratio of synthesis gas components accordingly must be about 1/2 for obtaining methanol.

Obtained synthesis gas is directed to methanol converter 12 for producing synthetic liquid fuel. The reaction of methanol synthesis from synthesis gas is a heterogenic, catalytic, reversible, exothermic reaction. It is described by following equations:



Preliminary analyses of thermodynamic equilibrium concentrations of gas components on the outlet side of the reactor are presented in table 1.

Table 1. Thermodynamic parameters of equilibrium concentrations of gas components

Position in the diagram (look fig.1)	Inlet 1	Inlet 2	Inlet 3	Outlet	
Pressure P, MPa	3	3	3	3	
Temperature T, K	573	573	573	1679,4	
Components	Mass, kg			Mass, kg	Concentration, %
O ₂	0	0	74	0	0
OH	0	0	0	0,00011	0
CO	0	0	0	82,31	42,43
CO ₂	0	0	30	32,34	16,67
CH ₄	48	0	0	0,004	0,002
N ₂	0	0	4	3,99	2,06
H ₂	0	0	0	8,87	4,57
H ₂ O	0	38	0	66,47	34,26
NH ₃	0	0	0	0,006	0,003
C (solid)	0	0	0	0	0
Overall mass, kg	194			-	

Considering mentioned ratio of components in synthesis gas unit production the reaction of combined conversion is realized with heat evolution. As a result there is the synthesis gas CO+H₂ with a ratio of 1/1,5. Thermodynamic analysis parameters of offered diagram depend on choice of catalyst and conditions of synthesis process.

The rest of depleted synthesis gas is directed to the combustion chamber 3 for afterburning.

Presented diagram can be used in practice for creation of mobile power generation unit, which can produce heat and electricity and also liquid transportation fuel, which is used for other energy cycles or it can be commercially realized. This mobile unit can be used for creation of marginal natural gas fields, which is disadvantageously to research by traditional methods. These methods mean monumental

construction of gas transmission station. Its cost can be higher than the profit of obtained gas realization. That's why such fields are mothballed and left. Overall gas cost in these marginal fields can be high because there are lots of them. That's why conception of universal mobile unit, which can be transported from one marginal field to another, is commercially advantageous.

Also liquefied carbon dioxide can be used for exploitation of hard-to-recover oil reserves [10, 11]. To achieve that, liquefied carbon dioxide after mobile unit is converted to gas phase and compressed into the oil field. Due to limited volume of the field, carbon dioxide forces up the oil which goes to the tank for further transportation.

3 Conclusions

As a result of modernization of airless cycle it is possible to increase a level of effectiveness for using natural fuel, which is got after producing heat and electrical energy and secondary synthetic liquid fuel. This energy cycle approaches industry field to the industry without waste products. It is an ideal of energy ecology.

Presented technology can be used for energy supply of marginal natural gas fields and it will allow to increase oil recovery of unconventional oil by pumping carbon dioxide in them. Installation which realizes modified airless cycle can be mobile. Then, dependence of field payout on following recovery volume will be dampened, because one such installation can maintain several fields.

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