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# Physical Modeling of Contact Processes on the Cutting Tools Surfaces of STM When Turning

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**Abstract.** This article describes how to create an optimization model of the process of fine turning of superalloys and steel tools from STM on CNC machines, flexible manufacturing units (GPM), machining centers. Creation of the optimization model allows you to link (unite) contact processes simultaneously on the front and back surfaces of the tool from STM to manage contact processes and the dynamic strength of the cutting tool at the top of the STM. Established optimization model of management of the dynamic strength of the incisors of the STM in the process of fine turning is based on a previously developed thermomechanical (physical, heat) model, which allows the system thermomechanical approach to choosing brands STM (domestic and foreign) for cutting tools from STM designed for fine turning of heat resistant alloys and steels.

## 1. Introduction

By results of research of process of a struzhkoobrazovaniye when cutting tempered staly by the tool from an elbor – are made P following conclusions: 1) turning by cutters from a composite 01 tempered staly is more expedient, than crude owing to more favorable conditions for deformation of a struzhkoobrazovaniye – when turning soft (not tempered) staly typical drain shaving is formed, when turning tempered staly processes of formation of elements of shift occur more intensively sustavchaty shaving with undivided elements iobrazutsya; microhardness of shaving tempered by staly is much lower than the initial size (material of shaving razuprochnyatsya), and at crude on the contrary; 2) intensity of deformation processes in a zone of contact of shaving with a forward surface of a cutter when turning tempered by staly is much lower, than when turning crude; 3) increase in speed and depth of cutting reduces deformation size; 4) wear of cutters sharply intensifies deformation processes of shift and friction.

From the analysis of literary data and operating experience of cutters the following scopes of composites when turning are recommended tempered staly: 1) composites 01 and 02 – thin and fair turning without blow of details from tempered with the staly hardness of HRC 55-70 with giving to 0.15 mm / about and cutting depths to 1-1.5mm; 2) a composite 05 and his modifications – fair and semi-fair turning without blow of details from HRC 40-60 tempered staly average hardness with giving to 0.3 mm / about and depths of cutting of 0.05-2.0 mm; 3) composites 09 and 10, 10D – thin, fair and semi-fair turning with blow and without blow of details from tempered by staly hardness not above HRC 60 with giving to 0.2 mm / about and cutting depths 0.05-1.5mm.

It is specified in work that the available information on application of cutters from a composite when processing of the hardly processed alloys is insignificant, it is often contradictory and can't be a basis for what - or recommendations.

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There are four main groups of the materials which are effectively processed by composites: the bleached cast iron or the white HRC 50-65 cast iron alloyed by nickel, or chrome; some strengthening HRC 38 alloys, some brands of gray HB 200-220 cast iron. When turning without cooling of nickel alloys with plates from a composite the following modes of cutting are recommended: speed of cutting is 80-120 m/min, giving of 0.2-0.3 mm / about, depth of cutting is 1 mm.

Efficiency of processing of metals cutting substantially depends on a right choice of geometrical parameters of the cutting tool. Geometrical parameters have to correspond completely to specifications of the carried-out operation, provide an opportunity to appoint the most economy mode of cutting and consequently, to allow to conduct processing with high efficiency at the minimum expenses of means.

On the basis of the pilot studies conducted in Vniialmaz and in other organizations the geometrical parameters of the lezviyny tool equipped with CTM, providing the high durability and the maximum wear resistance of the tool are determined.

Scopes of composites and ceramics are substantially blocked. Cutters with plates or inserts from a composite 01 possess ability to samozatachivatsya at wear, that is to keep the radius of a rounding off of the cutting edge almost invariable in limits ρ=20-50 micron during the entire period of firmness. It promotes reduction of a roughness of the processed surface and, as a result, increases firmness of cutters by technological criterion at fair processing. Cutters from ceramics don't possess such ability – the edge at them is rounded much more intensively and more. Therefore the composite 01 has advantage in comparison with ceramics when turning of the modes of cutting characteristic of these materials tempered staly high hardness in all range. The ceramics is more preferable when turning preparations from not tempered constructional staly at cutting speeds from above 250m/min composites of all brands are almost disabled.

The Lezviyny tool from STM (composites) at introduction in many cases replaces: 1. The cutters equipped with firm alloys, the cutting ceramics or diamonds on operations of fair and thin turning and boring. 2. Abrasive, elborovy and diamond wheels on grinding operations. The feasibility study on efficiency of the tool from STM in the first and second cases is provided in works.

In the first case the lezviyny tool from STM can fit into the existing technological processes as they are applied on the same equipment, as the replaced tool. However, ensuring higher speeds of cutting and receiving more quality processing leads in some cases to change and simplification of technological processing: operations of operational development, grinding in or a shabreniye are excluded, the necessary number the honingovalnykh of operations, that is in these cases is reduced, the existing technological processing of details undergoes some changes.

In the second case, when replacing abrasive tools and operations of grinding of heat resisting alloys and staly, technological processing of details undergoes considerable changes, the lezviyny tool from STM allows to concentrate operations, for example, on one machine with CNC. One of the basic principles of technology of mechanical engineering – concentration of operations – is carried out, as a rule, due to improvement of the machine and its automation. In this case the high cutting properties of the tool are the cornerstone of this principle. Experience of application the lezviynykh of the STM tools shows that concentration of operations is carried out due to performance of draft and fair operations on this equipment, one tool and simultaneous processing by one tool of details of various hardness. In this case technological processing should be made according to the scheme: exact preparation - heat treatment - full processing by the lezviyny tool from STM.

Cutters from STM are the tool for finishing processing therefore they should be used on the metal-cutting machines of the increased, high and especially high precision possessing necessary vibrostability and rigidity. The most effective is use of the tool from STM the machines having a high top limit of frequency of rotation of a spindle (3000 rpm and more) and a low limit of longitudinal giving (0,005-0,01) $\times 10^{-3}$ m / about.

The main area of effective use of the cutting tool equipped with STM, the automated production on the basis of machines with CNC, multi-purpose machines, automatic transfer lines, special high-speed machines, the flexible production modules (FPM) and the flexible production systems (FPS). Efficiency of such systems is provided with their ability to be reconstructed quickly on release of a new product with the high efficiency reached by round-the-clock work of the equipment in an automatic cycle. Under such circumstances works sharply increase requirements to reliable operation of machines, all industrial equipment and is concrete to reliability and wear resistance of the cutting tool.

When processing on machines with program control and GPM of preparations from tempered staly on many finishing operations by the abrasive tool it is almost difficult to provide the required rates of increase of productivity of processes owing to low dimensional firmness of circles, and also practical impossibility of processing (by the adjusted size) and with a deep water of cutting. Besides, when processing defects as charging of the processed surfaces of preparations and education in their blanket of cracks, prizhog and other defects arise the abrasive tool. Machining of such preparations by the lezviyny tool is more productive and practically excludes emergence of the specified defects. However, application of cutters from firm alloys or quick cutting steels is limited to his low dimensional firmness which is sharply decreasing with increase of hardness tempered by staly. In this regard the most perspective tool materials are STM on the basis of KNB.

It should be noted that reliability of the tool equipped with STM increases at increase in speeds of cutting in strictly recommended limits when processing each concrete material. It is essentially important to consider it when using such tool on the automated equipment.

High microhardness and heat resistance of modifications of nitride of pine forest in combination with fine-grained structure allow to receive optimum prerequisites for processing of the preparations produced from heat resisting and stainless steels and alloys. In comparison, for example, with turning by tools from firm alloys or quick cutting steels, processing by the tools equipped with STM is characterized by smaller forces that positively affects reduction of size of wear and fluctuation of the tool, elastic deformations in technological system. Also the deviation of a form and height of roughnesses on the processed surfaces decreases. These features are very favorable when processing of the basic, sealing, interfaced, step and shaped surfaces, boring of exact openings.

We have developed a thermo-mechanical model of a thin turning heat-resistant alloys and steels STM cutters on CNC machines, flexible manufacturing units (GPM) and machining centers is based on experimental studies. The basis of this model, the system proposed by thermomechanical approach to the selection of domestic and foreign brands to private label cutters for fine turning of heat resistant super alloys and steels [1].

This thermo-mechanical model allows to develop and implement in the course of processing optimization (physical, thermal) process model of fine turning of superalloys, and has become a tool of the STM. Design optimization model (physical optimization) is performed using graphical techniques - charting of the family (nomograph) to determine the contact characteristics and parameters of the cutting process the cutting conditions (t, s, $v_{opt}$) having a constant value for optimal values [2].

## 2. Thermomechanical model

Before considering the issues related to the creation and implementation of the optimization model of the process of fine turning of superalloys tools STM need to dwell on the problems of modeling and creating physical models of processes.

The term "modeling" is defined as a substitution of one object (original) to another (the model). Next, you need to study the properties of the model. The substitution is made in order to simplify, reduce the cost, accelerate the study of the properties of the original.

Initially, all models can be divided into two groups: physical (real, real); mathematical (abstract, conceivable).

Thus, process modeling involves making assumptions varying degrees of importance. This must be met a number of requirements to the models: the adequacy of sufficient accuracy, expediency, efficiency.

The need arises in the modeling techniques in different situations for the pilot study, a comprehensive analysis and forecasting of processes of passage. An important area of the simulation is to take management and design solutions in the study process.

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Thus, modeling of processes assumes acceptances of assumptions of this or that degree of importance. At the same time a number of requirements to models has to be met: adequacy, sufficient accuracy, expediency, profitability.

Need for methods of modeling arises in various situations for a pilot study, the comprehensive analysis and forecasting of passing of processes. The important sphere of modeling is adoption of administrative and design decisions at research of processes [3,4,5].

Thermomechanical model is the basis for the creation of an optimization model of the process of fine turning of superalloys and steel cutters of the STM, with low tensile strength. Implementation of thermomechanical model of the process of fine turning of superalloys and steel tools from the STM solves the thermal problems with differing from those given in the literature boundary conditions, approximating the calculated according to the actual contact processes fine turning of superalloys and steel cutters of the STM.

We set task is to carry out sufficiently substantiated systematic approach to the selection of private label brands (domestic and foreign) for fine turning heat-resistant alloys on CNC machines, machining centers and flexible performance model, as well as on the universal equipment. Thermomechanical proposed approach to selecting brand STM, consisting in simultaneous account while choosing the thermophysical characteristics STM thermal conductivity $\lambda_{toll}$ ($\lambda_t$) physical and mechanical characteristics of the STM (instrumental characteristics of the material strength) - the tensile strength $\sigma_{stretching}$ ($\sigma_{st}$). These boundary conditions when selecting brands STM differ from those given in the literature.

Thermomechanical approach to pilot studies of contact processes at a thin current of heat resisting alloys cutters from STM allows to draw a conclusion that the most effective from the point of view of dynamic durability from three considered STM (composites) - an elbor - P, a composite 05IT and a geksanita - R-is geksanit - P as due to redistribution of average contact tension on forward and back cutter surfaces from a geksanit - P tension of qN, qF on a forward surface increase, and on a back surface tension of $qN_1$ decreases by 1,1 – 1,5 times and tension of $qF_1$ a cutter from an elbor - P in the considered range of the modes of cutting decreases by 1,2 - 1,64 times in comparison according to tension of $qN_1$ , $qF_1$ . It is connected with influence of size of coefficient of heat conductivity $\lambda_t$ a geksanita - P on the fact that at a geksanit - P qN, qF increase, and $qN_1$ , $qF_1$ decrease in comparison with the corresponding contact tension at an elbor - P at thin turning of heat resisting alloys.

We have developed the principle of choosing the effective use of cutting tools made of composites and STM, manufactured abroad, in the processing of a variety of processed materials. This principle is the realization of thermo-mechanical approach to the choice of domestic brands STM (composites) and foreign STM CBN intended for fine turning of heat resistant steels and alloys tverdostyuHRC35-40, hardened alloy steel HRC35-40 hardness (medium hardness). The principle of choice of brands STM shows that the most effective composites, serially produced for the fine turning of heat resistant steels and alloys are domestic STM: composite 10, 10D composite, composite 05IT, composite 09 (PTNB-IR-1) and foreign STM CBN: vyurtsin (Japan), sumiboronBN200 (Japan), the ICE-50 (England). As the name STM CBN vyurtsin (Japan) is a method for preparation, composition and structure of the crystal lattice of the domestic analog STM CBN - geksanit - P as well, these are STM wurtzite-like hexagonal (wurtzite) modifications of boron nitride. Also in accordance with the above, vyurtsin and geksanit-P have almost the same size thermal characteristics- thermal conductivity ( geksanit- P – $\lambda_t$=20$\frac{Wt}{м*К}$; vyurtsin – $\lambda_t$=21$\frac{Wt}{м*К}$ ).

Our experiments show that hardened to a high hardness steel to effectively handle the entire range of composites. But superalloys most effectively processed composites 05IT, 10, 10D. This is due to the fact that they have low thermal conductivity in size, which leads to a decrease in the contact stress on the rear surfaces of the incisors and dynamic strength and the durability of the cutters will be higher than that of the composites of cutters 01, 02, 03, kiborita-1, amborita. Therefore, the composites 01, 02, 03, Kiborita-1, Amboro ineffective at HRSA. We have found that, ceteris paribus, along with the characteristics of strength, a determining influence on the resistance and dynamic strength of cutters is the coefficient of thermal conductivity of the selected brand STM. Krome addition, the need to use cutters of a composite 05IT, the composite 09, 10 of the composite, the composite · 10D, vyurtsina , sumiboronaBN200 (Japan), the ICE-50 (England) in fine turning heat-resistant alloys and steels tverdostyu HRC 35-40 (medium hardness) is caused by the necessity of rational use of tools STM CBN, cutters of which are expensive.

It was determined that the thermomechanical approach to choosing brands STM is connected not only with the peculiarities of physical and mechanical and thermal interaction of the processed materials and tools in the process of cutting, but is based on the principles of economic efficiency and expediency of the incisors of the STM.

Thus, the selection of stamps on the basis of STM thermomechanical systemic approach to the study of phenomena in contact relationship during the cutting process, that is, physical interaction analysis instrument and processed materials in fine turning of superalloys incisors and STM relies on the interaction of the physical laws.

System thermomechanical approach when choosing a brand STM for fine turning of heat resistant super alloys and steels provides a selection of brands CTM not only for the existing domestic and foreign instrumentation STM for cutting tools, but also for new tools STM (domestic and foreign), when known values of thermophysical characteristics (coefficient thermal conductivity $\lambda_t$ and the physical and mechanical characteristics of the STM tool (tensile strength $\sigma_{st}$). This is one of the main advantages of the process models created thermomechanical fine turning of superalloys tools from STM.

Identify physical pattern of systemic thermomechanical approach when choosing brands STM for processing high-temperature alloys and steels (based on established thermo-mechanical model of the process of fine turning of superalloys cutters from STM) applies, in our opinion, all the combinations of processed steel and alloys with different types of tool materials treatment process. For all treated steels and alloys in the choice of the brand of instrumental material groups (hard alloys Group VC, hard alloys TC group; hardmetal; cermet; mineral ceramics and other tool materials) necessary to implement the system thermomechanical approach, choosing the tool material grade for the respective brand of processed material (steel and alloy), taking into account the lower value of thermophysical characteristics (thermal conductivity $\lambda_t$) and the physical and mechanical characteristics of the tool material (tensile strength $\sigma_{st}$). This systematic approach thermomechanical brand when selecting a tool material must provide redistribution of contact stresses and temperatures at the front and rear surfaces of the cutting tool in the direction of reducing the contact stress and temperature on the back surface, and due to this rise period dynamic strength and durability of the cutting tool.

Before creating an optimization model of the process of fine turning of superalloys tools from STM we identified prerequisites of physical contact to optimize performance at the same time on the front and back surfaces of the tool from the STM.

Conducted research and comprehensive analysis of the results leads to the conclusion that the process of interaction between the treated and instrumental materials when cutting the front and rear surface of the instrument, followed by a chip, it is a single pin deformation process, so the chip velocity factor the $K_L$, defined on the front surface of the tool, affects not only the characteristics of the contact acting on the front surface of the tool [6], but also on the characteristics of the contact acting on the rear surface - forces $N_1$, $F_1$, friction coefficient $\mu_1$, contact stresses $\sigma N_1$, $\tau F_1$.

The analysis shows that the most pronounced decrease with the smooth growth factor chip shortening $K_L$ ot 1.14 to 1.48 in the process of fine turning HN62MVKYU alloy - VD, HRC38 "sharp" cutter of geksanit - P contact characteristics on the rear surface of the instrument - the normal pressure force $N_1$ i average normal contact $qN_1$ voltage. As is known, the cutting part of the tool is delicate, since the tensile strength limits constitute STM $\sigma_{st}$ = 240-490 MPa, so one of the main problems of these machining tool materials is simultaneous with the regular mechanical abrasive wear on the rear surface of the destruction of the instrument in the form of crumbling and spalling (sometimes chips) on the back side, which is actually the uncontrolled probabilistic nature [7,8,9]. This proves that you must strive to ensure the constancy of the coefficients of friction $\mu_1$ on the rear surfaces of the incisors of the STM in the process of fine turning of heat resistant super alloys and steels.

## 3. Results and Discussion. Creation optimizing (physical, thermal) models

The prerequisites for the creation of the optimization model and the physical optimization of the contact characteristics (under development) are the following: 1) Our study forces $N_1$, $F_1$, the average contact stress $qN_1$, $qF_1$, coefficients of friction $\mu 1$ on the rear surfaces of the incisors of the STM from the changes the velocity factor chips $K_L$ pri thin turning heat-resistant alloys. 2) Research Poletika M.F., which indicates that most clearly affects the chip velocity factor $K_L$ on hand at the back edge of $N_1$, $F_1$ and friction coefficient $\mu_1$ at $h_{flang}$ ($h_f$) = 0.03-0.04mm ( "sharp" cutting edge ), that is, immediately after the running-in period the tool [10]. Experiments have shown that with increasing power $K_L$ ,$N_1$, $F_1$ uvelichivayutsya. 3) We have used the method of physical optimization Makarov A.D. and the cutting speed $\upsilon_h^{opt}$ wholesale, meet the minimum relative wear hopz incisors of the STM. 4) Nekrasov Y.I. came to the conclusion that in the processing of hard materials in a range of cutting conditions "for the build-up" combination of cutting conditions in which the ratio shortening chips $K_L$opt changes ensure consistent power and thermal load of the cutting edges and the regime maintain a constant safety factor of the strength of the cutting tool ($n_{opt}$ = const) [11,12]. It has been proven that physical optimality criteria on the front surface of the tool in the contact zone are both constant optimum ratio shortening chips $K_L$opt wholesale, cutting temperature θopt and the mean normal contact stresses qN opt wholesale. Constant optimal ratio shortening chips $K_L$ opt wholesale determine the optimum cutting speed $\upsilon_{KL}^{opt}$ wholesale. In this case the optimum cutting speed wholesale $\upsilon_{KL}^{opt}$ is equal to the cutting speed corresponding to the relative tool wear on a back surface (on Makarov A.D.) - $\upsilon_h^{opt}$ wholesale, the wholesale est $\upsilon_{KL}^{opt} = \upsilon_h^{opt}$ (as provided by the constancy $K_L$ = const , θopt = consti, qNopt = const).

At a position where $K_L$opt = const, θopt = const, q Nopt = const, there is physical optimization of the process of cutting the front surface of the cutting tool for a given combination "processed material - Tool material", that is, the provision is actually physical law in the interaction of the specific tool and processed materials. At the same time at a constant depth of cut for different values of the respective innings obtain optimum cutting speed $\upsilon_{KL}^{opt} = \upsilon_{h}^{opt}$ wholesale.

Constant optimum ratio shortening chips $K_L$opt wholesale and constant optimal temperature cutting θopt are the criteria of the physical interaction of the processed materials and instrumental, that is determined by the voltage-thermal state of the cutting part of the tool at the wholesale vershiny.$K_L$opt is the physical criterion of deformation processes in the cutting zone with chip and θopt - criterion teplofizicheskogo interactions processed and instrumental materials.

Our studies have shown that at constant optimal values of the velocity factor $K_L^{opt}$ chips ~ wholesale, temperature cutting θopt , average normal contact stresses qNopt wholesale on the front surface of the tool of the STM with different combinations of the cutting parameters $\upsilon_{h}^{opt}$ ($\upsilon_{h}^{opt}$ - cutting speed corresponding to a relative minimum wear of the cutter hopz STM flank as a result of the physical process optimization method Makarov A.D.) relationship of forces on the rear poverhnosti $N_1$ / $F_1$ constant, ie constant ratio $F_1$ / $N_1$ = $qF_1$ / $qN_1$ = $\mu_1$. In addition, as mentioned above, the cutting speed $\upsilon_{KL}^{opt} = \upsilon_{h}^{opt}$wholesale.

As a result, detection of the background of the optimization model of the process of fine turning of superalloys tools from STM identifies areas (zones) of physical optimization contact characteristics (and contact processes) simultaneously on the front and rear surfaces of the incisors of the elbor - P composite 05IT, geksanit - P at Alloy turning HN62MVKYU-VD, HRC38. Provides constant optimal values $K_L$ opt wholesale, θopt, qNopt wholesale on the front surfaces of the incisors of the STM and the permanent optimal coefficients of friction $\mu_1$ on the rear surfaces of the incisors of the STM. It is also provided constant optimum cutting speed $\upsilon_{KL}^{opt} = \upsilon_{h}^{opt}$ for cutting tools from STM (at constant cutting depth t and feed S).

Thanks to the analysis of prerequisites of physical optimization of process the optimizing model of management in the course of thin turning of heat resisting alloys by contact characteristics at the same time on forward and back surfaces of the tool from STM has been created.

Physical optimization of contact characteristics of process of cutting extend not only to a lobby, but also to a back surface of the tool from STM. It occurs because the criterion of a physical optimality of interaction of the processed and tool materials - constant optimum coefficient of acceleration of $K_L^{opt}$shaving - operates not only contact processes on a forward surface of the tool (together with $\theta^{\circ}_{opt}$ and $q_N^{opt}$) but also on a back surface. $K_L^{opt}$= const operates the size of constant optimum coefficient of friction on a back surface $\mu_1^{opt}$=const on which size sizes of friction force $F_1$, forces of normal pressure of $N_1$ and average contact tension on a back surface of $qF_1$, $qN_1$ depend, that is also management of constancy of ratios $\mu_1^{opt} = f(K_L^{opt}) = \frac{F_{1opt}}{N_{1opt}} = \frac{qF_{1opt}}{qN_{1opt}} = \text{const}$.

Thus, the optimal ratio of permanent shortening chips $K_L$opt (chip shrinkage) - This is a combined (complex) characteristic of the interaction of the processed materials and instrumental in a physical process optimization, ie optimization criterion of physical contact processes simultaneously on the front and back surfaces of the cutting tool.

Developed a flowchart of an optimization model control during cutting contact characteristics simultaneously on the front and back surfaces of the tool in a STM physical optimization. Optimization model of contact management processes developed during the design phase operation of the process and is already being implemented at the time of surface treatment detali. Optimizatsionnaya model is presented as a family of graphs related to each other and forming a nomogram control the loading process at the same time on the front and back surfaces of the tool from the STM and for this nomogram determined optimal constant contact characteristics on the front and back surfaces of the STM tool and cutting conditions are optimized parameters for fine turning of the tool superalloy.

In accordance with the classification of physical models of the processes we have developed a nomogram optimization model can be attributed to the circuit (graphic) form a physical model as well as a representation of the model is produced in the graphical language (as a family of plots - nomogram).

## 4. Conclusion

Contact characteristics of thin turning of heat resisting alloys on a nickel basis by cutters from STM are experimentally determined and on the basis of it dependences of average contact tension on forward and back surfaces of cutters from STM from cutting mode parameters are established. At an intesifikation of these parameters of the modes of cutting in processing on machines about a CNC, flexible production modules and the processing centers in the conditions of real machine-building production, and also in vitro at application of the flexible production systems (FPS).

It is proved and experimentally confirmed that the most effective at thin turning of heat resisting alloys from the point of view of durability from three considered cutters from STM – an elbor - P, a composite 05IT and a geksanita - P – are cutters from geksanita-R as due to redistribution of average normal and tangent contact tension on forward and back surfaces of a cutter from geksanita-R average normal and tangent contact tension on a forward surface increases, and on a back surface average normal contact tension decreases by 1.1-1.5 times and average tangent contact tension decreases by 1.2-1.64 times in comparison respectively with the average normal and tangent contact tension of a cutter from elbora-R in the considered range of the modes of cutting.

The developed optimization model of fine turning of superalloys tools of the STM in a physical optimization has allowed to establish the relationship of contact performance and contact processes simultaneously on the front and back surfaces of the tool from the STM in order to stabilize the contact characteristics with the rear surface of the cutting part of the STM, as STM tools are fragile, that is, have a low value for the tensile strength $\sigma_{st}$.

The advantage of the implementation of process control optimization model cutting part loading of STM simultaneously on the front and rear surfaces based on the identified natural physical laws governing the interaction of the specific material being processed and the tool during the cutting process is that in this. There is no need to create complex devices and systems for the diagnosis and control of the parameters of the cutting process (contact characteristics and modes of cutting parameters). The process of contacting the treated material and in cutting tool takes the form of self-contact characteristics simultaneously on the front and back surfaces of the STM tool, based on the established physical contact superalloy patterns of interaction of the tool and in the STM processing.

In optimizing model of management of loading process at the same time on forward and back surfaces of the cutting parts of tools from STM at thin turning of heat resisting alloys and staly, the centers and the flexible production modules (FPM) tempered alloyed staly on machines with CNC, processing in the conditions of economic optimization of process of cutting at a design stage of operation of technological process and during processing of a surface of a detail criteria are involved: economic – the greatest economic efficiency of processing of a surface of a detail (profit) – $Э_{max}$, rub / with; criterion of reliability of the cutting tool – constant optimum probability of no-failure operation - $P_{З}^{opt}$, %; criterion of dynamic durability of the tool – constant optimum coefficient of margin of safety of the cutting part of the tool at top -$n_{opt}$; criterion of physical interaction of the processed and tool materials in the course of cutting (the generalized characteristic of the intense deformed state in a cutting zone) at the same time on forward and back surfaces – constant optimum coefficient of shortening of shaving -$K_{L}^{opt}$; criterion of physical interaction of the processed and tool materials in the course of wear and destruction of the cutting part of the tool on a back surface – constant optimum coefficient of friction on a back surface of the cutting part of the tool - $\mu_{1}^{opt}$; criterion of quality of processing of a surface of a detail of $R_{a}^{opt}$ ($R_{z}^{opt}$) – the constant optimum height of microroughnesses of the processed detail surface – external technological criterion of process of cutting (criterion of quality of processing of a surface) which unlike shrinkage of shaving and temperature of cutting is easier for controlling in the course of cutting by methods of active control when processing on the machine with CNC.

Physical and economic optimization of parameters of the modes of cutting at thin turning of heat resisting alloys with the hardness of HRC by 37 - 39 cutters from STM on machines with CNC, the processing centers and GPM is performed, are established economically reasonable, considering strength opportunities and necessary probability of no-failure operation of tools from STM in the conditions of the automated production.

## References

[1] R.Yu. Nekrasov, A.I. Starikov, M.A. Korchuganov. Performance assessment of carbide tooling under termal and loading conditionds. Applied Mechanics and Materials Vol. 682 (2014) pp 414 – 417.

[2] Lasukov A.A. Selection of machining conditions in terms of the temperature dependence of chip formation. Russian Engineering Research, 2015. Vol. 35, Issue 9, September 2015, pp. 679–681.

[3] R.Yu. Nekrasov, A.I. Starikov, I.V. Soloviev. Simulation of technological systems for diagnosis and management machining with CNC. Applied Mechanics and Materials, 2015. Vol.770. pp 617-621.

[4] O.S. Lomova. Mathematical modeling of structural changes in the surfaces of workpieces with thermal perturbations in the process of grinding // Omsk Scientific Bulletin , №2-120, Omsk : Izd.vo VPO OmSTU , 2013. - pp. 95-98.

IOP Conf. Series: Materials Science and Engineering **142** (2016) 012075 doi:10.1088/1757-899X/142/1/012075

[5] V.G. Shalamov . Mathematical modeling in metal cutting : a tutorial. - Ufa : Izd YuzhUrGU, 2007 .
[6] M. B. Gordon, Methodology and some results of a study of patterns of distribution of the friction forces and tangential stresses on the contact length of the chip from the front surface of the cutter, Issues in the application of cutting fluids in machining metals, Ivanovo. 1965, pp. 41 - 44.
[7] V. F. Bobrov, Determination of stresses in the cutting part of the cutting tools, High-performance cutting in mechanical engineering, Moscow, 1966, pp. 228-233.
[8] G. S. Andreev, The stress state of the cutting part of the cutter with periodic cutting, Durability of the cutting tool, Moscow, 1969, pp. 28-37.
[9] R.Yu. Nekrasov, A.I. Starikov, A.A. Lasukov. Entering the operative correction machining processes CNC. IOP Conf. Series: Materials Science and Engineering 91 (2015) 012042 doi:10.1088/1757-899X/91/1/012042.
[10] M. F. Poletika, M. H. Uteshev, Study of the processes of cutting the polarization-optical method, Bulletin of the Tomsk Polytechnic Institute, 1964, pp. 114-115.
[11] R.Yu. Nekrasov, U.S. Putilova, A.I. Starikov, D.A. Kharitonov. Diagnostics of cut-layer deformation and rational tool loading in numerically controlled lathes. Russian engineering research, 2014. Vol. 34, No.12, pp. 826–828, Allerton Press, inc. 2014.
[12] R.Yu. Nekrasov, U.S. Putilova, I.V. Soloviev. Laser interferometry method of stress determination in loaded cutting tool parts. Applied Mechanics and Materials Vol. 698 (2015) pp. 537–541.