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OBTAINING SYNTHETIC GASOLINE FROM NATURAL GAS

Aziz Dustov Yusupovich,
Hasan Togayev Abduvohid ugli
University of Economics and Pedagogy (Karshi)
Aziz787shng@mail.ru

Abstract:

High prices for oil and energy, which have persisted for a long time, as well as the increasing demand for automobile fuel, force us to look for alternative sources of production of fuels and chemical products. For this purpose, the article considered the possibility of producing synthetic gasoline from natural gas. The process of producing gasoline from synthesis gas using the Fischer-Tropsch method has been studied. Gasoline was obtained in laboratory conditions from natural gas on an iron catalyst under medium pressure. The obtained synthesis products were compared with the products obtained by the Fischer-Tropsch method.

Keywords:

Alternative fuel, natural gas, Fischer-Tropsch method, synthesis gas, methanol, dimethyl ether, synthesis, synthetic gasoline, catalyst.

Introduction

Industrial oil production began more than 150 years ago. Over the past century and a half, humanity has already used up more than half of the oil reserves. At first, oil was used as a source of thermal energy, but now it has become economically unprofitable. With the advent of the automobile era, oil fractionation products are mainly used as motor fuel. By 2030, oil reserves will be largely depleted, the cost of oil production will increase accordingly, and the world will be faced with the problem of using alternative (non-oil) sources of gasoline and other types of fuel [1].

Alternative motor fuels can be classified by type as follows: gas motor fuels (liquefied natural gas, compressed natural gas, liquefied petroleum gases - propane, butane); alcohols and gasoline-alcohol mixtures (methyl, ethyl, isobutyl and other alcohols and their mixtures with motor gasoline in various proportions); ethers (methyl tertiary butyl ether (MTBE), methyl tertiary amyl ether (MTAE), ethyl tertiary butyl ether (ETBE), diisopropyl ether (DIPE), and dimethyl ether (DME); synthetic liquid fuels (SLF) obtained from natural gas and coal; biofuels (bioethanol, biodiesel) obtained from renewable raw materials; hydrogen and fuel cells running on hydrogen [2].

Synthetic liquid fuels (SLF) are gradually becoming more widespread. Their production began in Germany in the 1930s, and the technology was developed in the mid-1920s by German chemists F. Fischer and H. Tropsch. Recently, the method of obtaining SLF, which is used in industry to obtain gasoline from natural gas, has become widely known. Most of the published

reports on this method relate to the technological side of the synthesis process and contain only general indications of the composition and properties of the resulting synthetic fuel [3].

The purpose of this article is to obtain synthetic liquid fuel from natural gas and provide information on the hydrocarbon composition of its gasoline fraction.

The process of obtaining synthetic gasoline from natural gas consists of four stages. The first stage produces oxygen, which is used to produce synthesis gas - a mixture consisting mainly of CO and H_2 (the second stage).

Synthesis gas from natural gas is obtained using technological processes that can be divided into two large groups:

1) partial oxidation of methane:

$CH_4 + 1/2O_2 = CO + 2H_2 – 10{,}62$ kcal/mol

2) steam reforming: $CH_4 + H_2O = CO + 3H_2 + 54{,}56$ kcal/mol

Each of these reactions additionally produces CO_2, which then reacts with methane to form additional C_O and H_2:

$CH_4 + CO_2 = 2CO + 2H_2 + 62{,}05$ kcal/mol

This process also makes it possible to use excess CO_2 from other technological processes, which reduces the volume of harmful emissions and serves to control the composition of the synthesis gas.

At the third stage, the Fischer-Tropsch process itself is carried out, in which liquid hydrocarbons are synthesized based on the components of the synthesis gas. In a simplified form, this process can be represented as follows:

$$nCO + (2n+1)H_2 = C_nH_{2n+2} + nH_2O;$$

$$2nCO + nH_2 = C_nH_{2n} + nCO_2.$$

The composition of the final products depends on the catalysts used, temperature and pressure, the ratio of CO and H2 in the working mixture and other factors. At the same time, modifications of the process with the targeted production of various semi-finished products (methanol, a mixture of linear alkanes and alkenes, aldehydes for the production of alcohols, carboxylic acids, amines, polyhydric alcohols, etc.) are possible.

Table 1. Comparison of synthesis products obtained in laboratory experiments and by the Fischer-Tropsch method under medium pressure.

Synthesis products	Data on the Fischer-Tropsch method under medium pressure (cobalt catalyst)		Own experimental data under medium pressure (iron catalyst)	
	output, % mass.	olefin content, % vol.	output, % mass.	olefin content, % vol.
C3 + C4	10	40	32	82
Naphtha fraction	30	26	56	85-90
Diesel fraction				
Residue	33	8	8	75-85
	27	–	4	–

At the final stage, the obtained semi-finished products are refined, bringing their quality to the required parameters. This stage is well-mastered at modern oil refineries as part of secondary oil refining processes.

The table provides our own experimental data on the fractional composition and properties of the synthesis products, which are compared with the data obtained using the Fischer-Tropsch method at medium pressure.

As can be seen from the above, the use of an iron catalyst in the process gives a significantly higher yield of gasoline. In addition, due to the higher yield of the C3-C4 fraction containing many olefins, there are more opportunities for obtaining polymer gasoline. At present, the production of gasoline by the proposed method is not yet carried out on an industrial scale and the data on its composition and properties given in the article were obtained during the study of products synthesized on experimental units in laboratories.

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