OPTIMIZATION OF TECHNOLOGICAL PARAMETERS FOR SEPARATION OF ETHYLENE MONOMER FROM PYROGAS COMPOSITION

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Abstract: *the article analyzes methods for extracting ethylene monomer from pyrogas and improving the technological apparatus. Based on the research, optimal parameters for the pyrolysis process were selected and the output amount of ethylene monomer was increased. Due to the improvement of technological devices in the process, the level of purity of the ethylene monomer has increased. Energy savings were achieved, and as a result, the devices were able to operate for a long time.*

Key words: *ethylene monomer, optimization, inhibitor, reboiler, ethane, pyrolysis, resins, carbon dioxide (CO_2), hydrogen sulfide (H_2S), carbon disulfide (COS). carbon disulfide (CS_2), mercaptans (RSH), thiophenes.*

INTRODUCTION

Worldwide, ethylene and propylene are the main monomers for petrochemical products. More than half of the ethylene produced is used as a monomer in the production of polyethylene-propylene copolymers, vinyl acetate, styrene and ethyl acrylate. Ethylene oligomers form the basis of synthetic lubricating oils. These products determine how important ethylene production is for the economy of our Republic and the national economy [1-3].

The extraction of ethane contained in natural gas, the study and technical improvement of technologies for the production of ethylene monomer is an important current problem in the world. In this regard, as a result of scientific research carried out throughout the oil and gas refining industry of our Republic, certain results have been achieved in the introduction of technological methods that ensure maximum extraction of hydrocarbon components from natural gas.

Currently, to find a positive solution to the problems of increasing production efficiency using the process of complete separation of natural gases into hydrocarbon fractions and pyrolysis of ethylene monomer. It is necessary to determine physical, chemical and technological indicators, find alternative options, indicators of factors influencing the implementation of the process, and apply it in production practice in foreign countries outside our republic and is considered very relevant in the conditions of the CIS countries [4-6].

Based on the analysis of existing scientific and research works, it should be noted that the properties of physicochemical and other effects have not been fully studied due to changes in the initial composition of the raw material during the extraction of ethylene monomer from the pyrogas composition. Based on this, the purpose of this study is to determine an innovative method for isolating ethylene monomer used in the production of polyethylene from pyrogas and studying the physicochemical properties in order to improve gas processing technology, protect process equipment and equipment from corrosion.

The object of study was raw materials containing methane, ethane, propane, n-butane, isobutane, C^{5+}, H_2S, CO_2, nitrogen, H_2O when extracting ethylene monomer from pyrogases at the Shurtan gas-chemical complex. Methane, ethane, ethylene, propylene, propene, butylene and hydrogen contained in the pyrogas were separated from the polymer composition using technological equipment.

Based on the purpose of the research and the assigned tasks, the installation shown in Fig. 1 was used for the pyrolysis of raw hydrocarbons with a carbon content equal to C_2-C_4 under laboratory conditions. This device contained methane-0.2, ethane-0.4, ethylene-19.0, propane-0.65, n-butane-6.4, isobutane-0.25, nitrogen-0.1 as raw materials kg and the work was carried out in the temperature range 550-850^{0}C. The rate of passage of the hydrocarbon mixture through the device was 25-100 ml/min, and the mixing time (τ) of the mixture phases was 0.5-2.5 s. It has been established that when the amount of ethylene hydrocarbon in the raw material increases from 0 to 0.7, its contribution to the product composition increases from 0.17 to 0.50. Thus, it was noticed that the level of ethylene in the product increased by 1.2-2.1 times compared to propylene. At the same time, it was found that under such conditions the formation of liquid-phase products decreases from 0.26 to 0.15 mass units. Based on these results, it is worth noting that the amount of products obtained during the pyrolysis process can be purposefully controlled by changing the composition of the gas feedstock.

Selection of alternative (optimal) parameters for the process of extracting ethylene from pyrolysis gas. The amount of ethylene monomers released during pyrolysis is influenced by the following technological indicators:

- Composition of raw materials for pyrolysis;
- conversion rate:
- temperature;
- saturated steam pressure;
- indicators such as the residence time of hydrocarbons in the reaction zone [2].

Composition of raw materials for pyrolysis. During the pyrolysis process, the yield of products depends on the level of the unit mass of the raw material. Liquid phase products were detected: 1-ethylene, 2-propylene, 3-liquid phase products. It has been established that when the amount of ethylene hydrocarbon in the raw material increases from 0 to 0.7, its contribution to the product composition increases from 0.17 to 0.50. Thus, it was noticed that the level of ethylene in the product increased by 1.2-2.1 times compared to propylene. At the same time, it was found that under such conditions the formation of liquid-phase products decreases from 0.26 mass units to 0.15.

Temperature. The results of the temperature and time dependence of the release of pyrolysis products are analyzed. In laboratory conditions at temperatures of 500-550⁰C, 550-650⁰C, 650-750⁰C, 750-850⁰C, the raw material was kept in the reaction zone for 6-12 seconds, the results were presented in the table. According to the results, the peak yield rate of ethylene monomer was 33.3% in 6-12 seconds at temperatures of 750-850⁰C.

Saturated steam. In the process, it was found that the most important factor is the saturation of hydrocarbons of the raw material for pyrolysis with water vapor, and the optimal addition is 34-35% to the amount of raw material.

The residence time of hydrocarbons in the reaction zone. In the pyrolysis process, an important indicator is also the residence time of the raw material in the reaction zone. In laboratory conditions, the raw materials were heated for 12 seconds at a temperature of 550-850°C and quantitative studies were carried out. formation of ethylene monomer. In order to reduce coking of the pipes of the pyrolysis furnace, it has been established that it is advisable to set the residence time of the raw material in the process to 6-12 seconds, and the temperature to 600-850⁰C (in the Regulations, the process time was up to 0.35 seconds, and the temperature was up to 1000⁰C). In this case, coking of the furnace pipes is observed, which affects the product yield [3].

Based on laboratory analysis based on the parameters suggested above, the following positive results were obtained.

Table 1.

The influence of temperature and time of phase contact on the yield of pyrolysis products

Pyrolysis products	Product yield			
	500-550⁰C 6-12 c	550-650 ⁰C 6-12 c	650-750 ⁰C 6-12 c	750-850⁰C 6-12 c
CH_4	15,6	16,6	16,8	16,7
C_2H_4	23,0	25,9	29,3	33,3
C_3H_6	13,6	12,7	12,2	11,7
C_4H_6	2,2	3,8	4,2	4,8
C_5 and above	32,8	29,7	27,8	23,9

CH_4/C_2H_4	0,678	0,641	0,575	0,501
C_3H_6/C_2H_4	0,591	0,490	0,418	0,351

Saturation of hydrocarbons in the pyrolysis feedstock with water vapor is considered the most important factor, since the yield of ethylene, 1,3-butadiene and butenes increases due to a decrease in the partial pressure of hydrocarbons. The formation of aromatic hydrocarbons and methane is also reduced, and the rate of secondary reactions leading to the formation of high molecular weight compounds is slowed down by the formation of coke in reactors. The indicator of saturation of raw materials with water vapor is given in Table 2.

Table 2.

Degree of saturation of raw materials with water vapor

	Ethane	Butane	Light gasoline	Heavy gasoline	Gas oil
Dilution with steam (%)	35	50	50-60	60-70	80-100

The presence of water vapor reduces the rate of coke deposition on the surface of the pyrolysis tubes and leads to excess pressure and temperature. As a result, this allows you to extend the period of cleaning pipes from coke. Therefore, diluting the pyrolyzed raw material with water vapor comprehensively leads to a softening of the process conditions and makes it possible to increase the level of ethylene yield without reducing the selectivity of the process [4,5].

The amount of ethylene monomer (mol%) was analyzed in the laboratory based on the studies performed, that is, the selected optimal parameters and changes in the improved technological system. The obtained analysis results are as follows: According to the regulations, the amount of ethylene monomer was initially 32.65%. technological indicators: composition of raw materials; conversion factor: temperature; saturated steam pressure; indicators such as the residence time of hydrocarbons in the reaction zone were optimized, and it was observed that the amount of ethylene monomer in the pyrolysis gas obtained as a result of the process was 33.325% and increased. The results based on the changes in the advanced technology system are presented in the table below.

It has been established that the amount of ethylene in pyrogas increases with changes in the conversion process in production.

The amount of ethylene in the composition of the pyrogas according to the project is 32.65 mol%.

The amount of ethylene in the pyrogas composition with an increase in the degree of conversion is 33.325 mol%. Then it was found that

$F=(33{,}325) - (32{,}65)\text{mol }\%=0{,}675\text{ mol }\%$.

Conclusion. When any hydrocarbon undergoes pyrolysis, it produces unique products depending on the technical parameters of the process. Depending on the pyrolysis raw materials, output products and the resulting mixture: degree of conversion; temperature; Saturated vapor pressure readings result in significant changes.

Calculation of ethylene yield for the project.

According to the project, the degree of processing of pyrolysis furnaces SRT-VI of the 60% ethane pyrolysis process of the Shurtan gas chemical complex is calculated based on the output material balance of products, in which:

Table-3

The amount of ethylene released in pyrolysis furnaces in the event of a change in the degree of conversion (mol%)

Name products	Amount of ethylene released in pyrolysis furnaces in the event of a change in the degree of conversion (mol%)	Amount of ethylene released according to design documents and standards (mol%)
Hydrogen	38,304	32,92
Carbon monoxide	0,0049	0,11
CO	0,0069	0,03
methane	4,539	3,56
acetylene	0,32	0,23
ETHYLENE	33,325	32,65
ethane	22,049	24,02
iso-butane	0,000141	0,07
n-butane	0,074	
propadiene/methyl acetate	0,0095	0,2
propylene	0,46	0,39
butenes	0,066моль	0,06
propane	0,0627	0,08
butadiene/C4 acetylene	0,536	0,29
methylacetylene	0,000193	-
Hydrocarbons with C6	0,0959	0,06
benzene	-	0,05
toluene	-	0,01

After the conversion process,

$$C = \frac{F}{F + R} = \frac{21.028}{21.028 + 14.046} * 100\% = 60\%$$

The amount of C_2H_6 received at the pyrolysis furnace is F = 21.028 tons/hour, the amount of ethane in the ethane + ethylene mixture returned to the DA-1402 column is R = 14.046 tons/hour.

The consumption of ethane return to the furnace is

$$R = \frac{F(1-C)}{C} = \frac{21.02(1-0.60)}{0.60} = 14{,}02\ \text{tons/hour}$$

The complex equipment will be in continuous operation for 8,000 hours per year and will be stopped for scheduled maintenance for one month if:

According to the project, ethylene production at the ShGCC is 140,000 tons/year and the amount of C_2H_4 produced within one hour is F=140,000/8000=17.5 tons/hour.

Based on the above data, the following calculations were carried out to increase the amount of ethylene in conversion furnaces:

Factors influencing the ethylene production process were analyzed at a conversion of 62% in furnaces in operating condition (Run Mode) when the mode reached the standard. The conversion rate is

$$C = \frac{F}{F+R} = \frac{22.4}{22.4+13.609} * 100\% = 62\%$$

The amount of C_2H_6 received at the furnace is F=22.4 tons/hour, the amount of ethane in the ethane+ethylene mixture returned to the DA-1402 column R=13.609 tons/hour.

The consumption of ethane return to the furnace is $R = \frac{F(1-C)}{C} = \frac{22.4(1-0.62)}{0.62} = 13, \frac{tons}{hour}$.

The integrated ethylene production workshop as of 07/06/2024, that is, in 24 hours, produced 428 tons/day:

Ethylene production per day is 428 tons/day;

The amount of C_2H_4 produced in one hour is F=428/24=17.83 tons/hour.

When ethylene production is calculated relative to the project.

- According to the project, during the furnace conversion process by 60%, the amount of ethylene produced (C2H4) is F1=17.5 tons/hour.
- When changing the technological process mode and increasing the degree of conversion by up to 62%, the amount of ethylene produced (C2H4) is F2=17.83 tons/soat;
- Thus Fethylene=F1-F2=(17.83)-(17.5)t/hour=0.33t/hour. This means that based on the optimization of the pyrolysis process, an additional 0.33 tons/hour of ethylene was obtained.

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