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BIOGAS CONVERSION TO SYNGAS IN AN ENLARGED LABORATORY PILOT TUBULAR REACTOR

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Introduction

Biogas is one of the renewable sources that could be used for the production of syngas and hydrogen via syngas. Hydrogen is the most promising energy carrier, while syngas is a building block for producing a wide number of petrochemicals. Among the existing biogas utilization technologies, dry reforming can convert two major greenhouse gases in biogas – methane and carbon dioxide into syngas (mix of hydrogen and carbon monoxide).

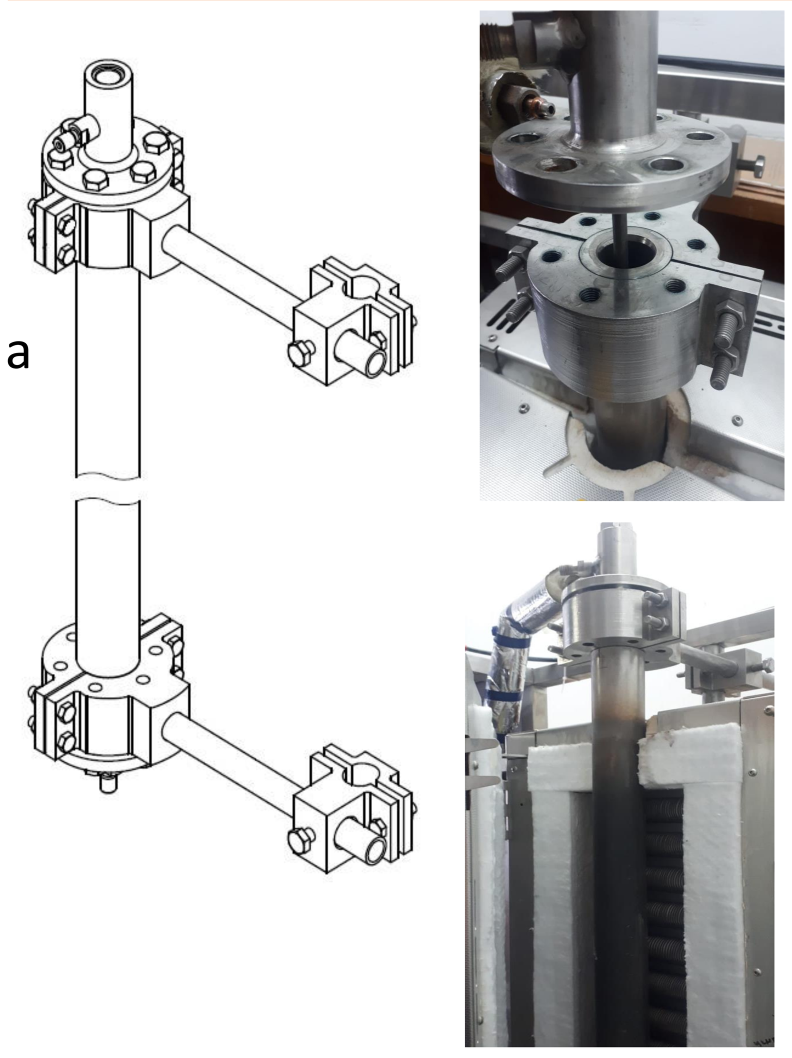
$$CH_4 + CO_2 \leftrightarrow 2H_2 + 2CO \qquad \text{(eq. 1)}$$

In application works, the completion of a laboratory stage of studying is followed by a scale-up of the process, which implies a gradual enlargement of a set accompanied with increasing the target product production. To provide the enlarged scale of the catalyst testing and optimization of the process parameters, a laboratory reactor was designed to meet the following requirements:

❖resistance to the corrosive environment under high temperatures (steam and carbon dioxide);
❖ operation in a broad range of temperatures varied within 50-1000˚ C;
❖ operation under pressures varied within 1-30 atm;
❖ reactor type with a fixed bed of catalyst is a tubular one, which is characterized by simplicity of construction and operation;
❖ low cost of the reactor and its repair.

Experimental

Reactor: scheme and photos of designed parts



- The working volume of the reactor - 300 ml;
- Maximum temperature - 1000 °C;
- Maximum pressure - 50 amt;
- Reactor materials - Inconel-600, AISI 304;

Photo: Catalytic unit including designed constructed reactor

CATALYST

Composition: 5%Co-Rh/Al_2O_3
Volume: 100 mL
Flow reactor,
P=0.1MPa
t=300-800°C
GHSV=1000-2000 h^{-1}
TOS: 100 hours

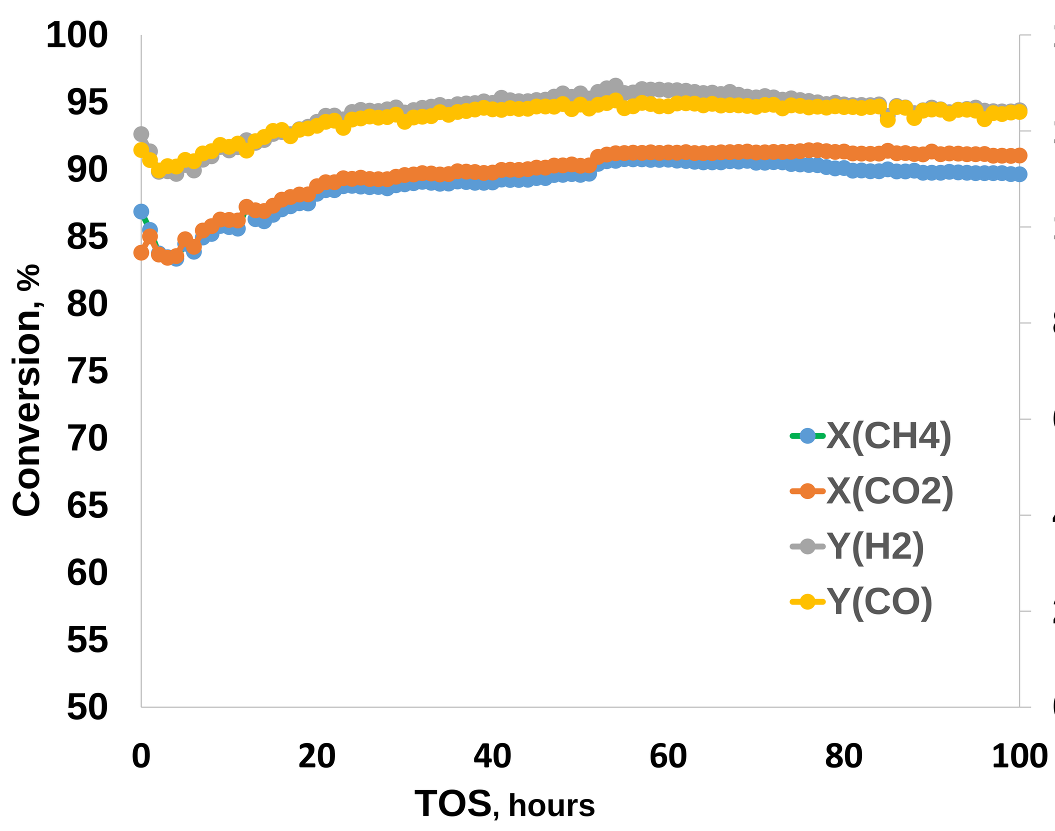
FEED

DRY reforming:
a model biogas: CH_4/CO_2=1

Steam reforming:

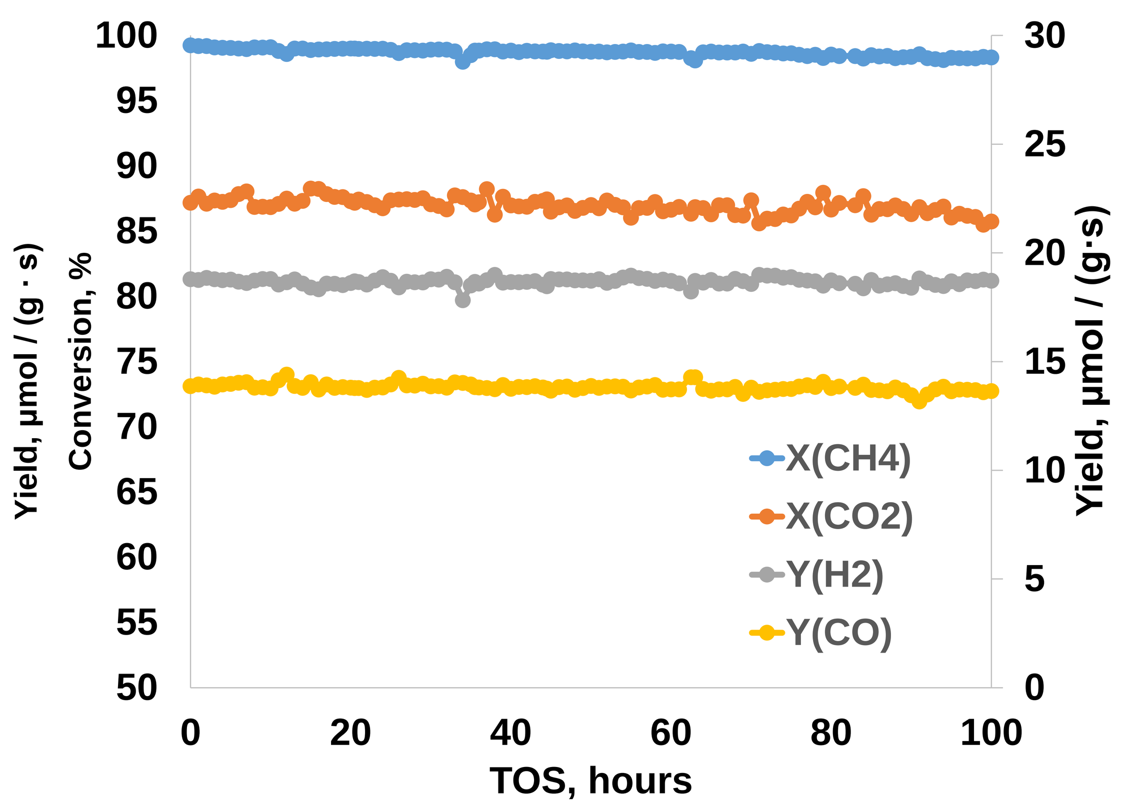
Model biogas/H_2O = 1/1÷2

Results: Catalyst testing



a

CH_4: CO_2 = 1: 1, P = 0.1 MPa, T = 700°C, V_o = 1000 h^{-1}



b

CH_4:CO_2:H_2O=1:1:0.5, P=0.1 МПа, T=670°C, V_o=1250ч$^{-1}$

Fig. 1. Influence of the process duration on the performance of the 5%Co-Rh/Al_2O_3 catalyst in
a) dry and
b) bireforming of methane

The average values of the degree of conversion of methane and carbon dioxide in dry reforming were 89 and 89.7%, respectively. The resulting synthesis gas has an average value of H_2/CO = 1.

In steam reforming, the degree of conversion of methane is on average 98.7, carbon dioxide is slightly lower - 87%, and the resulting synthesis gas has an average value of H_2/CO = 1.

Table 1.
BET surface and pore volume of the 5%Co-Rh/Al2O3

Treatment of the catalyst	S, m²/g
Fresh sample	144.5
Steam biogas conversion	88.3
Dry biogas conversion, after 100 hours	86.5

Conclusion

The designed and constructed reactor was tested in biogas conversion in the temperature range of 700-800°C, P=1-2 atm, and in corrosive environment at varying ratio of CH_4/CO_2/H_2O = 1/1/0.5-2 at presence of the bimetallic supported catalyst.
The designed reactor showed acceptable convergence.
Tests confirmed the high stability of the Co-based catalyst in the production of syngas from a model biogas. The extent of conversion of methane was higher than 80% and kept stable for 100 hours. The H_2/CO ratio in the formed syngas was varied depending on the feed composition.

Acknowledgments

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