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Creating of the Alternative Lubricants and Practice of their Use

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Annotation.

To reduce the wear of the side faces of rails and wheel flanges lubrication of rails is used. This paper discusses the possibility of using unconventional lubricants, which are wastes of chemical and related industries of the East-Siberian region. The chemical reactions, that determine the protective effect of the proposed materials and occurring only in a mechanical impact in the friction zone of wheel-rail, are considered.

Extremely tough working conditions of rail-wheel system suggests the possibility of using as lubricant not only the substances, conventionally used in this field, but also such substances, for which the decrease of the wear effect may occur during mechanical impact. That is, the chemicals may be suitable as lubricant components, if, during the mechanical action, they can have physicochemical transformations (tribochemical reactions), which promote the formation of protective films, which reduce friction and wear. This approach significantly expands the choice of lubricants, that promotes creation of cheaper lubricant compositions and, thus, increases the economic efficiency of lubrication.

As this wastes, the following products have been selected: low molecular polyethylene (LMPE) – waste, generated on the production of high-pressure polyethylene; coke breeze is produced in the manufacture of the electrode petroleum coke; polysulfide polymers, derived from organochlorine wastes of epichlorohydrin production – high-tonnage intermediate product for obtaining epoxy resins; vat residues of styrene rectification (VRSR) are formed during the production of this important monomer for plastics; lignin - the main waste of pulp and paper industry; lignin, chlorinated with chlorine (chlorine water) or hypochlorite.

Keywords: wheel-rail system, lubrication, tribochemical reactions, lubricants.

Reduced wear of the side edges of the rails on curved track sections and wheels flanges is an important task of modern railway transport [1, 2]. The rational solution of this problem not only increase the service life of wheels and rails, but in many cases, leads to lower electricity costs for draft of trains [3].

Reduced wear in mind the complexity of interactions in the system of wheel-rail is a complex problem and to solve it using a set of measures as a technical (rails slope, the elevation of the outer rail, modernization of cradle suspension, increasing of the wheels and rails materials hardness, etc.), and the process (temperature decrease in the friction zone, the use of lubricants). Despite the variety of approaches, many researchers acknowledge that the application of the lubricant in the contact zone of the wheel-rail in curves, is the most effective method of wear reducing [4]. As lubricants, greases are traditionally applied, used in other fields of technology. These are usually quite complex in content lubricating compositions based on graphite, molybdenum disulfide, synthetic lubricating oils, and other components, the main drawback of which is the high cost [1].

However, the rail-wheel system is significantly different from conventional friction units. The loads that arise in this system while friction because of the high train mass and its high velocity significantly superior loads, that appear even in highly loaded systems, such as gearboxes, engines and others. Mechanical influences, albeit acting briefly, provoking the manifestation of high-energy excited states of atoms and molecules of materials, which are directly in the friction system. On the one hand, these effects contribute to the wear, but, on the other hand, in lubricant presence they contribute to chemical reactions that determine the formation of protective films on the surface of the friction elements [5].

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In terms of the cost of used lubricant, promising is the use of wastes, generated during production activities, that is difficult to undergo skilled processing, and their recycling is a complex environmental problem. As an example of the use of wastes for lubrication of the rails, it can be specified application in the East-Siberian Railway of locomotive waste diesel oil, as in "pure" form, and with the addition of graphite or its substitutes [6].

This article describes the use of other wastes of chemical, petrochemical, pulp and paper industries of the East-Siberian region to create lubricating compositions for wheel-rail system and chemical reactions, occurring directly in the friction zone and contributing to the manifestation of the protective effect. Such as this wastes, the following products have been selected:

1. Low molecular polyethylene (LMPE) – waste, generated on the production of high-pressure polyethylene. The average molecular weight of this product is 1500 units. (Molecular weight of 10000-45000 is for commercial polyethylene). LMPE - non-toxic oily product which is virtually unsaleable, although it turns out only in Angarsk about 40 tons per year. According to its protective action in lubricating compositions, LMPE is similar to conventional hydrocarbon lubricants, but additionally has a structuring ability and more high adhesion to metal surfaces.

2. Coke breeze is produced in the manufacture of the electrode petroleum coke. Coke particles <6 mm are not suitable for the manufacture of electrodes, and in many cases, used as fuel. The structure of petroleum coke consists of graphite disordered crystals (Fig. 1) [7]. Under the action of high stresses, arising at the friction zone, and the local momentary temperature rise, it occurs reconstruction of the coke structure with an arrangement of graphite planes parallel to the friction plane (Fig. 2). Thus, in the wheel-rail system occurs tribochemical reaction of petroleum coke graphitizing. The possibility of such reconstruction is considered in [8].

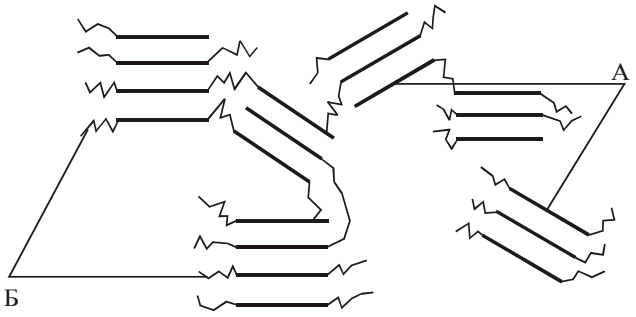


Figure. 1: The structure of petroleum coke:

A - crystallites with an ordered graphite structure; B - unordered carbon

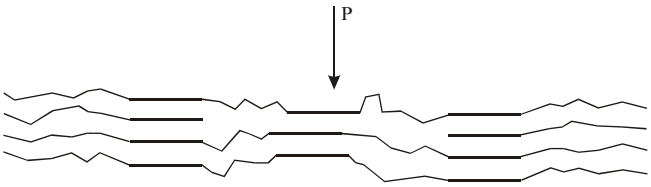
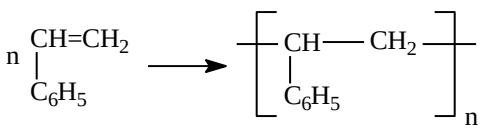


Figure 2: Reconstruction of petroleum coke structure in the impregnation by the hydrocarbon material and application of an external load

3. Polysulfide polymers, derived from organochlorine wastes of epichlorohydrin production – high-tonnage intermediate product for obtaining epoxy resins. Polycondensation of organochlorine wastes containing sodium polysulfide yields solid polymers, which besides carbon and hydrogen contain up to 70% of bound sulfur and 3.8% chlorine. When in the wheel-rail system, the polymer is thermally decomposed with forming surface sulfides and iron chlorides, which prevent wear. Such action of chloro- or sulfur-containing organic compounds (anti-wear and anti-seize additives to lubricating oils) are well known in the literature [9, 10]. Leaking during friction tribochemical reactions of degradation of polysulfide polymers and formation of protective films on metal surfaces define preservation of lubrication effect even after its removing from the surface. We had studied this issue in detail previously [11].

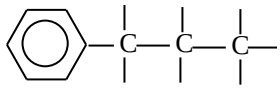
4. Vat residues of styrene rectification (VRSR) are formed during the production of this important monomer for plastics. VRSR mainly contains residual styrene, its homologs and dimers, as well as polymerization inhibitors. Using of VRSR in compositions for lubrication of the rails has shown that it can be used effectively to change the viscosity of the resulting compositions, and in the process of its application on the surface of the protected metal (the lateral surface of the rail head) a noticeable protective film appears. We hypothesized that, during friction, temperature effects initiate the polymerization of styrene and other monomers, presented in the VRSR, with forming of a polymer product (tribochemical polymerization):



Thus, VRSR additive in lubricating composition is similar in effect of adding a polymer film former in grease (grease PC-6B), which is pre-diluted with gasoline, which is a significant drawback of this lubricant.

5. The main waste of pulp and paper industry is lignin, which is formed about 70 million tons per year, and is useful only

about 1.5% of this amount. [12] Lignin is a natural crosslinked polymer, macromolecules of which have a shape similar to a rigid sphere, with molecular weight up to several million [13]. The structure of lignin is not completely installed, but it is conclusively proven that in the basis of lignin macromolecule there are arylpropane structural units


(C_6C_3),

having both the ring and the side chain oxygen-containing functional groups. These structural units are connected to each other by various bonds with forming of irregular polymer structure. We used dispersed lignin in lubricating compositions as anti-friction component. The anti-friction effect of the lignin molecules can be determined by their spherical shape, which at the nanoscale act as analogues of rolling bearings [14]. Obviously, that while mechanical action in the wheel rail friction zone there are degradation of lignin macromolecules with forming polymers with lower molecular weight, which at the expense of oxygen-containing groups are easily adsorbed on the metal surface, providing a protective anti-wear effect.

6. Lignin, chlorinated with chlorine (chlorine water) or hypochlorite. Taking into account anti-wear and anti-seize effects of organochlorine additives [6] we used in lubricating compositions the lignin, partially modified by chlorine. In this case, there is not only anti-friction effect due to the lignin macromolecules, but, obviously, tribochemical reaction of formation on the surface of the friction the film from ferric chloride. This is confirmed by the fact that the most effective protective action of chlorlignin manifested when chlorine content in lignin is up to 7% (wt). Obviously, that in this case, chlorine mainly enters into a side chain, from whence splits out quite easily by thermal effects in the friction system. Further increase of the chlorine content in chlorinated lignin leads to substitution of hydrogen for chlorine in the aromatic rings. This chlorine is known [15-16], for separation requires much more energy.

CONCLUSION

Thus, we have shown that some of the wastes of the East-Siberian region companies can be used in compositions for lubrication of the rails, which reduce wear in the wheel-rail system. The protective effect and influence on the movement parameters of the rolling stock and the safety of the transportation process [17-19] developed compositions was confirmed by tests on friction machine in real conditions.

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