ABSTRACT AND REFERENCES

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EXPLORING A POSSIBILITY TO CONTROL THE STRESSEDSTRAINED STATE OF CYLINDER LINERS IN DIESEL ENGINES BY THE TRIBOTECHNOLOGY OF ALIGNMENT (p. 6-16)

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Our research into the formation of a functional copper-containing surface layer on parts of automobile engines by using an alignment tribotechnology has established a decrease in the wear of parts during their operation. It was found that the formed coating creates an elastic layer that reduces strains in a material of engine parts. Our experimental study of the coercive force of parts' working surfaces has confirmed a decrease in the accumulation of destructive stresses in the near-surface layers of a components' material. In turn, a comparative analysis of the obtained results by using a coercimetric method confirms that the proposed aligning tribotechnology leads to reduction of the stressed-strained state and makes it possible to improve wear resistance and enhance the technical condition of diesel engine cylinder liners: the magnitude of coercive force reduces by 7.5 %, while operating time increases by 16 %. In this case, at larger operating time: 254.8 thousand km against 220.5 thousand km, according to data on the coercive force (14.2...9.1) A/cm and (13.2...9.0) A/cm, it is almost in the same condition.

The functional surface layer forms when introducing a composite oil to the tribotechnology of cold alignment of an automobile powertrain. We have proposed and implemented a circuit to connect electric current to components at an engine's cylinder-piston group as a result of studying the developed tribotechnology of alignment. The features of this scheme are that the constant electric current is supplied by the plus polarity, through the brush-collector node, to the crankshaft, and by the minus polarity, through the clamping contact, to the crankcase block.

The research results suggest a possibility to control the internal strains and the subsequent magnitude of wear in a material of working heavily-loaded components of automobile powertrains provided they are serviced properly. The proposed tribotechnology of alignment could be of interest for both service departments at trucking companies and for car service stations.

Keywords: liner, additive, copper glycerate, alignment, surface layer, electrolyte, coercive force, electrical circuit, strain, cylinder liner.

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EXPLORING THE PROCESS TO OBTAIN A COMPOSITE BASED ON Cr_2O_3–AlN USING A METHOD OF HOT PRESSING (p. 17-21)

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We have established the influence of heating rate of 150, 350 and 600 °C/min, pressure of 8 and 18 MPa, on the compaction process of the reaction mixture Cr_2O_3–$15AlN_{nano}$, the hardness and crack resistance of the dense material. The intensity of compacting the charge Cr_2O_3–$15AlN_{nano}$ depends on the pressure magnitude and the rate of heating. A pressure of 18 MPa ensures the complete compaction of the mixture regardless of the specified heating rate while a pressure of 8 MPa provides for the complete compaction of the material only at the rate of heating of 600 °C/min. For the heating rate of 600 °C/min, compaction curves of the mixture at pressures 8 and 18 MPa are similar in shape. It was established that at a heating rate of 600 °C/min the compaction process of the mixture, in addition to pressure, is additionally activated by the

effect of exothermic reaction among its components. Increasing the rate of heating from 150 to 600 °C makes it possible to improve the hardness and crack resistance of the dense material by, respectively, 1.0 GPa and 1.5MPa·$m^{1/2}$. It was revealed that the structure of the dense material, newly formed during HP(Hot pressing) of the mixture Cr_2O_3–15$AlN_{nano,}$ is of the dispersed-strengthened type: the matrix phase from a solid solution of variable composition from the composition $(Cr_{1-x}–Al_x)_2O_3$ (0<x<0.4) and the dispersed, stochastically distributed within it, Cr_2N inclusions the size of up to 2 μm that are alloyed with Al to 1.8 %. We have identified separate large inclusions the size of 10–40 μm of the structure, similar to the basic structure, but with the matrix phase of solid solution of the composition $(Cr_{1-x}–Al_x)_2O_3$ (0.5<x<0.9). The fracture toughness of the material, obtained in the course of research, is 1.5 times larger, while the hardness is 1.2 GPa less, than similar characteristics for the most common ceramics of the "mixed" type based on Al_2O_3–TiC.

Keywords: ceramics, Cr_2O_3, AlN, nano-, micro powders, composite material, cutting plates, hot pressing.

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EFFECT OF THE INTEGRATED TREATMENT ON THE MANUFACTURING OF PRINTING CYLINDERS (p. 22-28)

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We have developed a comprehensive technology to strengthen printing cylinders by forming a regular microrelief at the surface followed by chromium-plating.

Our research into the influence of comprehensive machining of a printing cylinder on the quality of printed products has established the mechanism for obtaining high quality parameters for the working surface of printing cylinders. Application of vibratory tool with a radius of R=2 mm, at effort P=550 N, the surface roughness amounted to the arithmetic mean deviation Ra 0.63 μm, which is 7.6 times lower than that without applying the surface-plastic deformation. A comprehensive machining of a printing cylinder includes a combination of the vibration knurling with the formation of the all-new regular microrelief followed by chromium-plating. Vibration knurling was performed at a tool indentation effort of 50–600 N; a spindle rotation frequency of 25–2,000 rpm; a deformative tool eccentricity of 0.2–1.0 mm; a deformative tool frequency of oscillations of 1,000–2,000 double step per minutes; a deformative tool feed of 0.08–12.5 mm/rev. The chromium-plating involved the electrolyte CrO_3≈290 g/l and H_2SO_4≈3 g/l; the electrolyte temperature was 57 °C; duration of chromium was 20 min; a current density was 80 A/dm^2, time activation was 20 s. As a result of this, it became possible to obtain the developed surface of the cylinder with high operational characteristics. Our experimental research has confirmed that the machining modes significantly change surface roughness, hardness, and microhardness. This reinforces the surface strengthening of the printing cylinder. In particular, it was found that the integrated technology contributed to a 1.2–1.6-time increase in hardness compared to the base metal hardness, and a 2.7–3.3-time increase compared with chromium-plated surface. That makes it possible to argue on that the revealed formation mechanism matches the predefined properties.

Thus, there is reason to assert that it is possible to prolong the service life of printing cylinders, to ensure stable operation of the equipment, to improve the quality of printed products owing to the application of the integrated technology followed by chromium-plating.

Keywords: surface-plastic deformation, chromium-plating, microrelief, surface roughness, durometric surface properties, printing cylinder.

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DETERMINING FEATURES OF APPLICATION OF FUNCTIONAL ELECTROCHEMICAL COATINGS IN TECHNOLOGIES OF SURFACE TREATMENT (p. 29-38)

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Approaches to the use of electrochemical coatings in surface treatment technologies are analyzed. It is shown that directed surface modification allows expanding the functional properties of the treated material, in particular, increasing the strength, wear resistance, corrosion resistance, catalytic activity.

The method for treating non-alloy steel and cast irons by forming thin-film coatings of ternary alloys of iron and cobalt with molybdenum and tungsten is proposed. It is shown that the incorporation of refractory metals up to 37 at. % into the surface layer leads to a change in the phase structure of the coating. This is found to provide an increase in wear resistance by 40 %, microhardness by 2.5–3.5 times, as well as a decrease in friction coefficient by 3–4 times in comparison with the substrate material. The resulting materials can be used for hardening and protection of surfaces in various industries.

To modify the surface of piston silumins, it is proposed to use the method of plasma electrolytic oxidizing with the formation of ceramic-like coatings. It is shown that in the galvanostatic mode, from alkaline electrolyte solutions containing manganese and cobalt salts, it is possible to obtain uniform, dense, highly adhesive to the base metal, oxide coatings, doped with catalytic components whose content varies within 25–35 at. %. It is shown that the morphology and phase structure of the surface layers changes with the incorporation of dopant metals. The formed coatings have a high degree of surface development, which is a prerequisite for enhancing their functional properties. The proposed approach is used to modify the surface of the KamAZ-740 piston. It is found that the use of ceramic-like coatings of the engine piston leads to a decrease in hourly fuel consumption and amount of toxic substances with exhaust gases, which makes them promising for use in in-cylinder catalysis.

Keywords: surface treatment, electrochemical coating, functional properties, repair.

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A STUDY OF ELECTROCHROMIC $Ni(OH)_2$ FILMS OBTAINED IN THE PRESENCE OF SMALL AMOUNTS OF ALUMINUM (p. 39-45)

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The research is related to the synthesis of electrochromic films of nickel hydroxide with aluminum as a dopant. Films were deposited via cathodic template synthesis in the presence of polyvinyl alcohol from solutions containing 0.01 M $Ni(NO_3)_2$ and $Al(NO_3)_3$. Aluminum nitrate was added in different concentrations: 0.138, 0.257 and 0.550 mM. The necessary aluminum concentration was calculated based on the theoretical grounding with the use of Faraday's law equation. All of the prepared films demonstrated electrochemical activity, and the film deposited from the solution containing 0.01 M $Ni(NO_3)_2$ and 0.138 mM $Al(NO_3)_3$ has demonstrated the best results. The film cycled reversibly with the coloration degree of – 81 %. At the same time, the film prepared under the same conditions without the dopant demonstrated the coloration degree of 75.8 %.

All films deposited in the presence of aluminum had lower switching, especially bleaching, speed in comparison to the undoped reference sample.

Morphology study of the prepared films revealed that the latter differs little. The film deposited in the presence of 0.138 mM $Al(NO_3)_3$ had spherical formations on its surface. It was also found that the morphology of the substrate, which was glass coated with SnO_2:F, differed significantly from the morphology of the films deposited with and without the dopant.

The film deposited from the solution of 0.01 M $Ni(NO_3)_2$ and 0.138 mM $Al(NO_3)_3$ was confirmed to contain aluminum. The mass ratio of aluminum to nickel in the Ni–Al-138 film varied between 1:10.23 and 1:6.44.

Keywords: $Ni(OH)_2$, nickel hydroxide, electrochromism, electrodeposition, cyclic voltamperometry, aluminum, solubility product.

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PREDICTION OF THE ELECTRICAL RESISTANCE OF MULTILAYER CARBON FIBER COMPOSITES (p. 46-54)

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The issues of calculation of electrical phenomena in multilayer carbon fiber composite materials are considered. The method for assessing the reliability of composite material models for modeling electrical phenomena in composite structures is proposed. The method is based on the comparison of the calculated and experimental values of the electrical resistance of material specimens with certain lay-up sequences of the layers. Experimental determination of the electrical resistance of specimens of single-layer and multilayer composites based on two types of carbon fiber reinforcing materials is carried out. The calculation of resistance of the composites on the basis of these materials using the homogeneous model, as well as the layered model of composite material implemented by the finite element method was carried out. The initial data for modeling in the form of the coefficients of the electrical conductivity of the layers were obtained from the experimental results. The comparison of the calculation results using the homogeneous and layered models with the experimental results was carried out. On the basis of the obtained numerical results, as well as distribution analysis of electric potential in the models of the specimens, the application areas of the models were evaluated. According to the results of the analysis, the homogeneous model gives acceptable

results with an accuracy of 12 % for materials that have an alternation of layers with different reinforcement angles. For the material where the layers with one reinforcement angle form clusters, the homogeneous model gave an error exceeding 50 %. In all cases considered, the layered model of the material provides high accuracy of modeling with an error less than 10 %. Based on the analysis, practical recommendations are given for modeling electrical phenomena in composite structures.

Keywords: composite material, homogeneous model, layered model, electrical conductivity, finite element method.

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EFFECT OF QUENCH AND TEMPER ON HARDNESS AND WEAR OF HRP STEEL (ARMOR STEEL CANDIDATE) (p. 55-61)

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The need for quenched and tempered steel increased, especially for the manufacture of the combat vehicle components. This steel is classified as high-strength and hardness and is bullet-resistant steel (armor steel). Maintaining the stability of steel hardness is very important because the quality standard for armor steel is hardness. High hardness causes brittleness increase, and tempers are needed to reduce it (residual stress is relieved by temper). Austenite temperature and temper affect steel hardness and wear resistance of quenched and tempered steel. To obtain hardness and wear due to the influence of quench and temper on hot rolled plate steel as the armor steel candidate. The material used in this research is hot rolled plate steel made in Indonesia with a carbon content of 0.29 %. The method used is heating the material to 900 °C, 885 °C and 870 °C (held for 45, 30 and 15 minutes) and cooling in water and quenched steel is produced. Quenched steel is heated to 150 °C (held for 45, 30 and 15 minutes) and cooled in atmospheric air. Optimum heat treatment parameters, the Taguchi and ANOVA methods were used. From the parameters and level of heat treatment chosen, the number of specimens needed can be known. The parameter of heat treatment has a strong influence on hardness, and ANOVA can obtain wear. Optimum hardness and wear are 566.48 HVN (±532 BHN) and 2.01×10^{-9} mm^2/kg, respectively. Both are influenced by austenite and temper temperature.

Keywords: crack, ductility, hardness, holding, martensite, quench, strength, temper, toughness, wear.

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