Analysis of materials for elaboration of national products

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Abstract. This article analyzes the information about the developed, introduced, industrially mastered domestic composite materials on domestic raw materials according to the developed technologies for their production and application in industry, which allows recommending these developments as import substitution of dishes used by Russian manufacturers with non-stick coating of composite materials. The reducing of the dependence of the imported raw materials and components is not just a slogan. It is the prospect of using PTFE in dispersion-filled coatings due to a number of its unique properties: an abnormally low friction coefficient among structural materials (0.04-0.05 for steel without lubrication); high temperature resistance (decomposition onset temperature 418 °C); high chemical stability (reacts only with melts of alkali metals, elemental fluorine at high temperatures); possesses excellent insulating properties. Based on the data on the Russian-made fluoroplast containing materials and coatings for various operational purposes created and introduced into production, it can be confidently stated: each of the developments individually and in the complex is import-substituting for technological, technical and quality indicators performed on domestic raw materials.

1. Introduction

Import substitution in modern Russia began after the 1998 crisis. Earlier, in the 1990s, as result of liberal reforms and the collapse of the system of industrial relations that existed in the USSR, there was a double drop in industrial production in the Russian Federation. Since 2014, import substitution has intensified sharply against the backdrop of the Ukrainian crisis and anti-Russian sanctions imposed after the reunification of Crimea with Russia.

In recent decades, Teflon, or fluoroplast-4, has gained great popularity. This milky-white plastic material has become known to the general public through its use in the manufacture of non-stick cookware (Tefal). But this scope of the polymer is not limited.

The reducing of the dependence of the imported raw materials and components is not just a slogan. It is the prospect of using PTFE in dispersion-filled coatings due to a number of its unique properties: an abnormally low friction coefficient among structural materials (0.04-0.05 for steel without lubrication); high temperature resistance (decomposition onset temperature 418 °C); high chemical stability (reacts only with melts of alkali metals, elemental fluorine at high temperatures); possesses excellent insulating properties.
2. Materials and methods

Analysis of the complex of positive properties of ftoroplast

Complex of positive properties of ftoroplast

Ftoroplastics or Fluoroplastics are fluorinated polymers belonging to the group of structural plastics. The most famous varieties of these polymers include:

- fluoroplast-4 (polytetrafluoroethylene (\(-C2F4\)) n, trademarks - Teflon, Hostaflon TF, Fluon G, Algoflon F, Polyflon M);
- fluoroplast-3 (polytrichlorofluoroethylene (\(-CF2CFCl\)) n, trademarks - Dyflon, KEL-F, Voltalef, Neoflon CTFE);
- fluoroplast-2 (polyvinylidene fluoride (CH2CF2) n, trademarks - Kynar, Solef, Neoflon VDF);
- fluoroplast-40 (copolymer of tetrafluoroethylene (CF2CF2CH2CH2) n, trademarks - Tefzel, Hostaflon ET, Neoflon ETFE).

Despite the lowest coefficient of dry friction among polymers, fluoroplastics are not mutual analogues of each other, differing in a number of technical characteristics.

- in mechanical engineering. Due to its resistance to abrasion and exposure to aggressive environments, seals, bearings, piston rings, anthers, and car tires are made from polymer. Resistance to heat allows you to make parts for motors from it;
- in electrical and radio engineering. The material can be used as an insulator or current conductor (when making modifications to its molecular structure). PCBs, cables, relay elements and switches are made from polytetrafluoroethylene.
- in light industry. Processing of products with this polymer makes them waterproof.
- in the chemical industry. Teflon is used for the production of laboratory glassware, including anti-corrosion tubes for chromatographs.
- in medicine. The use of fluoroplastic in the manufacture of prostheses of blood vessels and internal organs is due to the fact that it does not cause immunological reactions.
- in the food industry. Teflon is used in the production of frying pans and baking dishes with non-stick coating, syringes for creams, containers for perishable products, rolling mechanisms for dough.

The popularity of fluoroplast-4 is due to its technical characteristics. It is a substance that in appearance resembles polyethylene or paraffin, and is characterized by softness and fluidity. Its density is 2.18–2.21 g / cm³ (GOST 10007–80).

This material is characterized by heat resistance - its flexibility and elasticity are preserved at temperatures from -70 to +270°C, as well as adhesion, minimal surface tension, and resistance to ultraviolet rays, moisture, fats and organic solvents. It is physiologically and biologically safe.

PTFE production in Russia is carried out in three stages. In the first of them, by the Swarts reaction, chlorodifluoromethane is obtained. Then tetrafluoroethylene is obtained from it by pyrolysis. In the third stage, the polymerization of tetrafluoroethylene produces a fluoroplastic powder.

PTFE has a number of significant drawbacks: difficult to process; fragile in products; unstable under pressure drops and loads (flowing); insufficiently wear-resistant in tribo-bonded systems (wear is 4–5 times greater than in polyamides, polyethylene); the fluoroplastic suspension forms a porous, non-elastic coating, completely lacking adhesive strength to the substrate of any metal. The main characteristics of Ftoroplast are presented in table 1.
Table 1. Comparison of the characteristics of different types of fluoroplasts.

| Characteristic               | Fluoroplast 4 | Fluoroplast 3 | Fluoroplast 2 | Fluoroplast 40 |
|------------------------------|---------------|---------------|---------------|---------------|
| Density, kg/m³               | 2150–2240     | 2090–2160     | 2090–2160     | 1700          |
| Destructive stress, MPa      |               |               |               |               |
| - Stretching                 | 16–35         | 35–43         | 44–55         | 27–50         |
| - Compression                | 10–12         | 55–60         | —             | 50            |
| - Bend                       | 14–18         | 60–80         | —             | 34            |
| Temperature, °C              |               |               |               |               |
| - Melting                    | 270–327       | 210–215       | 150–175       | 265–275       |
| - Glass transition           | 127           | 50            | -30...-20     | -90           |
| - Decomposition              | 425           | 320           | 400           | 400           |
| - Operation / exploitation   | -260...+260   | -195...+190   | -45...+150    | -200...+200   |
| Resistivity, ohm/m           | $10^{17}$–$10^{18}$ | $10^{15}$–$10^{17}$ | $10^{20}$–$10^{13}$ | $10^{16}$ |

The application of the set of positive properties of fluoroplast, while eliminating its drawbacks, one of the first in the 50s of the twentieth century was able to American scientists in solving the problem. “To facilitate the work of women when washing dishes” by developing composite materials, which when applied to the surface of metal products with subsequent heat treatment, form a coating with non-stick properties was one of the problems.

Non-stick coating materials under the trademark Teflon-2 entered the world market in the 1980s. 30 years went into revision. In the Soviet Union, these materials appeared in 1982 simultaneously with two Dutch ferro lines purchased, each amounting to 5 million rubles. The lines were built in the
related metallurgical plants: KUMZ in Kamensk-Uralsk - Sverdlovsk Region and "Kalitva" in the city of Belaya Kalitva - Rostov Region. Since 1982, we have known the charm of non-stick cookware!

Compositions "Teflon-2" of DuPont (USA) for dollars flowed in the USSR "River" until 1986 - 4 years. About 400 tons per year. The task for the development of domestic non-stick materials in 1985 was received by the Novocherkassk Synthetic Products Plant (NZSP). It was situated in Rostov Region. On the one hand, it is 150 km from the Kalitva factory, a manufacturer of tableware and a consumer of materials, and on the other, the most important thing is a highly organized chemical factory with trained personnel.

Analysis of the coating requirements

The requirements for coatings were known about Teflon-2 materials: lack of porosity, food sticking, milk burning, good adhesion to aluminum (cookware made from extruded aluminum), heat resistance, good presentation and decorative appearance. US patents were pending. Publications on multicomponent polymer systems in the scientific and technical literature were practically absent.

Series of modifying additives were picked for the experiments. They included film-forming, binding polymers; surfactants; sizing mixtures of solvents; agents that increase wear resistance, adhesive strength with metal, etc. As result of hundreds of experiments, we were able to akin these heterogeneous components into a single homogeneous system, provide the technological properties required when applying materials: viscosity, flowability, lack of sedimentation and coagulation during application, transportation and storage for a long period without changing properties.

We managed to eliminate the complex of negative properties of fluoroplastic. In 1985 - 1986 we introduced the composite materials for non-stick coatings at the NZSP (design production capacity - 400 t / year) and at KUMZe that are not inferior in properties, but in a number of indicators superior to foreign analogues, in particular, "Teflon-2" - for dishes, baking equipment, allowed by the Ministry of Health for contact with food.

Imports replacement with domestic products

Analysis of the imports replacement with domestic products development

Replacing imports with domestic development allowed:

1. Save 2 Dutch foreign currency lines Ferro intended for processing Teflon-2 materials and use them to process our materials that are fully consistent with all American technological and quality parameters of the American counterpart (results of testing coatings and compositions by American and Dutch specialists);

2. Exclude the waste of currency on the purchase of imported analogues. Thus, we can distinguish three main components of maintaining the stability of the territory: 1) ensuring the vital activity of the population; 2) production capacity of the economy; 3) the number of victims in the territory under consideration for a specified period of time. In this case, the impact is characterized by the degree of lesion of the management of regional, urban and municipal systems.

Developers in 1989 were awarded the Prize of the Council of Ministers of the USSR.

The list of non-stick coated products is wide and diverse:

In almost 3 years (1985 - 1988), in addition to Teflon analogues, composite materials for heat-resistant, anticorrosion, wear-resistant, and antifriction coatings were developed and introduced, in addition to the Teflon analogues, not supplied to the USSR, but very needed by our industry. The production of coating materials at the NZSP before perestroika was 12-14 tons per month.

Development and improvement of materials based on fluoroplastic analysis

Despite the cessation of the industrial production of Adgelast materials since 2005, due to the general situation in the country, the development and improvement of materials based on fluoroplastic, given its unique properties and wide possibilities, have not stopped. New series and a wide range of materials for coatings for various operational purposes have been improved and developed, in particular:

1) Non-stick - “Adgelast” - a trademark for kitchen utensils, baking molds, confectionery baking sheets, electric waffle irons, electric grills, deep fat fryers, patty units, coffee makers, thermal flasks, cookware sets for military personnel, geologists, long-lasting in field conditions, thermal flasks, flasks
come in picking for tanks exported to eastern countries; kitchen appliances and utensils - knives, drushlaks, ladles, etc.

The color range of coatings has been developed - more than 25 colors on domestic and imported pigments.

The hygienic safety of the coatings is confirmed by Certificates of the Russian Federation.

2) Aggressive - for application on molds (pressing rubber products, polyurethane automotive caps; polymer blanks for shoe soles, gaskets for table tennis rackets, etc.); on thermocouples, valves of chemical equipment; thermal knives when gluing a plastic film (production of chips); inserts in inhalers; plugs for oil pumping units; chemical water treatment tanks; medical sterilizers and tanks for sterilization of canned food; containers for storing wine and chemically aggressive waste; samplers for sampling water from the deep sea; shut-off ball valves; equipment and devices of the special purpose of long-term storage, etc.

3) Release - wear-resistant - for applying to the soles of irons, in order to prevent adhesion of fabrics when ironing; on guides; stubs; friction shock absorbers; circular and band saws, in order to save sawing material and extend the performance of saws; wedge and paint baths in the printing industry; photocopy rollers; automobile pistons, etc.

3. Results and discussions

The Analysis of patent information and experiments on the reproduction of a number of proposed compositions for antifriction coatings showed their inconsistency with the set of requirements for the working conditions of a pressure bearing: with a low coefficient of friction, high heat resistance, limited performance, brittleness, sliding of the coating onto the bearing rotor predominate.

Foreign companies manufacturing hydraulic fractures protect their construction and coatings as a trade secret, but their design is relatively simple. The bearing surface of the bearing is formed by the thin elastic metal plates. Depending on the conditions under which the LHP operates, they change their shape to create the optimal gap geometry. The use of this type of support can significantly reduce the number of failures of high-speed turbomachines. The predicted service lives of turbomachines with LGD bearings are approaching 300 thousand hours.

The ECAO laboratory conducted accelerated life tests (on the "start-stop" mode) of a bearing with a 50 mm axle diameter. After 30,000 cycles, the bearing remains in good condition. The MPEI studies on an AIS-2 coated radial bearing managed to achieve a maximum specific static load of 30 kPa (a standard value of 15 kPa). Starting from the 70s, support nodes of small turbomachines were created, in which axial and radial bearings (thrust bearings and bearings) of a new type are used — petal gas-dynamic bearings, which, compared with other types, have a long service life, heat resistance, autonomy.

Several standard sizes of support units for rotors from 0.1 to 40 kg with rotation frequencies from 16,000 to 200,000 rpm have been developed. In a 2003 US publication, it says: “The required performance properties of polymer composite materials can be obtained by modifying the polymer, its matrix, in various ways, however, their number is very limited for PTFE.” In this regard, the search for new ways to modify PTFE and the development of composite polymer materials based on it with a set of improved operational and technological characteristics is an urgent problem in the field of creating tribotechnical materials."

Therefore, we are 10 years earlier than the authors of the article (Western scientists). We expanded the limitations of the methods for modifying the matrix by adding additives, changed the approach to the properties of fluoroplastic, leveling negative, improving - positive properties, and developed our own method for producing polymer-polymer tribological materials with high operational properties, having solved "an urgent problem in the field of creating tribotechnical materials.

4. Conclusion
Based on the data on the Russian-made fluoroplast containing materials and coatings for various operational purposes created and introduced by us into production, we can confidently state: each of the developments individually and in the complex is import-substituting for technological, technical and quality indicators performed on domestic raw materials.

The list of implemented developments includes:
1) Technologies for preparing the surface of metals (cast and rolled aluminum, alloy steel, special steel and carbon, bronze, brass, cast iron);
2) Compositions of composite materials for coatings for various operational purposes: primers, facing compounds (for internal and external coatings - a gamut of colors of more than 20), monosystems;
3) Technologies for the preparation of composite materials;
4) Technologies for coating application and heat treatment;
5) Methods of quality control of composite materials and coatings based on them;
6) Recommendations have been developed on the assembly of production shops and testing laboratories with a list of equipment and instruments necessary for the manufacture of compositions and their application to products. Training staff to work with the proposed water-containing compositions.

Thus, based on the development results, the following areas were identified that require attention and development:
1) Creation of competitive import substitution products.
2) Reducing dependence on imported raw materials and components.
3) Protect your own value chains.
4) Creation of new capacities, modernization of existing, increased labor productivity. Import substitution alone does not make sense for its own sake. We must exit the import substitution regime with a more competitive industry.

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