«Nizhnekamskneftekhim» new pyrolysis furnaces of SRT-VI type were put into commercial operation. They can work both on gas raw materials (propane and butane) and on straight-run gasoline. Two new furnaces of SRT-VI type will be able to replace 4 old ones, because they have higher power and selectivity [4].

To develop a mathematical model of a pyrolysis furnace with a coil of SRT-VI type we will use the data of the ethylene plant «Nizhnekamskneftekhim». For the basis of the SRT-VI furnace model we will use the SRT-II furnace model, which is described in detail in [1–3]. Taking into account the design features of the pyrolysis furnace it is presented as a model of a polytropic reactor of ideal displacement and includes [2]: equations of material balance, heat balance, hydrodynamics and others describing the change in flow characteristics along the length of the coil.

The SRT-VI furnace has a coil with 16 inlet and 4 outlet pipes. Since the coil at the inlet and outlet has a different number of pipes the coil is divided into zones. And the calculation is carried out in the furnace zones, in each zone its diameter, length and number of pipes are given.

The device of these furnaces will help to increase the yield of target products. The introduction of more modern furnaces into the pyrolysis unit will reduce the consumption of fuel gas and the emission of harmful substances into the atmosphere. The main advantages of the new equipment are its energy efficiency and environmental safety [4].

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CHARACTERISTICS OF COATINGS BASED ON MALEINIZED ALIPHATIC PETROLEUM RESINS

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The raw materials for petroleum polymer resins (PPR) are cheap and affordable liquid pyrolysis products that formed in a large quantity in petrochemical plants. But as independent film formers PPR are rarely used, since there are no functional groups in their composition, which negatively affects to their properties. It is necessary to introduce various functional groups into the composition of the molecule for improving performance and significantly expand the areas of application.

In this work, the raw material for the preparation of modified petroleum resins are PPR samples based on the C_5 fraction (PPR_{C5}): PPR_{C5O} resins obtained by polymerization of unsaturated compounds of the C_5 fraction under the action of $TiCl_4$ – $Al(C_2H_5)_2Cl$ and the PPR_{C5K} resin that produced under the Hikorez brand (Kolon Industrial Product, Korea) [1].

The purpose of the work is to synthesize PPR_{C5} modified with maleic anhydride and polyethylene polyamine and to study the properties of paint coatings based on them.

Synthesis of modified resins is carried out into two stages: maleinization of PPR_{C5} and imidization of maleinated PPR_{C5}.

The maleization of PPR_{C5} is carried out at the temperature of 160 °C – 2 hours and at the temperature of 180 °C – 4 hours. At the temperature of 60–80 °C we precook prefabricate: a mixture of PPR and maleic anhydride (MAN). The ratio of components is 90–10 % mass. According to the completion of the synthesis check the solubility of the samples.

The syntheses of maleinization of PPR_{C5} samples showed that the interaction of PPR_{C5O} with MAN leads to the formation of a non-melting and insoluble sample (PPR_{C5O-10}). This fact is associated

Table 1. Properties of Resins and Resin-Based Coatings

Sample	Adhesion point	Adhesion, kgf/cm^2	Hardness, kg
PPR_{C5O}	4	4.48	0.4
PPR_{C5K}	4	3.99	0.4
PPR_{C5O-10}	U	U	U
PPR_{C5K-10}	2	4.98	0.4
$PPR_{C5K-10(1:0,5)}$	2	6.48	0.4
$PPR_{C5K-10(1:1)}$	1	7.48	0.4

with increased unsaturation of PPR_{C5O} and, probably, the production of a cross-linked structured product in the process of maleinization. A sample of PPR_{C5K} resin is hydrogenated, and maleinization leads to the formation of a soluble products (PPR_{C5K-10}).

Imidization of maleinized PPR_{C5K-10} is carried out with polyethylene polyamine (PEPA) for 2 hours at a temperature of 120 °C and a molar ratio of MAN : PEPA of 1 : 1, 1 : 0.5.

As a result, PPR_{C5K-10} (1 : 0.5) and PPR_{C5K-10} (1 : 1) resins were obtained respectively with improved characteristics of the properties which are listed in Table 1. The coating characteristics were investigated by using standard methods [2–3]: the method of lattice cuts, the method of quantitative determination of adhesion of paints and varnishes by the pull-off force, the method of determining the hardness of a paint and lacquer coating.

Thus, modified PPR_{C5} resins were synthesized by maleinization and imidization.

The comparison of the technical characteristics of coatings based on them showed us a higher adhesion of coatings compared to the coatings with using unmodified resins.

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PROCESS INTEGRATION AND OPTIMIZATION IN CHEMICAL ENGINEERING

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1. Introduction

Process integration is a holistic approach to process design which involves the following general activities [1]:

1) Task definition: expression of the design criterion as a quantifiable function of selected design variables and constraint identification; 2) Generation of alternatives: definition of a search space that includes all the possible alternatives for flowsheet configuration and process conditions; 3) Selection of alternatives: Determination of the optimum – the alternative that best meets the design criterion and constraints

The selection of alternatives can be carried out with optimization techniques. This approach can yield globally optimal design solution, surpassing the limitations of graphical and heuristic decision tools [1].

2. Design task as an optimization problem

In a process integration framework, the design task can be defined as a mixed non-linear optimization program, as shown in equations (1)–(3) [2].

The flowsheet variables express the structure of