ENHANCEMENT OF WEAR RESISTANCE OF CUTTING TOOLS DURING RAILWAY CAR'S WHEEL TURNING

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ABSTRACT

Accuracy and quality of manufacture and repair of critical parts of the rolling stock running gear are directly related to manufacturing quality, accuracy and durability of the used cutting tool. One way to improve its wear resistance in material processing is reduction of the thermal stress of the contact layers of the tool and the component part by the intensification of heat removal in the cutting zone [1].

The most effective way to improve heat removal is to use coolant-cutting fluids and media (CCF and CCTM). However, there are cases where their application is impossible due to technical or technological requirements.. The objective of the authors is to analyze a problem of wear resistance increase of the cutting tool at railway car-wheel processing, using engineering analysis, modeling, statistical method, evaluation method. One of the important results of this work was to identify rational areas for the use of heat-conducting interfaces for different types of mechanical processing of the wheel tread profile. A method to increase the resistance of carbide cutting tools with the use of special silicone elastic compositions of high thermal conductivity, offered by the department «Technology of transport engineering and repair of rolling stock» of MIIT, was tested. Such compositions, applied to the reference plane of the tool holder socket plate, provide elimination of air pockets in the place of contact with the carbide plate which in turn improves heat removal from the cutting plate and thereby increases its wear resistance. The use of carbide tool with flexible thermally conductive gaskets of sheet reinforced material allowed increasing resistance of the cutting tool by almost 17% according to performed tests.

Keywords: rolling stock, wheel set, wheel tread processing, carbide cutting tool, heat removal, thermal interface, thermal compound, tool life.

Background. *Accuracy and quality of manufacture and repair of critical parts of the rolling stock running gear are directly related to manufacturing quality, accuracy and durability of the used cutting tool. One way to improve its wear resistance in material processing is reduction of the thermal stress of the contact layers of the tool and the component part by the intensification of heat removal in the cutting zone [1].*

To improve heat removal the most effective way is to use coolant-cutting fluids and media (CCF and CCTM). However, there are cases where their application is impossible due to technical or technological requirements. Thus, the use of CCTM is impossible in the presence of active chemical interaction of the medium with the process material (medical, chemical, military, aerospace industry, and others.). A typical example of the lack of technical specifications in relation to CCF is mechanical processing of the rolling profile of wheel sets, roughing of axes, boring of tread bands etc., when machining equipment constructively is unable to supply, collect and re-use coolant-cutting fluid.

Due to the high thermal stress of the processing of component parts of railway rolling stock (the area of the cut metal is up to 15–25 mm ^{2}) there is a considerable heating of the cutting area (the contact temperature reaches 800–1000 C), which leads to a high rate of wear of the tool. In the case of using a tool with mechanical fastening of replaceable carbide plates [2] due to the heterogeneity of the surface between the cutting plate and tool holder socket plate air gaps are inevitably present, as well as leakages and scallops, dramatically reducing the transfer of heat in the body of the tool, which is a massive heat absorber.

The department «Technology of transport engineering and repair of rolling stock» of MIIT offered a method of increasing the wear resistance of the carbide tool with special elastic silicone compositions of high thermal conductivity. Such compositions (with thermal conductivity – 2–3 W/(m·K)) allow to displace the air, which thermal conductivity is 0,03 W/(m·K), from the air gaps and scallops between the cutting plate and the bearing surface of the tool body socket plate, providing good conditions for heat removal [3].

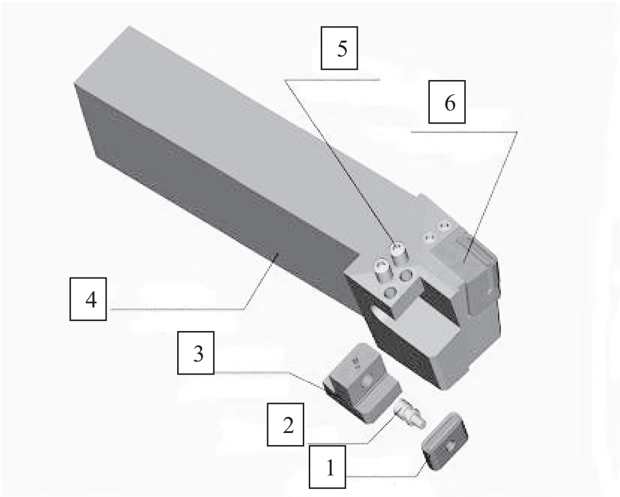
Objective. *The objective of the authors is to analyze a problem of wear resistance increase of the cutting tool during railway car's wheel processing.*

Methods. *The authors use engineering analysis, modeling, statistical method, evaluation method, comparison.*

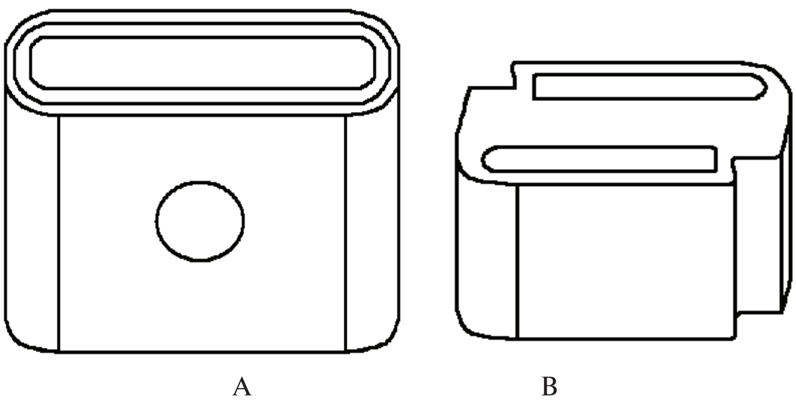
Results. *A number of laboratory and industrial research and tests of various silicone thermally conductive compounds were conducted during mechanical processing of component parts, including rolling stock. Evaluating the effectiveness of heat-conducting interfaces of domestic and foreign manufacturers concerned more than 50 of their species.*

Laboratory studies were conducted at the university department for external turning cut of workpieces with diameters ranging from 60 to 80 mm of steel brands 3,45 and U8 (with the corresponding average hardness of 150 to 250 HB). Processing of component parts was carried out on turning lathe 16K20PF1. The cutting tools were tool holders PSBNR 2020M19 and MCLNP 2525M12 (with plates SNMM 190616 and CNMA 120408). Tool holders have been further developed, which allowed determining the average temperature in the cutting zone by natural thermocouple method, under the surface of the supporting plate an artificial thermocouple was installed to measure the intensity of the heat flow in the body of the tool.

Production research took place in the machine shop of Lublino Casting and Mechanical Plant (LLMP) on turning lathe 16K25 at external turning cut of work pieces with a diameter of 250 mm made



Pic. 1. Prefabricated turning tool for car-wheel processing:
1 – carbide plate type LNMX-301940; 2 – fastening mechanism of the plate; 3 and 6 – removable cutter cartridges; 4 – body of the tool holder; 5 – screw of cartridge's fastening.



Pic. 2. Forms of two-sided cutting plates for car-wheel processing (a – type LNUX 301940 and b – type BNUX 201540).

of steel 45 (with an average hardness of 217 HB). The cutting tool was a tool holder PSBNR 4040S25 with plates LNMX 301940. In these circumstances the use of thermocouples was difficult because of the large amount of continuous chip formed during processing, so to get the thermogram of the cutting area in real time a high-precision professional infrared imager «ThermoVision» model A40M was used.

Production tests included the processing of real component parts of rolling stock. Evaluation of the effectiveness of various thermal interfaces was associated with durability parameters of the cutting tool, working under the same conditions. The tests took place:

– For boring of tread bands of motor cars in the wheel shop of Moscow locomotive repair plant (MLRP) on boring lathes KS 412 (tool – tool holder PSBNL 4040S25 with plates SNMM 250724);

– For roughing of axes of freight cars in the machine shop of Lublino casting and mechanical plant on the lathe KZTS model KZH 1832.02 (the tool – tool holders PSBNL / R 4040S25 with plates SNMM 250924);

– For finishing of axes of freight cars on the lathe CNPU KZTS 1A740RF3 (tool – holder PCLNL / R 3232P19 with plates CNMG 190616);

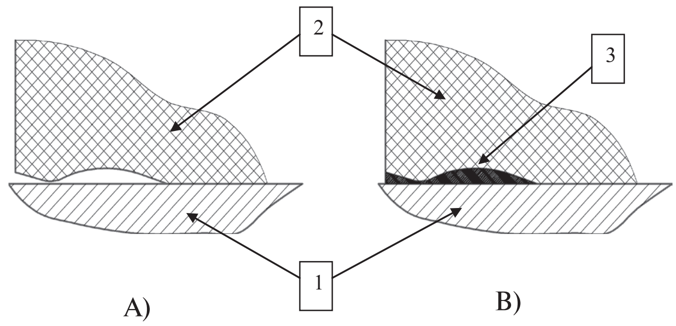
– For machining of the rolling profile of wheel sets of the multiple units in the wheel shop MLRP on the car wheel lathe «Rafamet» UDA-112 (the tool – special tool holder with interchangeable cartridges for carbide plates LNMX 301940).

According to the results of comprehensive research and testing of various thermally conductive silicone elastic compositions for turning of component parts it was found that they can reduce the thermal stress in the processing zone by 15–20% (depending on operating conditions). Additionally, were identified:

– The most rational areas for the use of thermally conductive interfaces of various types;

– The most effective brands of thermally conductive interfaces of domestic and foreign production;

– A measure of the influence of cutting conditions and thermal stress of the processing on durability and stability of thermal interface properties;



Pic. 3. Contact of the base of the tool holder and the cutting plate: 1 – tool holder; 2 – carbide plate; 3 – thermal gasket.

– The influence of surface scallops and shapes of chip-breaker grooves on the front surface of the plates on the efficiency of the thermal interface;

– The impact of the brand of the tool cutting alloy (including surface wear-resistant coating) on the efficiency of the thermal interface.

Conclusions. *One of the important results of this work was to identify rational areas for the use of heat-conducting interfaces for different types of mechanical processing of the wheel tread profile. At car-wheel processing the most wide application received prefabricated turning tools, consisting of a tool holder, cutting plate and clamp (fastening mechanism) (Pic. 1). Double sided cutting plates are placed with large forward angles (γ = 12–15 ˚), reinforcing chamfers on the cutting edges (γ = –15 ˚) and wide chip-breaker grooves along the contour of the front surface (2,5–3,5 mm) (Pic. 2). In the two-sided construction the front surface of the cutting plate serves as a bearing surface, being in contact with the bearing surface of the tool holder.*

Due to the large forward angles and wide chip-breaker grooves in the contact zone of bearing surfaces of the plate and the tool holder large air pockets are formed (the area of actual contact of bearing surfaces is 50–65% of the total area of the bearing) which gradually deteriorate the heat removal from the cutting plate in the tool holder body (see. Pic. 3a). Since during railway car's wheel processing large cutting forces arise, to ensure reliable fastening of the plate in the tool holder a powerful clamping mechanism is required, so the use of viscous heat-conducting interfaces (thermal compounds) in this case is ineffective, since the thickness of the layer of applied thermal compound should not exceed 100 micron, which does not allow to fill the chip-breaker grooves completely on the front surface of the plate, and moreover, at a high clamping force the compound is extruded from the contact, reducing fastening reliability of the plates.

To improve the heat removal at the front surface of the cutting plate which interacts with the cutter cassette thermally conductive elastic gaskets of sheet ceramic-reinforced polymeric material (type NOMAKON KPTD-2) were glued,corresponding by shape and size to the thickness of the chip-breaker grooves. Such thermo layers possess high elasticity (at least 50%) and thermal conductivity (0,8–1,4 W / (m · K)), provide an effective heat transmission across the bearing surface, eliminating air gaps (see. Pic. 3b). Due to fiberglass reinforcement the material withstands compression to 40 MPa, which ensures reliable fastening of the cutting plate. At its indexing when the bearing surface of the plate turns into a front surface, a portion of the gasket, located in the contact zone, is easily removed by moving chip scraps.

The use of carbide tool with flexible thermally-conductive gaskets of sheet reinforced material allowed increasing resistance of the cutting tool by almost 17%.

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Article received 01.12.2014, accepted 17.02.2015.

The article is based on the papers, presented by the authors at the International scientific and practical conference «Rolling stock's Design, Dynamics and Strength», dedicated to the 75th anniversary of V. D. Husidov, held in MIIT University (March, 20–21, 2014).