

LOW TEMPERATURE CATALYTIC STEAM CONVERSION OF LIGHT HYDROCARBONS INTO METHANE-RICH GAS MIXTURES FOR POWER PLANT FEEDING APPLICATIONS

P.V. Snytnikov^{1,2,3*}, S.I. Uskov^{1,2}, D.I. Potemkin^{1,2}, V.D. Belyaev^{1,2,3},
V.A. Kirillov^{1,2,3}, V.A. Sobyenin¹

¹Boreskov Institute of Catalysis, Novosibirsk, Russia

²Novosibirsk State University, Novosibirsk, Russia

³“UNICAT” Ltd., Novosibirsk, Russia

*e-mail: pvsnyt@catalysis.ru

Processing and utilization of associated petroleum gas (APG) is one of the key tasks ensuring the progress of gas-and-oil producing industry in the north regions of Russia and new oil-field territories of Arctic shelf. APG is a high-caloric gas of variable composition consisting of methane, ethane, LPG, nitrogen, carbon dioxide. Because of relatively high content of non-methane fraction, APG could not be pumped directly into gas pipelines or used as a mono-fuel for power generation. Since oil fields in Russian North and Arctic shelf locates far away from industrial centers and cities where construction of transportation infrastructure comes highly expensive, the APG utilization approaches are focused mainly on generation of electric power, which can be used both for local needs and transported for long distances. Direct use of APG as a mono-fuel for power generation (gas engines, gas turbines) is limited by low methane content, unstable gas composition and high coking risk that decreases service life and causes engine damage. Direct use of APG as a fuel for solid oxide fuel cell (SOFC) is also problematic. To overcome these problems, it is proposed to perform preliminary catalytic steam reforming of APG hydrocarbon components [1-4] to produce methane-hydrogen mixture, which can be used for different power generation applications, figure 1.

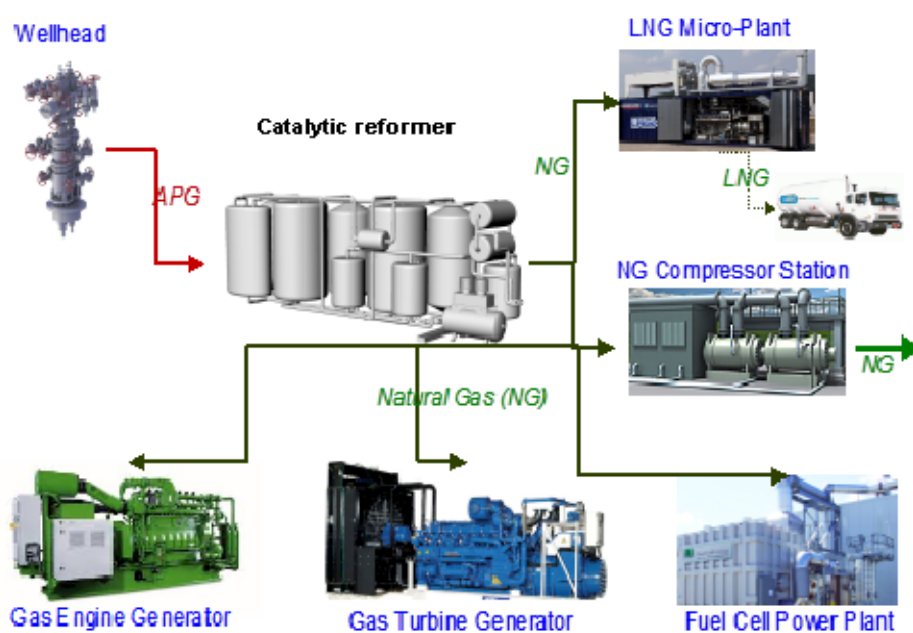


Figure 1. Applications of APG catalytic reformer.

Laboratory and small pilot scale studies of the reaction of steam reforming of light hydrocarbons into methane-hydrogen mixture were performed. Ni- and Ru-containing systems were studied as the catalysts. A prototype catalytic converter capable of 10 m³ APG /h was developed and tested using real APG. Conversion of LPG fraction and ethane was more than 95-99% during converter testing at 330°C. Increasing reaction temperature leads to increasing H₂ and CO contents in reaction mixture with complete conversion of LPG and ethane fraction. Both initial and reformed APG were used for fuelling a power plant on the base of gas internal combustion engine MTES-30 (nominal power 36 kW). In case of initial APG fuelling, electric power of the plant decreased by 8 kW (power loss ~22%), exhaust gas contained black smoke. When the power plant was fuelled by methane-hydrogen mixture produced by APG catalytic reforming, the engine power increased by 21% and attained the nominal value; the engine showed excellent dynamic and temperature characteristics, stably supported crank rotation frequency.

Full size study of the reaction of steam reforming of light hydrocarbons into methane-hydrogen mixture was developed at Kropivinskoe oilfield (Gazpromneft'-Vostok Co., Tomsk) [5]. Industrial size propotype capable for APG conversion of 300 m³/h was developed and investigated (Figure 1).



Figure 2. Full size prototype of APG conversion unit.

The benchmark test, pilot-scale and pre-commercial experimental studies and the results of mathematical modeling clearly demonstrate that the proposed technology is promising for APG processing into fuel gas that is similar in characteristics to commercial natural gas. Depending on the C₂+ content of APG, the process results in a considerable increase in the volume of the fuel mixture. It is believed that, at present, there is no other commercially reasonable technical solution

intended for small and low-pressure oilfields and aimed at obtaining a gas fuel for local autonomous energy production including usage of SOFC technology

References

1. Zyryanova M.M., Snytnikov P.V., Amosov Yu.I., Belyaev V.D., Kireenkov V.V., Kuzin N.A., Vernikovskaya M.V., Kirillov V.A., Sobyenin V.A. // *Fuel*. 2013. V. 108. P. 282-291.
2. Zyryanova M. M., Badmaev S. D., Belyaev V. D., Amosov Yu. I., Snytnikov P. V., Kirillov V. A., Sobyenin V. A. // *Catalysis in Industry*. 2013. V. 5. P. 312–317.
3. Zyryanova M.M., Snytnikov P.V., Shigarov A.B., Belyaev V.D., Kirillov V.A., Sobyenin V.A. // *Fuel*. 2014. V.135:76-82.
4. Uskov S.I., Enikeeva L.V., Potemkin D.I., Belyaev V.D., Snytnikov P.V., Gubaidullin I.M., Kirillov V.A., Sobyenin V.A. // *Catalysis in Industry*. 2017. 17. P.11-17.
5. Kirillov V.A., Amosov Y.I., Shigarov A.B., Kuzin N.A., Kireenkov V.V., Parmon V.N., Aristovich Yu.V., Gritsay M.A., Svetov A.A. // *Theor. Found. Chem. Eng.* 2017. V. 51. P. 12-26.