Research of thermal cycle parameters and surface condition of the samples from high-tension steel 30ХГСН2А at cylindrical external grinding

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Abstract. Description of composite and combined grinding wheels, which are used for research performance and lubricating - cooling elements, being a part of their content, is introduced. The parameters of thermal cycle under different machining conditions at the operation of cylindrical external grinding of the specimen rings from high – tension steel 30ХГСН2А and metastable diagrams of its condition, what allowed to predict possibility of structure changing occurrence in the surface layer of these rings.

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Introduction

The structure-phase condition of the surface layer of the part has a significant impact on its reliability and durability, and, consequently, on the reliability and durability of the product. And in a greater degree, the above spoken refers to highly loaded parts experiencing significant alternating loads and vibrations.

Forming of the surface layer of the parts in machining operations, particularly at grinding, is carried out under influence of force and temperature factors under the dominant influence of the first one if the set of parameters of the thermal cycle, characterizing the thermal process, does not result to structural and phase changes [1, 2]. Under thermal cycling set of parameters characterizing the thermal process at grinding, should be understood: mean contact temperature θ in the cutting zone, the heating rate $\upsilon_{heating}$ and the cooling rate $\upsilon_{cooling}$. As it is known, the rates of heating and cooling at grinding can reach the values equal to $10^5…10^6$ °C/sec that is why for prediction of the structural- phase condition of the surface layer at the known parameters, characterizing the thermal process, it is necessary to use the metastable diagrams of the material condition. [3-5].

For research of prediction possibility of the structural condition of the workpiece surface layer from high – tension steel 30ХГСН2А at the operations of cylindrical external grinding on the base of using of thermal cycle parameters and metastable diagrams of condition, were performed numerical and full-scale experiments.

This steel is widely used at performance of gear legs and cylinders of the landing gear of high capacity planes. The tensile strength of this steel in the hardened condition, depending on the tempering temperature, is in the range from 1600 to 1750 MPa. The major type of machining at the final operations of the parts, manufacturing with such a material tensile strength, is grinding. Though, taking into consideration that occurrence of burn marks and cracks is not acceptable at grinding of heavy loaded parts, this type of processing in the batch production terms cause some difficulties. Therefore prediction of the material structure condition after grinding is of undoubted interest.

Methods

Thermal cycle parameters were determined based on using of analytical dependences, presented in the work [5-7]. These dependencies, implemented in the calculation programs, in difference from dependencies, presented in the work [8-11], allow to calculate the temperature fields in the workpieces at grinding with grinding wheels of various configuration and, consequently, to determine the parameters of the thermal cycle.

A special dilatometer system for getting of the metastable condition diagrams for steel 30ХГСН2А was used.

Numerical and full-scale experiments were performed on specimen - rings from high-strength steel 30ХГСН2А in the conditions of external grinding. Machining was carried out in modes: rotation speed of $\upsilon_{rotation}$ = 30 m/sec, the rotation speed of the specimen - rings (workpiece) $\upsilon_{workpiece}$ - = 10 ... 50 m/min, longitudinal feed S_{long} = 0.5 m/min, cross - feed per a double stroke of the machine table S_{2x} - = 0.03 mm/double strokes.

At full-scale experiment the specimen – rings grinding was performed on a universal grinding machine of model 312M. Machining of the rings was carried out by wheels with a solid operation surface 1300 × 127 × 40 25AF60L7V 50 m/s 2 cl. GOST R 52781-2007. Cavities on the operation surface of the wheels at composite grinding wheels are filled with solid lubricant. Combined grinding wheels are symbiosis of intermittent and composite wheels. Cavities are made before the cutting cogs in the lubricating – cooling elements (segments) of these wheels.

Lubricating - cooling elements of composite and combined wheels were made from a mixture of graphite-based brand GL-I, binding of which was formaldehyde resin. Lubricating-cooling elements based on the schedule in combination with the previously mentioned above binder have a better combination of properties (strength, wear resistance, lubricating - cooling effect) compared with lubricating cooling elements, made on the basis of sulfur, charcoal, molybdenum disulfide (MoS2), and etc.

The research results showed that the stress limit of lubricating cooling elements for stretching and compression can be increased by 20% if to produce them with the hot pressing method that is to carry out polymerization of binding lubricating – cooling elements at a compression pressure. Higher strength of the hot pressed lubricating – cooling elements in comparison with the cold pressed lubricating – cooling elements is determined by better conditions of forming their structure at hot pressing. Framework forming of the binder at hot pressing is accompanied by decrease of its pore volume and number of defects due to eliminating of the conditions for increasing of the binder volume at the process of the polymerization reaction.

Measurement of the average contact temperature in the cutting zone was performed with using of a semi-manufactured thermocouple, and determining of the structural changes occurrence in the surface layer was carried out on the base of measuring of the microhardness at the surface layer depth and metallographic studies. Measurement of microhardness was carried out at the gage PMT-3 with a load of 1.0 N, and metallographic researches were carried out at a microscope MBI-6.

The main part

Numerical experiment carried out for the conditions of external cylindrical grinding of the specimen - rings from steel 30ХГСН2А with the wheels of different designs for different modes: $\upsilon_{rotation}$ = 30 m/s, $\upsilon_{workpiece}$ = 10 ... 50 m/min = 0.5 m/min, S_{long} = 0.03 mm/double stroke allowed to determine the parameters of the thermal cycle on the base of temperature fields using, calculated for the cutting zone. The temperature fields in the cutting area are presented as an example in Fig 1, obtained by grinding of the specimens by the abrasive discs with solid operation surface, combined and composite.

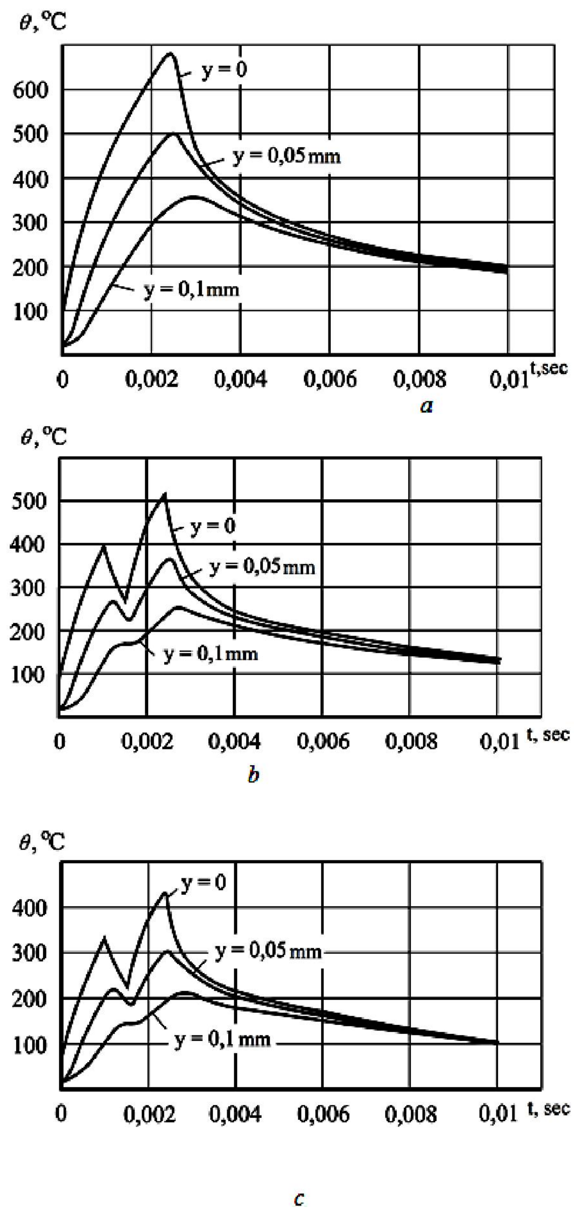

Fig. 1 Temperature field at external cylindrical grinding in the contact area of the wheels with the rings from steel 30ХГСН2А

Wheels: a – solid, b-combined, c-composite; mode: $\upsilon_{rotation}$ = 30 m/sec; $\upsilon_{workpiece}$ = 30 m/min;

S_{long} = 0,5 m/min; $S_{2stroke}$ = 0,03 mm/double stroke

Experimental researches, carried-out with dilatometric device and consist in heating and cooling of special specimen with speeds which are typical for machining processes and also their metallographic analysis, render possible to get the metastable diagrams of condition for steel 30ХГСН2А, presented in Fig. 2 and 3.

Availability of the thermal cycle parameters and metastable diagrams of conditions makes it possible to give findings about possibility and impossibility of structure changes occurrence in a surface part layer.

The parameters of the thermal cycle and the results of occurrence prediction of the structure secondary changes in the surface layer of the rings from stainless steel 30ХГСН2А after grinding with the wheels of different construction at the indicated cutting mode in Table 1.

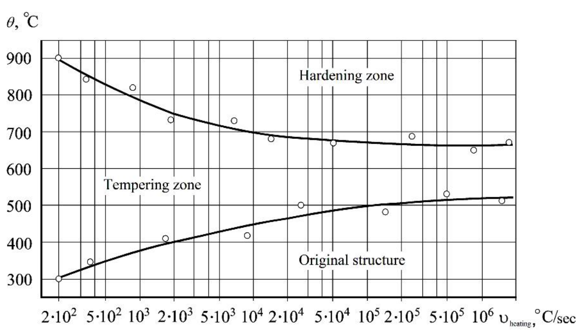

Fig.2. Influence of temperature and speed of heating on the nature of the structural changes in steel 30ХГСН2А

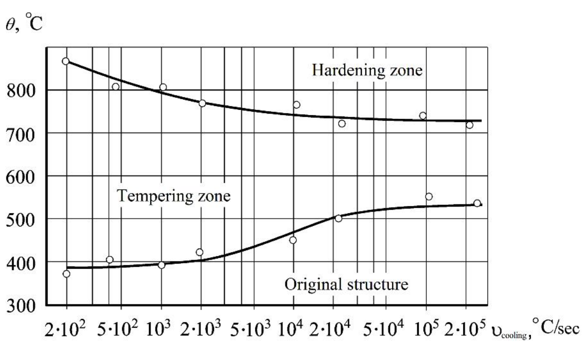

Fig. 3. Influence of heating temperature and cooling speed on the nature of structural changes in steel 30ХГСН2А

As it is seen in table 1, speed increasing of rotation of the rings from 10 to 50 m/min, rendered possible completely to eliminate the occurrence of secondary structural changes in the surface layer at the work by combined and composite wheels. When working by the wheels with solid operation surface, the structural changes in the surface layer are available.

Inference

The results of the numerical experiments, indicated in Table 1, completely confirmed the full-scale experiment, carried-out for the identical conditions of machining. Carried out researches made it possible to choose the rational cutting modes for machining of various parts from high-strength steel 30ХГСН2А in a working production.

Table 1. Influence of the rotation speed of the specimen - rings and the wheel design on the thermal cycle parameters at grinding and structural condition of the surface layer

Rotation speed of the rings, m/min	Disc	Parameters of the thermal cycle			Occurrence of the secondary changing of the surface layer
		Temperature, °C	Speed of heating, °C/sek	Speed of cooling, °C/sek	
10	Solid	780	$1{,}07\cdot10^5$	$1{,}76\cdot10^4$	**exists** austenite-martensite secondary hardening
	Combined	630	$8{,}62\cdot10^4$	$2{,}14\cdot10^4$	**Exists** troostomartensite and troostite of the secondary tempering
	Composite	545	$7{,}46\cdot10^4$	$2{,}36\cdot10^4$	**Exists** troostomartensite and troostite of the secondary tempering
50	Solid	590	$4{,}13\cdot10^5$	$1{,}36\cdot10^5$	**Exists** troostomartensite and troostite of the secondary tempering
	Combined	460	$3{,}22\cdot10^5$	$1{,}82\cdot10^5$	no
	Composite	350	$2{,}45\cdot10^5$	$2{,}33\cdot10^5$	no

Notes. 1. Grinding mode: $\upsilon_{rotation}$ = 30 m/sec, S_{long} = 0,5 m/min, $S_{2stroke}$ = 0,03 mm/double stroke.
2. Features of the abrasive tools Характеристика абразивных инструментов - 1 300x32x127 25A F60 L 7 V 35 35 m/sec 2 class. GOST P 52781-2007

Inference

Thus, knowledge of the thermal cycle parameters at the specified criteria of grinding and availability of metastable diagrams of machining material conditions gives it possible to predict the surface layer condition of the workpieces and reasonably to choose the machining mode.

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