Application of the Polymeric Material RIMAMID for Production of Machine Parts

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Abstract. Modern polymeric materials have properties that, in some respects, exceed the properties of traditionally used materials (steel, aluminum and titanium alloys, wood). The uniqueness of the Rimamide polymer material is that it is possible to pre-design the material in such a way as to give the product from it the properties necessary for a particular application. The production of blanks and the use of Rimamide material for the manufacture of sliding and rolling bearings, bushings for wheels and rollers, pulleys, blocks, brackets, wheel hubs, gears, sprockets, gears and worm wheels and other parts to reduce weight, noise and vibrations. The characteristics of the material, examples of the manufacture of blanks, the advantages and disadvantages of the RIMAMID material for the manufacture of machine parts, prospects for use in mechanical engineering are shown. Due to their properties, they can be used in almost all industries. For example, modern aviation and space technology is characterized by the intensive use of new materials, technologies, and promising designs based on them. When using RIMAMID material using antifriction components (molybdenum sulfide, graphite, etc.), the friction coefficient is significantly reduced and the friction units can be operated without lubrication. The main advantages of this material is a low coefficient of friction for steel, which provides a 3-4-fold increase in the service life of parts in the friction units, as well as low weight, high strength, good machinability on metal cutting machines, resistance to aggressive environments, and environmental safety.

1. Introduction

The expansion of the use of polymers in the production of machine parts is due to their unique properties such as high specific strength (strength to density ratio), wear resistance, resistance to chemical influences, the possibility of varying properties over a wide range due to the modification of polymers and combining them with various ingredients, good dielectric characteristics, etc.

The use of plastics in modern engineering has reached a fairly high level compared to steel, due to a significant decrease in the mass of parts, an increase in durability, reliability, and a reduction in the cost of manufacturing parts. Moreover, due to the reduction of waste during processing, the utilization rate of materials increases significantly (the average utilization of plastics is approximately two times higher than for metals).
2. Statement of the research problem

RIMAMID polymer material [1] has good prospects for use in aircraft and automotive industries, as it allows you to replace heavy and expensive materials in the manufacture of machine parts and assemblies, such as stainless steel, aluminum, antifriction cast iron, porcelain, fluorine-plast, bronze, brass, textolite, wood-fiber plastics and other antifriction and structural materials [2]. The comparative density of materials for the manufacture of machine parts is shown in table 1.

In addition to low weight, the main advantage of this material is the low coefficient of friction on steel, which provides an increase in the service life of parts of the friction unit by 3 to 4 times. When using the RIMAMID material using antifriction components (molybdenum sulfide, graphite, etc.), the friction coefficient is significantly reduced and the friction units can be operated without lubrication [3].

RIMAMID material for a single production is made in the form of blanks (plate, rod, pipe, etc.) of various sizes for further machining into products on turning, milling and other processing machines (figure 1). To produce a batch of parts, casting technologies are used for the manufacture of blanks from RIMAMID material, which are as close as possible to the dimensions of the part being manufactured (figure 2) [4, 5, 6].

| Name of material | Density (kg / m³) | Comparative density with RIMAMID material |
|------------------|------------------|----------------------------------------|
| Copper           | 8900             | 7.77                                   |
| Bronze           | 8700             | 7.60                                   |
| Brass            | 8500             | 7.42                                   |
| Steel, iron      | 7800             | 6.81                                   |
| Cast Iron        | 7000             | 6.11                                   |
| Aluminum         | 2700             | 2.36                                   |
| Ftoroplast       | 2210             | 1.93                                   |
| RIMAMID          | 1145             | 1.00                                   |
| Kapron           | 1100             | 0.96                                   |
| Polyethylene     | 920              | 0.80                                   |

Due to the high wear resistance of the material (ten times greater than bronze) and a low coefficient of friction, the noise level in the sliding units is reduced, and it is also possible to use parts in dusty installation locations. In addition, the Rimamid material is highly resistant to dynamic shock loads, which can significantly improve the reliability of equipment in difficult conditions. High heat resistance of the material ensures long-term operation of products at temperatures from –40 to +160 °C while maintaining the properties of the material [7, 8].

Figure 1. Blanks for bushings and gears.
The material RIMAMID is manufactured and supplied by the following brands [2]:
- RIMAMID-200, which has high hardness and wear resistance;
- RIMAMID-200-U, which has high impact strength;
- RIMAMID-200-STU, which has an additional high heat resistance and light resistance.

The results of the study of the properties of the material “RIMAMID” produced by NPO “Start-Plast” are presented in table 2.

**Table 2. The Properties of the polymer material RIMAMID**

| No. | Name indicator | RIMAMID 200 | RIMAMID 200-U | RIMAMID 200-STU | Test methods |
|-----|----------------|-------------|---------------|-----------------|--------------|
| 1   | Melting point (°C) | 220–225     | 218–223       | 218–223         | GOST 21553   |
| 2   | Density (kg/m³)   | 1145–1150   | 1135–1145     | 1135–1145       | GOST 15139   |
| 3   | Tensile stress, tensile strength (MPa) | 80–85 | not less than 30 | not less than 30 | GOST 11262   |
| 4   | Relative elongation at break (%) | 25–30 | 25–40 | 25–40 | GOST 11262 |
| 5   | Tensile modulus (MPa) | 2800–3200 | 2200–2800 | 2200–2800 | GOST 9550 |
|     | Charpy impact strength of the specimen without notch (20° C) (kJ/m²) | 25–40 | without kink | without kink | GOST 4647 |
| 6   | Water absorption in 24 hours (%) | 1.0–2.0 | 1.0–1.5 | 1.0–1.5 | GOST 4650 |
| 7   | Maximum water absorption (%) | 2.5–3.0 | 1.5–2.0 | 1.5–2.0 | GOST 4650 |
| 8   | Thermal conductivity at room temperature (W/(m °C)) | 0.29 | 0.29 | 0.29 | GOST 23630.2 |
|     | Average coefficient of linear thermal expansion by 1°C in the temperature range from 0 to 50°C | 9.8·10⁻⁵ | 9.8·10⁻⁵ | 9.8·10⁻⁵ | GOST 15173 |
| 9   | Shore hardness D | 80–85 | 75–80 | 75–80 | GOST 24621 |
| 10  | Friction coefficient for steel without lubrication | 0.15–0.3 | 0.2–0.3 | 0.2–0.3 | GOST 11629 |
| 11  | Friction coefficient for steel with lubricant | 0.04–0.08 | 0.04–0.08 | 0.04–0.08 | GOST 11629 |
| 12  | Content of extractable substances (%) | 1.0–3.0 | 1.0–1.5 | 1.0–1.5 | GOST 17824 |
Currently, from the material “RIMAMID” are made:

- sliding and rolling bearings, bushings for wheels and rollers, guides and liners of friction units with or without lubrication [9];
- pulleys, blocks, support and guide rollers of hoisting mechanisms [10];
- brackets, wheel hubs and other parts that are subject to increased requirements for impact resistance (figure 3) [11];
- gears, sprockets, gear and worm wheels, screws, screws of various devices and mechanisms in order to reduce noise and vibration (figure 4), etc. [12].

3. Prospects for the use of RIMAMID

Modern polymeric materials possess properties that, in some respects, exceed the properties of traditionally used materials (steel, aluminum and titanium alloys, wood), and the higher the specific characteristics of the composite, the lighter or stronger the construction. The uniqueness of the RIMAMID polymer material is that you can pre-design the material in such a way as to give the product from it the properties necessary for a particular application [13].

Due to their properties, they can be used in almost all industries. For example, modern rocket and space technology is characterized by the intensive use of new materials, technologies, and promising designs based on them [14].

Due to their properties, they can be used in almost all industries. For example, modern rocket and space technology is characterized by the intensive use of new materials, technologies, and promising designs based on them. The development of the commercial sphere of application of new technologies and equipment in space and the global competition for receiving orders for the delivery of payloads to Earth’s orbit stimulate a decrease in the cost of launching cargo and force developers of rocket and space
technology to actively use composites to optimize the energy-mass characteristics of launch vehicles and increase the volume of payload [15].

Figure 4. Gears from the material RIMAMID.

In the future, it is possible to use RIMAMID material for the manufacture of car radiator grilles with subsequent metallization or surface painting, fan blades, sliding bearings, ventilation pipes, accelerator pedals, steering wheels, control buttons, interior parts, etc. [16].

The use of RIMAMID material has the following advantages over metals:

- The structure of the RIMAMID material is homogeneous, therefore, unlike metals, there are no phases of different hardness, microcracks do not form and uneven wear occurs [17].
- Gear wheels made of RIMAMID material do not form strong intermolecular bonds at the point of contact, therefore there is no pitting and braking of the wheels [18].
- During operation of parts made of RIMAMID material during wear, abrasive particles do not form, leading to wear of the working surfaces of the teeth and contamination of the lubricant [19].
- RIMAMID does not enter into an electrochemical interaction leading to surface oxidation [20].

4. Conclusion

The experience in the production, implementation and operation of Rimamide material at NPO “Start-Plast” enterprise revealed the following problems:

- large industries and consumers (aircraft, automotive, shipbuilding, energy, etc.) avoid the introduction of new materials, because additional tests, certification, development and approval of new standards are required. These processes are labor intensive and costly. In turn, the absence of large consumers impedes the further development of the production base for the
production of Rimamid material, the improvement and development of new parts and the corresponding technological and design documentation;

- it is necessary to improve the system of technical regulation, the creation of modern standards governing the production and testing methods of new materials. The solution of these problems will create the necessary conditions for a wider use of Rimamid material.

The main advantages of this material is a low coefficient of friction for steel, which provides a 3–4-fold increase in the resource of parts in friction units, as well as low weight, high strength, good machinability on metal cutting machines, resistance to aggressive environments, and environmental safety.

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