The paper reports an analysis into tribological efficiency of mating parts “polymeric-composite materials – steel” is carried out. Improperly selected materials produce significant operating costs in terms of tribology. Therefore, selecting the type of polymeric-composite materials to be used in the structures of nodes and machine parts is a task related to substantial improvement of their technical level.

The testing of samples made from polymeric-composite materials for relative abrasive resistance when mated with samples made from steel 45 has made it possible to establish that the lowest value for weight wear was demonstrated by material Nylon 66. Among the examined materials, the closest to Nylon 66 in terms of the values for relative abrasive resistance is the material PA-6-210KS that demonstrated the values that are 1.65 times less. During operation of machines, in the presence of abrasive wear, it is advisable to mate the materials “Nylon 66 – steel 45” and “PA-6-210KS – steel 45”. The results from a tribotechnical study without lubrication at friction machine SMC-2 for the mating parts “polymeric-composite material – steel 45” make it possible to establish that the least wear was demonstrated by sample made from the material UPA-6-30, that is 0.00083 g. In terms of wear resistance, the closest to it is a sample from the material PAG/6.6 R196-GF30, which is 6.1 times greater for weight wear. The sample made from steel 45 mated with a sample from the material UPA-6-30 has the lowest value of weight wear, 0.00005 g. At the same time, the lowest value for the friction coefficient is demonstrated by the mated materials “steel 45 – UPA-6-30”, 0.163. The progress of the mating process is achieved fastest, after 20 minutes, when using the material UPA-6-30 at a temperature in the friction zone of 348±2 K.

Our research is necessary to substantiate further utilization and selection of polymeric-composite materials for mating parts working under difficult conditions. The current study is of interest to manufacturers of agricultural and quarry machinery and various transport machines.

**Keywords:** polymeric-composite material, weight wear, steel 45, mating of samples, friction coefficient, relative abrasive resistance.

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DOI: 10.15587/1729-4061.2019.176698 DESIGNING THE ORGANOPLASTICS BASED ON AROMATIC POLYAMIDE, STUDY OF THEIR OPERATIONAL PROPERTIES AND APPLICABILITY (p. 16-22)

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Polymeric composite materials that are reinforced with organic fibers are characterized by great possibilities in terms of improving the durability of friction nodes in machines and mechanisms. These composites successfully compete with non-ferrous metals and their alloys and, in some cases, outperform polymeric and metallic analogs by their properties. In this regard, we have studied the influence of the organic fiber lola on operational characteristics of the aromatic polyamide phenylene, brand C-1, and on possibilities to apply the developed polymeric composite materials.

Experimental studies have confirmed that the reinforcement of phenylene with the organic fiber lola in the amount of 5–15 % by weight improves its operational characteristics. This is predetermined by the arrangement of the supramolecular structure of the basic polymer due to the introduction of organic fiber. Thus, at the interface “phenylene-filler” one clearly observes the transformation of the binder’s globular structure into fibrillar one. That leads to a positive effect: there is an increase in destruction energy (by 1.5 times) and chemical resistance (by 1.1–1.36 at aging in 5 % HCl, and by 1.27–1.6 – in 10 % HCl). It should be noted that the developed organoplastics are stable at a temperature of 673 K, while the starting polymer begins to destroy intensively at 400 K. Specifically, it was determined that at a further increase in the mass fraction of the filler these indicators deteriorate, due to insufficient adhesion between the filler and the binder.

Using the organic fiber lola (in the amount of 5–15 % by weight) makes it possible to obtain composites with improved operational characteristics: enhanced thermal and chemical parameters, high resistance to impact loads. Thus, there is reason to argue about the prospects of using the fiber lola as a filler for composites. Organoplastic with an optimum fiber content (15 % by weight) is recommended for manufacturing the components of tribological nodes for modern equipment instead of non-ferrous metals and their alloys due to sufficiently high operational properties.

Keywords: phenylene, polyamide, organic fiber, lola, organoplastics, heat resistance, chemical resistance, structuring, tribological nodes.

Reference


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**“SMART” ANTICORROSION PIGMENT BASED ON LAYERED DOUBLE HYDROXIDE: CONSTRUCTION AND CHARACTERIZATION (p. 23-30)**

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Paint coatings are widely used for decorative purposes and to prevent corrosion of metal surfaces. However, regular paint coating only provides passive protection of the metal. To create an active type of corrosion protection, various anti-corrosion additives are added to paint formulations. As a result of analyzing available data, a bi-functional (colored and anti-corrosion) pigment was theoretically constructed as monophase Zn-Al-triopolyphosphate LDH with the generalized formula 
\[ \text{Zn}_{10-x}\text{Al}_x\text{PO}_{4(3-x)}\text{OH}_{2x}\text{SiO}_{2-4x} \]
In this LDH, Zn

2+ as “host” cation and Al

3+ as “guest” cation govern white color of the pigment, and intercalated triopolyphosphate-ions – corrosion inhibitor. A continuous constant pH synthesis at a temperature of 70 °C was selected as a preparation method. This method was used to prepare theoretically constructed pigment. The crystal structure of the pigment sample was studied by means of X-ray diffraction, morphology and particle size were determined by means of scanning electron microscopy, thermal properties were evaluated by means of thermogravimetry. Color characteristics were recorded using the color comparator, anti-corrosion properties were evaluated by recording anodic polarization curves of 0.8KPH steel in 5 % (wt.) Na_2SO_4 solution with and without the pigment extract. By means of X-ray diffraction analysis, it was found that bi-phase precipitate, containing the constructed LDH (Zn-Al-triopolyphosphate) structure and Zn-Al LDO (ZnO) structure was formed. This indicated partial decomposition of the prepared pigment has high whiteness value (diffuse reflection coefficient above 90 %), color purity below 1 %, lightness

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above 96 %). This is due to the color of both LDH and LDO phases. By recording anodic polarization curves, it was found that corrosion rate in the presence of water extract of the pigment is lower by 5.36 times (corrosion current density decreased from 5.63 mA/cm² to 1.03 mA/cm²). All of this shows that a bi-functional pigment was prepared, which has great pigment properties, high whiteness, and high anti-corrosion properties.

**Keywords**: paint coats, Zn-Al LDH, “smart” bi-functional pigment, tripolyphosphate, inhibitor.

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The tests have shown that a 1.3 times sample weight reduction and a 23 % specific density reduction occurred in the process of heat treatment of the samples based on scheelite concentrate.

Several batches of spongy tungsten instead of standard ferrotungsten were produced and tested in smelting high speed steels. Advantages of the new technology of tungsten metallization from a scheelite concentrate and positive efficiency of using the new material in special metallurgy were shown.

Key words: tungsten concentrate, carbothermic reduction, induction heating, metallization, phase analysis, microstructure, resource conservation.

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Abstract and References. Materials Science


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STUDY INTO THE STRUCTURALPHASE TRANSFORMATIONS ACCOMPANYING THE RESOURCESAVING TECHNOLOGY OF METALLURGICAL WASTE PROCESSING (p. 37-42)

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The paper reports a study into the physical-chemical properties of a doped alloy obtained from reduction smelting. That was necessary to identify the parameters that reduce the loss of Ni and Cr when processing oxide alloyed raw materials and utilizing the doping additive received. It was determined that the alloy at Si:C in the charge 0.14–0.50 (O:C=1.78) contains the following phases: a solid solution of C and the alloying elements in 1.48 % by weight. Local areas of the microstructure with increased Mo in the form of silicides or carbosilicides. It follows from the presence of Mo in the form of silicides or carbosilicides. The content of C and the alloying elements in the charge to 0.26, 0.38, and 0.50 led to the increased manifestation of Mo in the form of silicides or carbosilicides. The alloy’s microstructure at different Si:C in the charge clearly manifested several phases, with a different content of the basic alloying elements. The content of Ni is 2.97–14.10 % by weight, that of Cr is 0.91–17.91 % by weight. An increase in Si:C in the charge from 0.14 to 0.50 led to the increased manifestation of FeSi. The alloy’s microstructure at different Si:C in the charge clearly manifested several phases, with a different content of the basic alloying elements. The content of Ni is 2.97–14.10 % by weight, that of Cr is 0.91–17.91 % by weight. An increase in Si:C in the charge from 0.14 to 0.50 led to the increased manifestation of FeSi. The alloy’s microstructure at different Si:C in the charge clearly manifested several phases, with a different content of the basic alloying elements. The content of Ni is 2.97–14.10 % by weight, that of Cr is 0.91–17.91 % by weight. An increase in Si:C in the charge from 0.14 to 0.50 led to the increased manifestation of FeSi. The alloy’s microstructure at different Si:C in the charge clearly manifested several phases, with a different content of the basic alloying elements.
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WELDING METHOD FOR HIGH CRACK SENSITIVITY OF Q&T STEEL (p. 43-51)

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Components for combat vehicles need (such as body panzers, main battle tank, armed personnel carrier) to be made of high strength and hardness steel. However, during and after the welding process is complete, this steel often leaves cracks. Quenched and Tempered Steel is made of Hot Rolled Plate Steel (thickness 8 mm), which is heat-treated with quench and temper to increase strength and hardness. The novelty of this research is the welding method to create a welded joint consisting of fine structure, high strength, and high hardness produced. This joint is produced by manual gas metal arc welding. The scheme of investigation:

a) The first step. Preparation of welded specimen 120×100×8 mm in size (Fig. 3). The specimen is divided into five parts, each is given code SS (without heat treatment), S750 (heating at 750 °C), S800 (heating at 800 °C), S850 (heating at 850 °C) and S900 (heating at 900 °C). Heating rate used=10 °C/minutes.

b) The second step. Heating specimen S750 at 750 °C and holding for 30 minutes, then quenching in the water medium. The same way applied to specimens S800, S850, and S900.

c) The third step. The observation of metallography, hardness, and impact energy was done for SS, S750, S800, S850, and S900.

d) The fourth step. Removing the first layer of the weld in half-plate thickness using a hand grinding machine of each specimen, and continue to the second layer welding.

e) The fifth step. The second layer of the welds is ground in half and proceed to the final welding.

The results of the tests carried out on KSTA 500 Steel include the chemical composition of base metal; microstructure and hardness for standard and water quenched weld joint. Medium carbon steel is equivalent to Quenched and Tempered Steel used in this study and has a high cracking susceptibility.

The microstructure for the standard welded joint is dominated by martensite when quenched and tempered steel made, and martensite produced when water quenched heat treatment is conducted on the welded joint.
Water quenched weld joint shows the finer microstructure of the heat-affected zone, but weld metal tends to be coarse and brittle. The highest hardness is achieved after 850 °C water quenching, i.e., base metal=578 VHN, heat-affected zone=555 VHN, fusion line=457 VHN, and weld metal=252 VHN.

**Keywords:** austenite, brittling, coarsening, crack, cracking, hardening, martensite, quenching, refining, weldability.

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**INCREASING EFFICIENCY OF PLASMA HARDENING BY LOCAL COOLING OF SURFACE BY AIR WITH NEGATIVE TEMPERATURE (p. 52-57)**

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The martensitic transformation interval of some hypoeutectoid, all eutectoid and all hypereutectoid steels covers to a large extent the region of negative temperatures. Due to the fact that the plasma hardening operation is carried out in workshops where the minimum temperature is +20 °C, the surface temperature of the part after plasma heating cannot reach negative values. Because of this, the temperature range of the martensitic transformation is not fully used and in the hardened structure there is a certain amount of austenite, which has not undergone martensitic transformation. This circumstance reduces the hardness of the hardened layer and often low tempering is required to convert residual austenite to tempered martensite, which lengthens and makes the heat treatment more expensive. Complete or almost complete martensitic transformation is possible if the surface heated by the plasma beam is immediately cooled to a negative temperature. It is shown that local cooling of the hardened surface to a temperature of −40 °C can be carried out by air using the Ranque-Hilsch tube, which significantly expands the possibilities of full hardening.
for eutectoid and hypereutectoid steels. The studies consisted in heating the surface with a plasma stream to a temperature of 750 °C and 900 °C. The temperature was changed by the plasma torch current and by changing the velocity of the plasma flow spot moving along the sample surface. The experiments were carried out on steels 45 (0.45 % C), U8 (0.8 % C) and U10 (1 % C). The study of the structures was carried out on a MIM-7 microscope with a video camera and with the image displayed on the screen. The approximate quantitative composition of austenite, martensite, and associated structures was determined by the areas on the screen.

During plasma hardening of steel 45 from a temperature of 900 °C using the Ranque–Hilsch tube, there is practically no residual austenite in the structure. When hardening U8 steel, residual austenite is detected in a small amount. When hardening U10 steel, the amount of residual austenite is approximately 15%. Local surface cooling allows high-quality hardening of steels of most grades, regardless of the carbon content.

**Keywords:** carbon content, martensitic interval, cooling temperature, hypoeutectoid steel, eutectoid steel, hypereutectoid steel.

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