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Development of the Technology of Obtaining the Inner Layer of Composite Panels on the Basis of Polyethylene in the "Shurtan Gas Chemical Complex"

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Abstract Composite panels are integral components in various industrial applications, necessitating continuous improvements in their physical and mechanical properties. This study investigates methods to enhance these properties specifically at the Shurtan Gas-Chemical Complex, focusing on the incorporation of both primary and secondary polyethylene granules from diverse brands. The research employs a comprehensive approach involving experimental analyses encompassing mechanical testing and material characterization to optimize the composition of composite panels. The primary objective is to achieve superior performance characteristics while concurrently ensuring the production of high-quality liquid products. By systematically varying the types and proportions of polyethylene granules, the study evaluates their impact on critical parameters such as tensile strength, impact resistance, and thermal stability. The findings underscore the effectiveness of this approach in significantly improving the overall quality and functionality of composite panels. The research contributes valuable insights into advancing manufacturing processes within the gas-chemical industry. It underscores the feasibility of integrating various polyethylene sources to enhance product durability, sustainability, and economic viability. Ultimately, this work seeks to inform and guide future developments in composite panel production, aiming to meet evolving industrial demands for robust and versatile materials.

Keywords Polyethylene, Density, Yield index, Tensile strength, Shore hardness, Fraction composition

1. Introduction

Currently, the production of polymer composite materials occupies an important place in global industry. As you know, today it is very difficult to imagine the construction industry without three-layer composite panels. There are several examples of this, one of the main reasons for this is the wide range of physical and mechanical properties and advantages of this product. Today we are witnessing the use of three-layer composite panels in various fields, for example, exterior decoration of ventilation systems, facades of new and reconstructed buildings, cladding of balconies, cornices and canopies, cladding of gas stations, tunnels and pillars, various special and non-standard objects, etc. These can offer a long service life (50 years), insulation and protection, ease of processing, availability of various colors, etc.

In the Republic of Uzbekistan over the past few years, a number of enterprises have been formed for the production of aluminum plastic profiles - various finishing materials used for interior and exterior decoration of buildings. For example, "ALCO", "ALSTAR", "AND-POLIC", "ALUCOBOND" and others.

Three-layer composite panels are in great demand for finishing the exterior facades of new and reconstructed buildings.

The purpose of this article is to improve the physical and mechanical properties of three-layer composite panels produced at Shurtan gas chemical complex using primary and secondary polyethylene granules and to obtain highly marketable products.

2. Objective

The aim of the study is to create a technology for the production of three-layer composite panels and the production of an inner polymer layer based on secondary raw materials produced in Shurtan GCC, determine the optimal formulation, polymer grades, select the technological mode and improve the physical and mechanical characteristics of a three-layer composite panel.

Today, all manufacturers in the Republic of Uzbekistan use different grades of polyethylene from Shurtan GCC for the production of three-layer composite panels. Shurtan Gas Chemical Complex produces 16 grades of polyethylene with a density of 0.918 to 0.965 g/sm^3, and a flow rate of 0.19 to 30 g/10 min. About 130 thousand tons of polyethylene

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granules are produced annually, of which more than 30-35% is used for the production of three-layer composite panels.

3. The Experimental Part

The technological process of the three-layer composite panel uses secondary grades of polyethylene. For the application of secondary grades of polyethylene and the production of highly liquid products, different grades of secondary raw materials are used. Linear polyethylenes of the LLDPE, MDPE and HDPE grades which are produced by "Shurtan GCC" LLC were selected as a matrix for filling (Table 1).

In the article, I would like to focus on the preparation of samples, the formulation of raw materials and the results obtained.

Table 1

№	Grades of polyethylene	Density, g/sm³	Melt flow rate, g/10min	Toughness at stretching, MPa	Toughness at rupturing, MPa	Shore hardness, unit of measurement: Shore
1	**Pipe**	0,936 ÷ 0,958	0,27 ÷ 0,56	16 ÷ 30	30 ÷ 31	62 ÷ 67
2	**Film**	0,92 ÷ 0,946	0,23 ÷ 3	10/11 ÷ 18/18	26/28 ÷ 18/51	0
3	**Injection**	0,925 ÷ 0,961	4,9 ÷ 25	10 ÷ 26	26 ÷ 27	52 ÷ 65
4	**Rotary**	0,933 ÷ 0,948	2,7 ÷ 4,0	15 ÷ 20	0	56 ÷ 58
5	**Cable**	0,934	0,38 ÷ 0,72	14 ÷ 15	16	62 ÷ 64

4. Experimental Results and Their Discussion

Table 2. Fractional composition of calcium carbonate

№ sit	Particle size, microns	Residue on sieve	
		in gr.	in %
Sample – 1 (Natural calcium carbonate of Kitab mine)			
0335	355	0,238	0,24
025	250		0
024	240		0
02	200	0,0517	0,053
0105	105	0,8186	0,83
008	80	2,167	2,2
0056	56	2,758	2,8
005	50	4,728	4,8
Sample – 2 (Natural calcium carbonate of Yangiyul mine)			
0335	355	--	--
025	250	--	--
024	240	--	--
02	200	--	--
0105	105	--	--
008	80	0,135	13,5
0056	56	0,185	18,5
005	50	0,175	17,7

Sample-1 10.9% of the sample taken for analysis, and 89.1% of the sample taken for analysis passed through the sieve No. 005;
Sample-2 49.7% of the sample taken for analysis, and 50.3% of the sample taken for analysis passed through the sieve No. 005;

Table 3. Volumetric weight and specific volume of fillers

№	Filler	Volumetric weight, g/ sm³	Specific volume, ml/g
1	Sample-1	0,92	0,57
2	Sample-2	0,915	0,54

In order to fulfill the tasks set, samples of composite panels were obtained to determine the optimal formulation based on different grades of polyethylene, the choice of technological mode and physico-mechanical characteristics. At the same time, to regulate the physical and mechanical properties and suffocation, local raw materials were introduced into the formulation of the middle layer of the panels - natural calcium carbonate from Kitab and Yangiyul mines. The fractional composition, volumetric weight and specific volume of fillers are presented in Tables 2 and 3.

Calcium carbonate as a filler of polymer materials has such advantages as wide variation of particle sizes and particle size distribution, ease of applying various coatings to the surface of particles to improve the rheological properties of filled polymer materials and resistance to temperatures up to 550℃.

To determine the most rational method of processing the source material and the resulting compositions, a melt flow index test was performed using method A according to GOST 11645-2021 with a load of 2.16 kg and a temperature of 190℃ (Table 4).

Table 4. Melt flow rate of the resulting compositions and starting polymer material

Substance	Density, g/sm³	MFR, g/10 min
Initial PE (0% weight)	0,920÷0,946	0,3÷5
Composition 1 (PE 90 K 10)	1,0	0,25÷4,6
Composition 2 (PE 80 K 20)	1,05	0,23÷4,0
Composition 3 (PE 70 K 30)	1,1	0,2÷3,8
Composition 3 (PE 60 K 40)	1,15	0,18÷3

With a filler content of 40 wt. % there is a decrease in the MFR value by 0.6 times compared to the MFR of the original polymer. With a subsequent increase in filler content by 10 wt. % and 20 wt. The % melt flow rate expectedly continued to decrease from 4.6 and 4.0 g/10 min, respectively, compared to the MFR of the original polymer material.

Table 5. Melt flow rate of the resulting compositions

Name	MFR value, g/10 min	Name	MFR value, g/10 min
Sample-1	3.32	Sample-7	2.93
Sample-2	2.65	Sample-8	2.36
Sample-3	3.08	Sample-9	2.06
Sample-4	3.4	Sample-10	2.04
Sample-5	3.3	Sample-11	2.498
Sample-6	2.71	Sample-12	3.19

But to assess the technical properties of materials, only the MFR value is not enough, because to a greater extent the conclusion is based on the physical and mechanical properties of the compositions.

In the process of manufacturing and testing samples of three-layer composite panels on technological equipment, the influence of different grades of polyethylene on their properties was studied (Tables 5-7).

The polyethylene grades used are encrypted A, B, C and others. The dimensions of the manufactured products are equal to – 1220 x 2440 x 4mm.

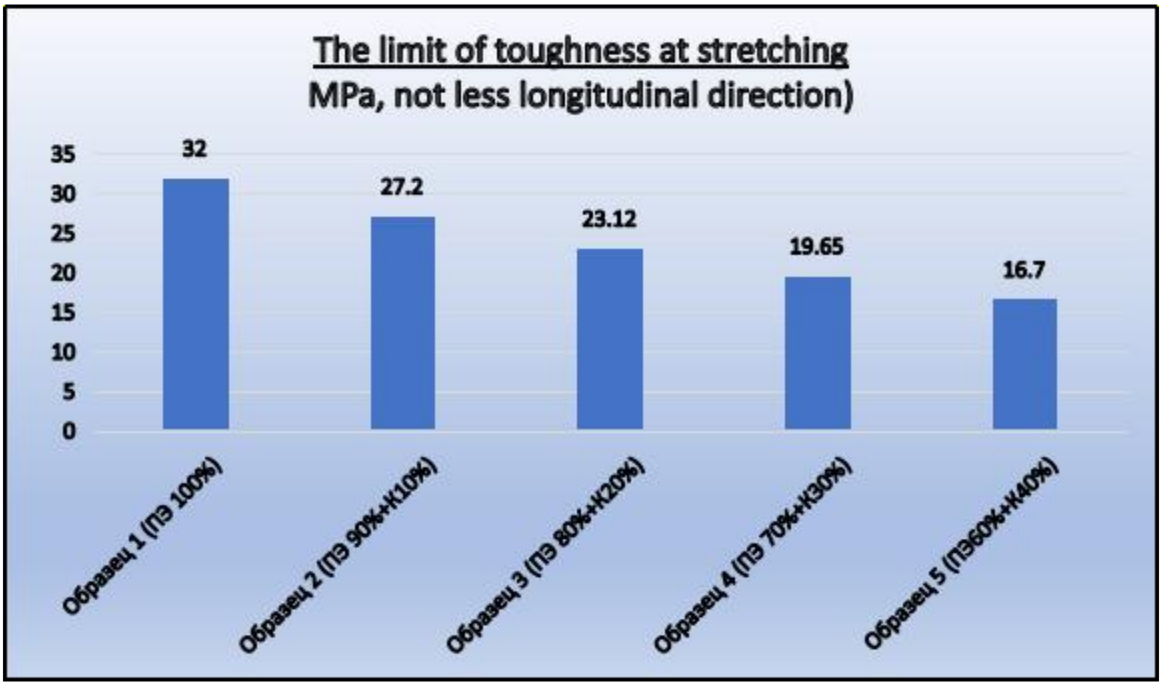
Table 6. Density of the resulting compositions

Name	Density, g/ sm³	Name	Density, g/ sm³
Sample-1	0.9241	Sample-7	0.9231
Sample-2	0.9254	Sample-8	0.9295
Sample-3	0.9235	Sample-9	0.923
Sample-4	0.9242	Sample-10	0.9276
Sample-5	0.9243	Sample-11	0.932
Sample-6	0.9272	Sample-12	0.9244

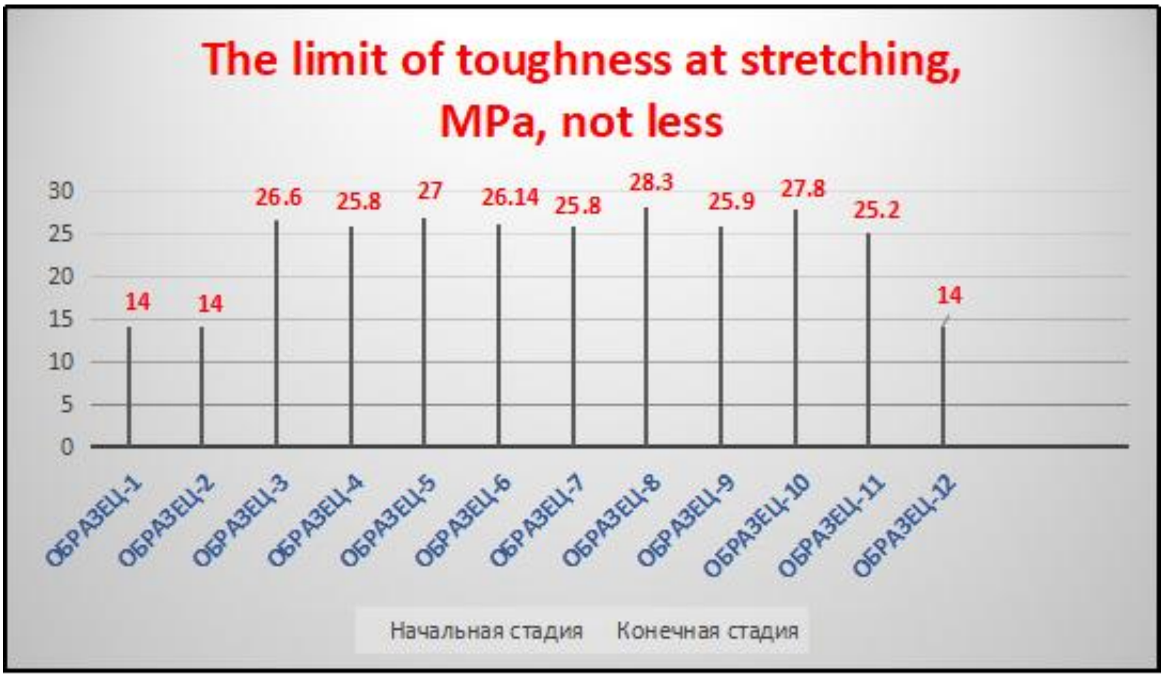
Table 7. The composition of the inner layer of polyethylene for the production of three-layer composite panels

№	Samples	The ratio of the inner layer of polyethylene, %	The limit of toughness at stretching, MPa, not less	The limit of toughness at rupturing, MPa, not less	Heat resistance of decorative paintwork at 110 C
1	**Sample-1**	A : B : C (38,5% : 38,5% :23,0%)	14	12	persistent
2	**Sample-2**	A : B : C (38,5% : 25% : 36,5%)	14	12	persistent
3	**Sample-3**	A : B : C (47% : 23,5% : 29,5%)	26,6	12,3	persistent
4	**Sample-4**	A : B : C (37% : 33,3% : 29,7%)	25,8	11,4	persistent
5	**Sample-5**	A : B : C (17,24% : 55,17% : 27,6%)	27,0	11,3	persistent
6	**Sample-6**	A : B : C : D (14,28% : 45,27% : 22,8%: 17,14%)	26,14	12,1	persistent
7	**Sample-7**	A : B : C : D (12,82% : 51,28% : 20,5%: 15,38%)	25,80	8,5	persistent
8	**Sample-8**	A : B : C : D : E (21,27% : 14,9% : 21,27%: 25,53% : 17,03%)	28,30	9,6	persistent
9	**Sample-9**	A : B : C : D : E (10,4% : 31,2% : 20,8%: 16,6% : 20,08%)	25,90	7,8	persistent
10	**Sample-10**	A : B : C : D : E : L (10,3% : 10,5% : 20,8%: 20,8% : 16,6% : 20,08%)	27,80	10,5	persistent
11	**Sample-11**	A : B : C : D : E : L (20,0% : 20,0% : 20,0%: 8% : 16,0% : 16,0%)	25,20	10,9	persistent
12	**Sample-12**	A : B : C (37,5% : 37,5% : 25,0%)	14,00	12	persistent

According to the Table, the following graphical dependencies were obtained, shown in Fig. 1, 2.

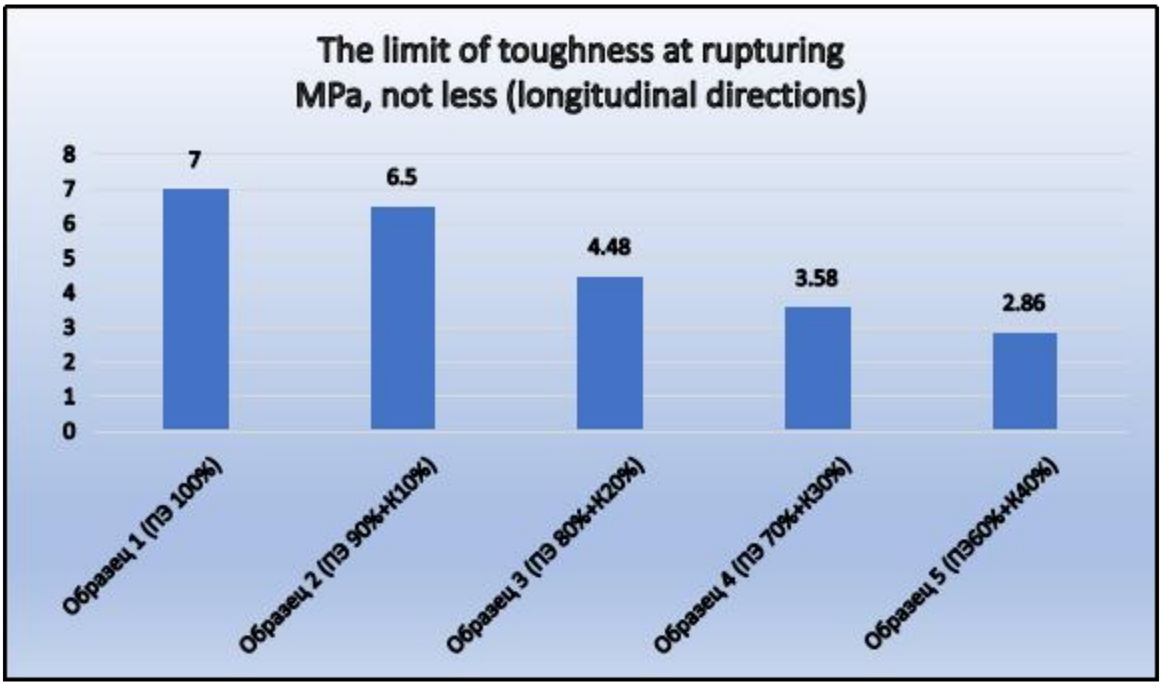


The limit of toughness at stretching (PE ÷ K 40).

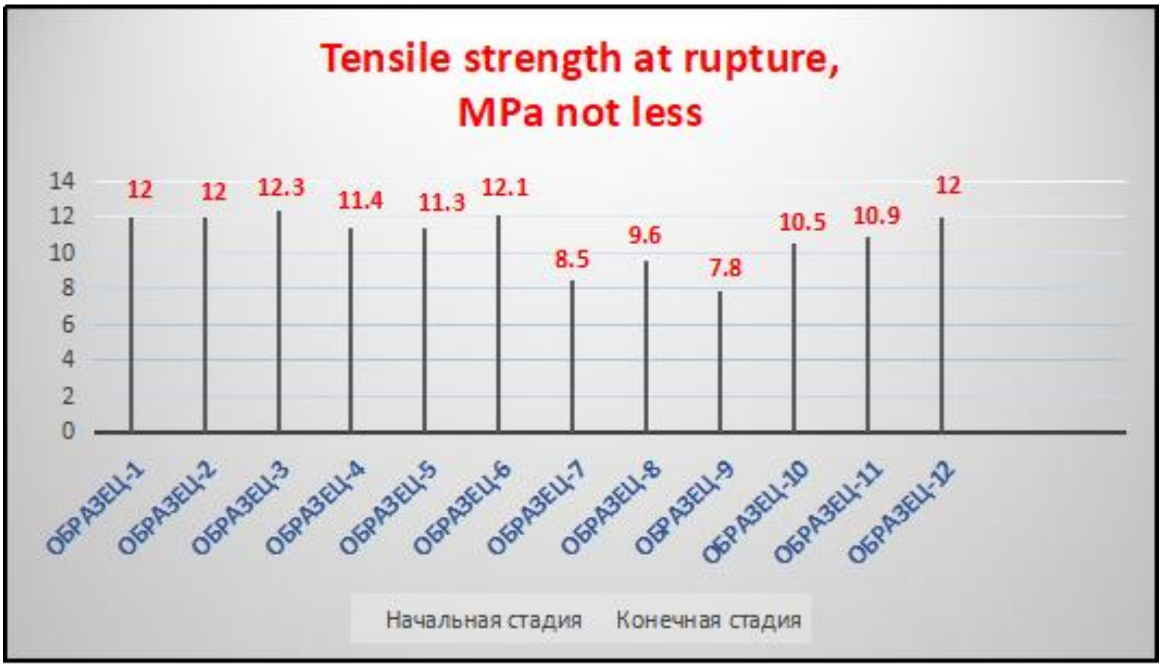


The limit of toughness at stretching (ratio of polyethylene components)

Figure 1



The limit of toughness at rupturing (PE ÷ K 40).



Tensile strength at rupture (ratios of polyethylene components).

Figure 2

5. Conclusions

The main purpose of the work is to determine the optimal formulation of polyethylene grades of Shurtan GCC for the production of three-layer composite panels and analyze the selection of the technological regime, as well as to improve the physical and mechanical properties of the produced three-layer composite panels. Based on production factors (technological mode of equipment) and laboratory tests, we have determined:

To produce three-layer composite panels, it is necessary to use injection grades of primary and secondary grade polyethylene;

1) The composition of injection grades should not exceed 14% to 16%.
2) In the production cycle of secondary grades of polyethylene granules, it is not required to use mineral additives such as calcium carbonate.

The use of recycled polyethylene allows not only the use of local raw materials, in addition to obtaining highly liquid products, but also will attract new jobs and profits due to new products.

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