STUDY ON THE INFLUENCE OF POLYMETHYLMETHACRYLAT ON THE WEARPROOFNESS OF STEEL

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ABSTRACT

The influence of products of destruction of high molecules when presented in the composition of a lubricating - cooling liquid, on the mechanical properties of metals in the zone of contact tribocouplings and at treatment of metals cutting is presented. Perspective is the application of polymethylmethacrylat as additive for the increase of wearproofness details of the tribomechanical systems, providing efficient lathe treatment. The complicated mechanochemical character of interaction of polymethylmethacrylat with a metal depending at treatment cutting is considered.

Keywords: wearproof surface, superficial layer, nanostructural state, tribocoupling, polymer destruction, polymethylmethacrylat.

INTRODUCTION

A perspective way for improvement of tribology situation at tooling of details, machines and mechanisms, as well as to increase the wearproofness of tribocouplings at different exploitation conditions, is the introduction to the composition of lubricating-cooling technological environment (LCTE) different by nature and chemical structure additives. Among the results of researches on this problem it should be noted the usage as effective additive to the LCTE (to the lubricating-cooling liquid (LCL)) of high molecular connections, due to their deep and multilateral affecting physical, chemical, mechanical processes and phenomena that occur in the zone of contact.

In most cases lubricating-cooling compositions applied today are mixtures of low-molecular products that cannot in the conditions of treatment and contact of metals decompose chemically of active agents of high concentration. Environments with polymer except a lubricating and cooling action, entering into the chemical co-operating with a metal, form chemical connections, which on energy considerably exceed forces of connections, taking place at physical adsorption of low-molecular components in LCTE.

Change of mechanical properties metal under influence of superficial and active environment (durability, deformability, longevity on loading) bind usually to her by adsorption, which defiant the facilitation of development new surfaces because of decline free superficial energy of the deformed solid on a border with an environment (effect of Rebinder). It is the object of study in a number of works of the followers of P.A. Rebinder. In theory well-grounded and confirmed by practice ideas about physical nature of decline mechanical properties of materials under influence of such environment allowed to define the ways of searching for most effective methods of management the coupling forces in solids at optimal combination of mechanical co-operations and physical, chemical factors, which are created by a superficial and active environment or small adsorbed additions [1 - 4].

A large value is acquired by substitution of superficially active substances, step-up efficiency treatments. According to literary data like low-molecular superficially destruction polymers activate destruction

of particles iron active substances, that is expressed in a splitter action superficially of active substances at their hit in the cavity of superficial cracks (internal effect of Rebinder) [5].

Herein we report development of scientifically-practical bases for management the wearproofness of steel details by mechanochemical influence of polymer destruction products.

Polymers included in composition LCL, adsorbed on a metal under the action of high temperature and mechanical tensions, undergo mechanodestructions and thermodestructions. The high - activity fragments of macromoleculs (ions, ion-radicals, radicals), atomic hydrogen and carbon able chemically to co - operate with the processed metal, appear. The temperature limits of polymers destruction are considerably below, than liquid hydrocarbons.

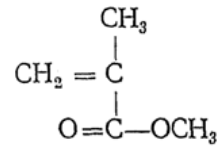
The decouplig of most polymers at thermomechanical destruction takes place on free - radical or to the ion radical mechanism. Free radicals are found out in products of destruction of many natural and synthetic polymers. Radicals, initiating further chemical transformations, change properties of high molecular connection, assisting appearance of new end groups in polymers, changing the concentrations of branching and sewing together and other [6], which in large part determines efficiency of application polymeric additive in LCTE.

The characteristic feature of polymer destruction consists in decline of molecular mass, by the change of macromoleculs structure and a basic value has chemical composition, structure of high molecular connection here. It is known that with the increase of molecular mass of substance mobility of their molecules diminishes. The physical changes of substances are always related to moving of molecules. The chemical transformations are impossible without a direct contact between the molecules of reactive substances, and also without moving, diffusive penetration of one component in other mass, etc. Therefore small molecules, which are more movable than macromoleculs is easier exposed to chemical and physical transformations [6].

Taking into account the progress in the chemistry of high molecular connections and practical application in different industries of various types of polymers, which differ not only on physical and chemical properties but also on a cost, there is a necessity for determination of polymer that will provide maximal efficiency as a high molecular additive to LCL. Low energy of activating process of decouplig polymer comes forward the basic criterion of choice additive that is accompanied by his ability to be exposed to destruction in the conditions of tooling details or exploitation of concrete tribocouplings.

One of the most perspective high molecular functional additive to LCL can be polymethylmethacrylat (PMMA). He is practically widespread polymer, which fully disintegrates to the monomer. At other polymers the exit of monomer is varied from a zero to the considerable proportion in the general exit of volatile products. So, the energy of activating destruction of polyethylene is 60 - 70 kcal $mole^{-1}$, PMMA is a 27 kcal $mole^{-1}$.

Polymethylmethacrylat $[-CH_2C(CH_3)(COOCH_3)-]_n$ is characterized with his low heat – resistance, near 160°C, and assists the decline of energy activating thermal destruction. The structural formula of the monomer of methylmethacrylate is:



As is generally known [9], most stability to thermal influences is possessed by a carbon - carbon connection, the presence of a hydrogen atom at them strongly lowers energy C - C and the ramified of molecular chain diminishes durability of this connection. Therefore ramified hydrocarbon macromoleculs are less heat - resistant, what unramified.

The presence of more loosely - coupled connection initiates the generation of free macroradicals disintegration at more low temperatures. The most important point of these weak links is a presence of the end groups related to the initiator, with the transmission of chain or with a stop.

Presently large interest is caused by technologies of thin organic synthesis, allowing in a prospect to create synthetic materials with the set properties. One of modern methods for synthesis molecules of organic polymers is pseudoliving polymerization that consists in varying of kinetic parameters reactions due to introduction of different regulative agents. With the use of regulators of the polymerization it is possible the selection of suitable terms polymerization to change the middle molecular mass and the properties of related polymers. Possibilities of realization of polymers synthesis are thus opened with

managed polydispersion, i.e. on the whole modelling of macromolecular design of the synthesized materials.

The application of PMMA gives at polymerization to adjust in wide limits of number molecules and their molecular masses with providing at a contact with a metal the determined quantity of thermomechanical destruction products and, accordingly, the required influences on the metal. So, during radical polymerization the increase of reaction temperature or the quantity of initiator increases the number of growing radicals. Because speed of reaction chain has the first order for the concentrations of growing radicals, and speed of reaction break is the second order, then middle molecular mass falls down at the increased speed of polymerization. The decline of the monomer concentration also results in the receipt of polymer with a small molecular mass, but here speed of polymerization goes down too.

Therefore more perspective direction to decline molecular mass is the addition of regulators - substances through that easily the transmission of chain comes true. Already at small concentrations these substances strongly reduce middle molecular mass. Speed of polymerization here does not increase substantially. In [7] an analysis of the influence of row regulators is focused on the polymerization of PMMA, however, taking into account their variety, the estimation and choice of optimal regulator polymerization must come true taking into account changes of polymer properties for the concrete terms of tooling or exploitation of tribocoupling.

RESULTS AND DISCUSSION

Taking into account the perspective of the use of PMMA as a high molecular additive to LCL, the estimation of its influence was studied on the efficiency of turning treatment stainless steel cutter from high-speed steel P18 (Standard of Ukraine). The results of researches are compared at a move in the zone of cutting at a speed of 0,5 l min^{-1} of acetone and solution of PMMA in an acetone with the concentration of 1 %. Cutting modes: move is longitudinal a 0,57 mm rev^{-1}, cutting speed 20 m min^{-1}, a cutting depth is 0,25 - 1,15 mm, machine time of treatment 1minute.

As follows from Fig. 1 mechanochemical affecting solution of PMMA contacting surfaces in the zone of cutting is accompanied by the increase of wearproofness cutter to 53%. Thus with the use of solution PMMA dispersion of force cutting of P_z diminishes and than the greater concentration of polymer, the greater reduction of dispersion is. It specifies on stability of power expenses and increase of cutting evenness in the process of treatment related to destruction of polymer.

In addition, treatment with a polymer brings to the decline of 10 % roughness over of the treated surface of Rz with the receipt of more even microgeometries (see Fig. 2).

Microgeometries of surface is the index of the state superficial layer. The marked increase of evenness microgeometries of the treated surface stainless steel specifies on the receipt of more homogeneous on

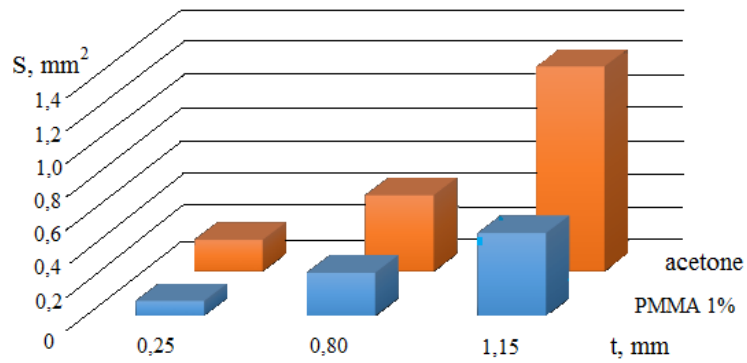
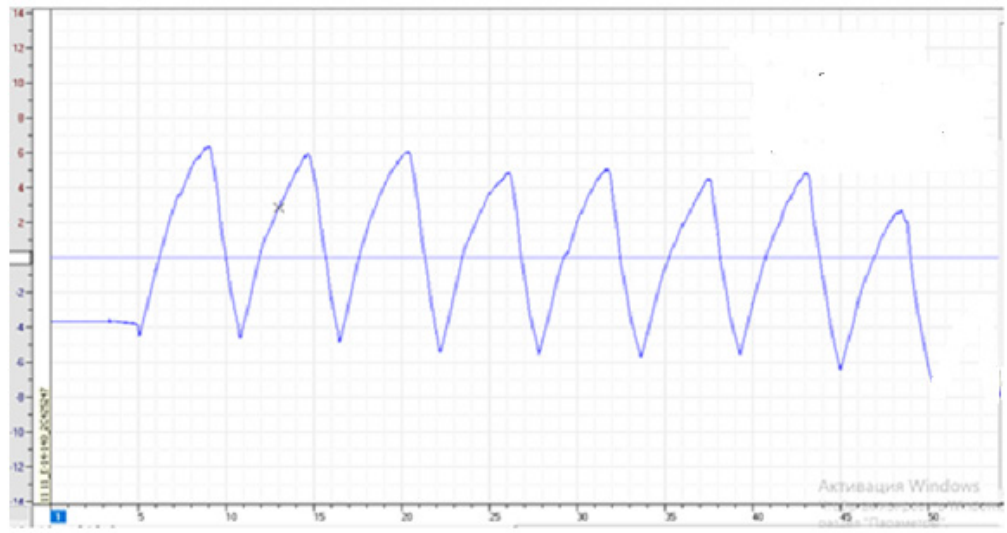
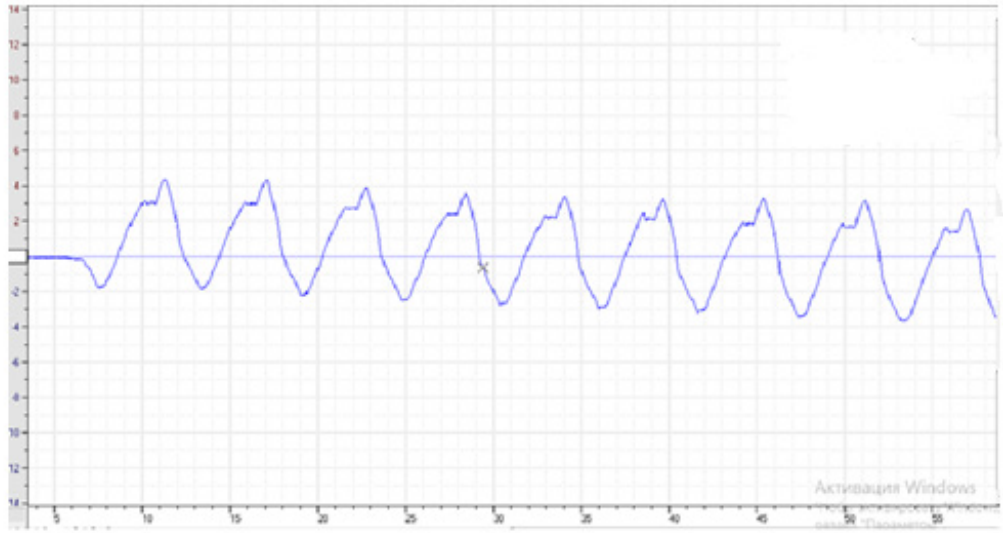


Fig. 1. Dependence of wear cutter on the depth of cutting: a) - sharpening with acetone; b) - sharpening with solution acetone + PMMA.



a)



b)

Fig. 2. Change of force friction slipping and rest.

durabletion and deformation properties of superficial layer. As the preliminary researches showed [8 - 10], a homogeneous equally durable superficial layer is characterized by subzero wearproofness. The receipt of such surfaces is expedient in case of necessity realizations of subsequent operations on forming of detail.

However, influence of products destruction polymer on a roughness and wearproofness of contacting surfaces at treatment metals cutting not simply and depends both on the terms of ladening in a contact and chemical-physical properties of materials. In particular, as stated above got increase wearproofness of lathe cutter from high - speed steel. In addition, there is an increase roughness of the treated surface at the analogical terms of cutting construction steel [11] that specifies on difficult character of the influence of polymethylmethacrylat on the state of superficial layer workpart.

Taking into account that the marked difference in wearproofness of surface metal can take place because of change size of coefficient friction, the estimation of influence maintenance solution PMMA of concentration 0,5 % was produced on force of friction slipping (motions) and force of friction at rest on the tribometer model of TMM 32A (see Fig. 3). Comparative researches

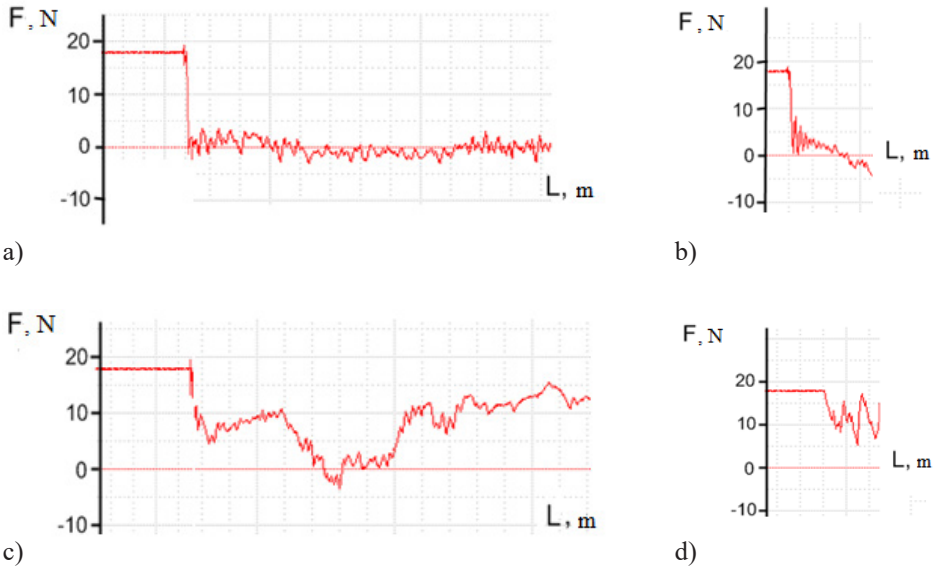


Fig. 3. Profiling of the treated surface: a) - force of friction slipping with an acetone; b) - force of friction at rest with an acetone; c) force of friction slipping with solution acetone + PMMA; d) - force of friction at rest with solution acetone + PMMA.

produced in terms steel on steel with the use of standard methodology and annular pattern weighing 0,39 kg. Presence of acetone and solution of acetone with PMMA in the zone of contact pattern and steel flag came true by the preliminary abundant greasing of flag and pattern at determination of force friction at rest and abundant greasing of flag before a motive pattern at determination of force friction slipping.

The analysis of tribograms allows to establish that introduction of PMMA to the acetone in the examined proportions is accompanied by the substantial change of both force of friction slipping and rest. At a general decline almost in two times of forces friction there is to be observed enlarge variation of their values on length of route of slipping. It specifies on the unevenness of the physical and chemical phenomena in the zone of contact at a friction with the presence of PMMA and can be the result of uneven kinetics of mechanochemical reactions on surfaces steel, the source of that is destruction of polymer.

Complicated mechanochemical character of co-operation in the zone of contact at presence of PMMA is accompanied by different intensity of wear tribocoupling. In particular, in the conditions of three-component dynamic ladening (blow and slipping in two mutually perpendicular directions) in the mode of half-dry and liquid friction feeding in the zone of contact of the investigated patterns of 0,5 % solution of PMMA results in the substantial increase of intensity of wear steel as compared to a friction in the environment of acetone [10, 12].

A three - component ladening assists the decline of level of external tensions necessary for the action of mechanism rotary plasticity in surface structures. As a result the superficial layer of more even texture appears with homogeneous on the size of fragments an equally durable superficial layer, that is accompanied by an enhanceable wear. The change of character ladening causes the change of the state superficial layer and, as a result, changes of wearproofness of tribocouplings [13, 14].

CONCLUSIONS

The use of polymethylmethacrylat in composition of LCL opens wide possibilities of management the processes of destruction or creation of wearproof surfaces of details tribocouplings. It is expedient to consider physical bases of the plastic and destruct phenomena at a wear taking into account a presence in the zone of contact foods destruction polymer chemical and physical properties of materials and terms of friction both at making of details and exploitations in the certain modes and environments.

It is possible to suppose that affecting of products of

thermomechanical destruction of PMMA wearproofness tribocouplings in large part depends on physical and chemical properties and structural state of superficial layer of contacting surfaces. Thus, complex influence of different factors of terms contact can result in a display, both outward and internal effect of Rebinder.

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