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Pyrolysis Of Hydrocarbon Feedstock

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ABSTRACT. *The composition of the pyrolysis products of raw materials is given, which depends on the conversion depth (degree of conversion), which in industrial practice is determined by specific production conditions: the need to produce a given volume of products, the workload of the compression unit of the gas separation system, energy costs, and others. The change of some parameters of the equipment during pyrolysis is considered.*

KEYWORDS: *pyrolysis, pyrolysis oven, conversion, process rigidity.*

I. INTRODUCTION

Gaseous feed - ethane, propane, H-butane and mixtures thereof - are the best feed in terms of maximizing ethylene and propylene yields. The composition of the pyrolysis products of this raw material depends on the depth of conversion (degree of conversion), which in industrial practice is determined by specific production conditions: the need to produce a given volume of products, the load of the compression unit of the gas separation system, energy costs and others. Some changes in ethane pyrolysis are discussed below, as in practice the degree of conversion varies widely.[1]

II. METHODS

Figure 1 shows the relationship between ethylene and methane-hydrogen yields and ethylene selectivity (ethylene to ethane conversion ratio) and ethane conversion for one type of furnace. In industry, ethane conversion ranges from 0.53 to 0.73. With its increase, selectivity drops, as the yield of by-products grows faster than the yield of ethylene.[3]

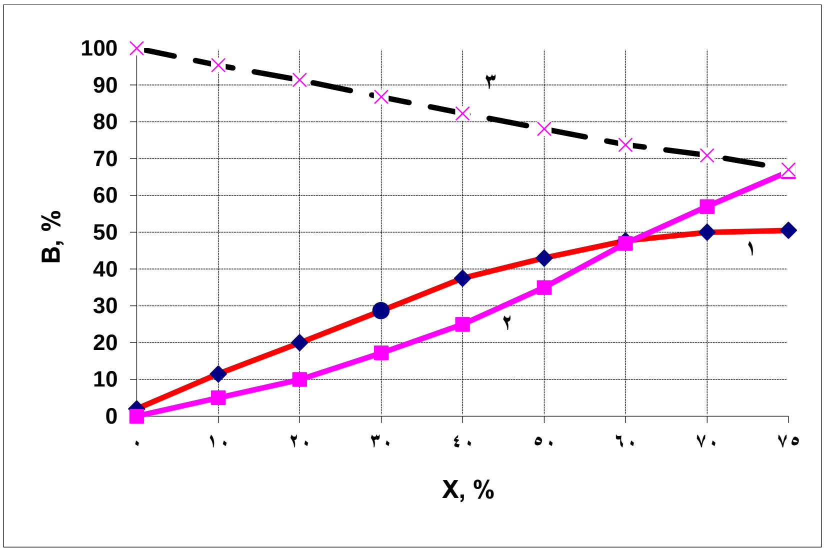

Fig. 1. Dependence of yield B of ethylene (1) and methane-hydrogen fraction (2) on degree of conversion of ethane X, dotted line (3) selectivity to ethylene.

Therefore, more feed is required to produce a predetermined amount of ethylene. As the conversion rate decreases, the proportion of ethane returned to pyrolysis increases, more furnaces are required, and the load on the compressor and the gas separation system increases. Figure 2 shows the change in feed rate, compressor load and cracking furnaces depending on the conversion rate. The basic mode was taken at 60% ethane conversion per pass. As can be seen from the figure, as conversion decreases to 50%, raw material consumption decreases by 4.7%, and the compression load increases by 14% relative to the base mode. The required number of furnaces or their productivity increases by 20%.

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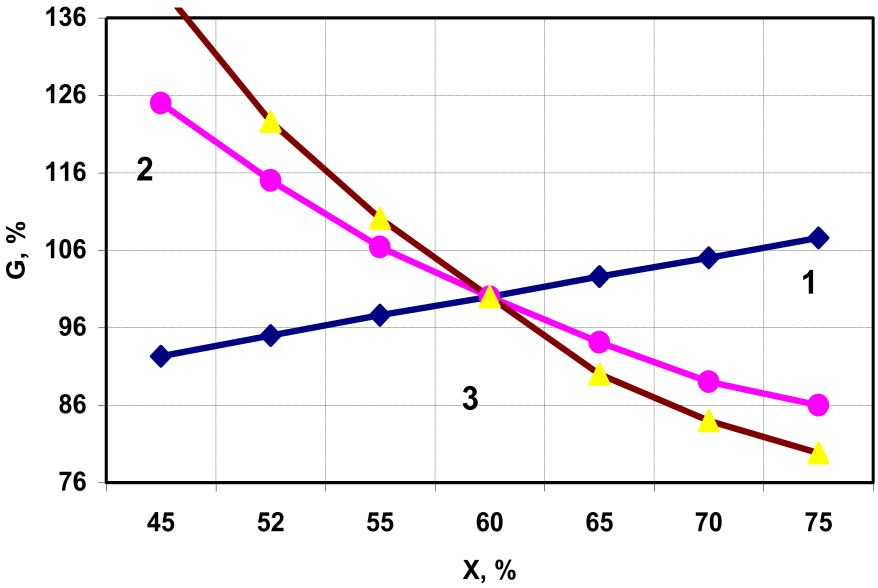

Fig. 2. Dependence of relative feed rate (1), compressor load (2) and pyrolysis furnaces (3) on conversion of ethane X,%

III. RESULTS

Table 1. Shows the effect of conversion on ethylene and other cracking products.

Table 1.

№				Note
1	conversion	60	65	Conversion change has a major impact on production.
2	coil	SRT V	SRT V	
3	Coil outlet pressure, kgf/sm^2	2.0	2.0	
4	Ratio. Steam/Feed	0.3	0.3	
5	Coil outlet temperature (COT), ^{0}C	836	846	
6	Delay time, sec	0.2	0.2	
7	CH_4	3.65	4.55	
8	C_2H_4	**49.2**	**52.0**	
9	C_3H_6	0.85	1.0	
10	C_6 -204 ^{0}C	0.80	1.25	
11	C_3H_6/ CH_4	0.233	0.22	
12	C_3H_6/ C_2H_4	0.017	0.019	

Table 2 shows the yields of ethane pyrolysis products in industrial furnaces at different degrees of conversion. As can be seen from the table, as the conversion rate increases, the hydrogen yield varies slightly. The same applies to propylene, while methane yield increases dramatically. The yield of liquid products from ethane is 2-3%: most of them are aromatic hydrocarbons: benzene-1.3%, toluene-0.2%, hydrocarbons C_8-C_9-0.6% and heavy resin-0.3%.

A sharply different product composition is obtained by pyrolysis of ethane in Millisecond furnaces. Here, with a coil residence time of < 0.1 s and a COT temperature of 830-850 ^{0}C, as well as due to low ethane conversion, little methane, propylene and liquid pyrolysis products are formed, which ensures high selectivity of the process.

Table 2. Process conditions and product yield during ethane pyrolysis in industrial furnaces of various types

Indicator	**Type of furnace coil**				
	more vertically [8]	**more horizontally**	**more vertically**	**more horizontally**	**Millisecond SRT V [2]**
T in a coil, entrance, ^{0}C exit, ^{0}C	680 835	670 830	640 835	600 845	658-650 825-830
Dilution steam, %	40	30	40	30	35
Response time, sec.	--	--	0,85	1,8	0,07
Ethane conversion, %	60,0	63,2	67,4	78,5	60,0
Exit, %: H_2	3.71	4.18	4.42	5.72	4.18

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CH_4	3.35	5.60	7.36	9.66	5.82
C_2H_2	0.20	--	0.50	0.94	0.4
C_2H_4	48.68	48.9	48.30	54.8	45.47
C_2H_6	39.27	36.4	32.20	21.3	40.0
C_3H_6	1.09	1.47	1.48	1.57	1.26
C_3H_8	0.21	0.14	0.14	0.13	0.18
C_4H_6	1.12	0.88	1.74	2.06	1.92
C_4H_8	0.21	0.14	0.6	0.12	0.17
C_4H_{10}	0.30	0.20	0.18	0.12	0.23
C_{5+}	1.60	1.96	3.0	3.7	0.37

IV. DISCUSSION

In recent years, worldwide ethylene production tends to use liquefied hydrocarbon gases as raw materials [5]. At the same time, problems arise in the joint pyrolysis of various hydrocarbons - raw materials and recycle streams. The opinions of researchers differ. So, G. Froment et al. [2] considers that the yield of ethylene in the combined pyrolysis of ethane and propane, ethane and butane, as well as propane and butane, falls in comparison with those processes where hydrocarbons are pyrolyzed separately to the same degree of conversion. According to A. Mola [2], the combined pyrolysis of ethane with propane contributes to an increase in ethylene yield by 1.5% compared to the separate pyrolysis of these hydrocarbons. Using the Terasug program, the authors calculated the combined and separate pyrolysis of ethane with propane at their various contents in the mixture. Table 3 shows the results of calculations (for comparison, the results of calculations of separate pyrolysis of these hydrocarbons at the same degrees of their conversion as in joint pyrolysis are given) [5].

Table 3. Results of the process of combined and separate pyrolysis of ethane and propane.

Indicator	Composition of the initial mixture					
	$25\%C_2H_6+75\%C_3H_8$		$50\%C_2H_6+50\% C_3H_8$		$75\%C_2H_6+25\% C_3H_8$	
	Joint	separate *	Joint	separate *	Joint	separate *
Exit, %:						
H_2	1,66	1,51/1,72	1,93	1,89/2,03	2,3	2,38/2,44
CH_4	15,43	14,52/14,73	11,71	10,52/10,71	7,63	6,19/6,27
C_2H_4	30,56	27,9/30,7	31,89	30,14/32,06	33,74	32,88/32,96
C_2H_6	18,36	21,85/18,36	31,07	32,43/31,07	42,89	43,87/42,89
C_3H_6	12,33	12,61/12,65	8,26	8,83/8,85	4,63	5,08/5,1
C_3H_8	13,03	13,03/13,03	8,72	8,72/8,72	4,6	4,6/4,6
Transformation degree, %:						
Ethane	26,6		37,9		43,0	
propane	82,6		82,6		82,6	
Exit, C_2H_6 from C_3H_8, %	--	3,55/--	--	2,39/--	--	1,07/--

* - the indicator shows the values of indicators taking into account the complete conversion of ethane formed from propane during separate pyrolysis.

V. CONCLUSION

It has been considered that separate pyrolysis produces ethane from propane, which must be completely converted, and the pyrolysis products thereof are combined with the pyrolysis products of propane. Calculations show that ethylene yield at co-pyrolysis is higher than at separate ethylene yield only at ethane content of more than 70% in the mixture; the difference can reach 2-3% (elev.). However, at any ratio of hydrocarbons in the mixture at co-pyrolysis, the yield of propylene is lower and methane is higher than their yield at separate pyrolysis. Besides, at pyrolysis of ethane together with other hydrocarbons the extent of transformation of C_2H_6 is low that leads to increased load on the compressor and the system of gas separation.

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