THERMAL STREAMS AT USE OF A CUTTING TOOL WITH WEAR-PROOF COATING

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ABSTRACT. Productivity of metal cutting operations can be increased by means of processing speed increase. At that, a limiting factor is the decrease in wear resistance of the cutting tool. Software «DeForm3D» has been used for simulation of the cutting, which makes possible to vary in heat-physical parameters and tribological properties of a contact zone, simulating characteristics of wear-proof coatings on border "tool-detail". Such a parameter can be not only heat conductivity of the coating, but also entry conditions of a pre-contact zone (for example, friction factor) which in turn influences formation of sources of heat and their intensity. In order the influence degree of the specified factors on efficiency of process of cutting to be assessed, the following experimental researches have been carried on: Analysis of tribo-technical characteristics at various temperatures which is made on an adhesion measuring instrument at use spherical indenters from High-Speed Steel without a covering and with coverings (TiCr)N and (TiCr)N, and also indenters from High-Alloy Steel with coverings TiN, (TiCr)N, (TiAl)N, (AlTi)N, (TiAlCr)N, (AlTiCr)N. In quality of pair a friction special samples from a Constructional Steel with hardness 20 HRC are used. As a result of researches, the role of the arrangement of the various coating layers of the multilayered architecture, synthesized at use of thermochemical processes CVD is defined. It is revealed, that the greatest temperature of cutting corresponds to processing by the tool without a coating. The maximum decrease in intensity of thermal streams in system "tool-preparation" is provided with the coatings having multilayered architecture, and intensity of a thermal stream considerably depends on sequence of making layers of a multilayered coating.

ТЕМПЕРАТУРНИ ПОТОЦИ ПРИ ИЗПОЛЗВАНЕ НА РЕЖЕЩ ИНСТРУМЕНТ С ИЗНОСОУСТОЙЧИВО ПОКРИТИЕ

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РЕЗЮМЕ. Производителността на металорежещите операции може да се увеличава чрез увеличаване на скоростта при обработка. При това ограничаващ фактор е намаляването на износоустойчивостта на режещия инструмент. Софтуерът «DeForm3D» е използван за симулация на рязане, което позволява топлинно-физичните параметри и трибологичните свойства на контактната зона да бъдат изменяни при симулацията на характеристиките на износоустойчивото покритие на границата инструмент-детайл. Такъв параметър може да бъде не само топлопроводимостта на покритието, но също и началните условия на доконтактната зона (например коефициентът на триене), които от своя страна определят източниците на топлина и тяхната интензивност. Анализът на трибо-техническите характеристики е направен за различни температури, като са използвани адхезионен измервателен уред и сферични индентори от бързорежеща стомана без покритие и с покрития от (TiCr)N и (TiCr)N, а също и от висколегирана стомана с покрития от TiN, (TiCr)N, (TiAl)N, (AlTi)N, (TiAlCr)N, (AlTiCr)N. Като двойка са използвани специални фрикционни мостри от конструкционна стомана с твърдост 20 HRC. Като резултат от изследванията е определена ролята на подреждането на различните слоеве на покритието в многослойната структура, синтезирана чрез термохимичния CVD процес. Установено е, че най-високата температура при рязане съответства на обработка с инструмент без покритие. Максимално намаляване на интензивността на температурните потоци в системата „инструмент-подготовка" се осигурява от покритие с многослойна структура и интензивността на температурния поток зависи значително от последователността на слоевете в многослойното покритие.

1. Introduction

Productivity of metal cutting operations can be increased by means of processing speed increase. Limiting factor thus is decrease in wear resistance of the cutting tool. Therefore it is important to understand the factors influencing destruction of a tool material to create such conditions at which the given factors influenced in the least image wear of the cutting tool [1, 2]. Most important of such factors are thermal influence on cutting tool and a thermal condition in the course of cutting [2, 3, 4].

Simulation of cutting process can essentially reduce terms of working out of technology in connection with manufacture preparation, especially at use of innovative tool materials [5]. There is a requirement for the mathematical models authentically describing the thermomechanical phenomena, accompanying cutting process, and allowing to predict properties of materials cutting, and also wear resistance of the tool already at the stage of technological preparation of manufacture.

In the course of cutting practically all mechanical energy turns to thermal energy. Thus resistibility of the tool to wear process is in many respects defined by temperature conditions of cutting system. For pair the tool-detail irrespective of cutting modes exists optimum temperature of cutting, which corresponds to the minimum wear of the tool. It means, that if in the course of processing cutting temperature less optimum it is necessary to increase it. If temperature of cutting more optimum, it is necessary to create conditions of its decrease. Management in temperature of cutting and maintenance at the set level excludes the factor of negative influence of temperature on wear of the tool. Such management can be reached at the expense of regulation by thermal streams in system «the tool - preparation - a shaving - environment».

Coverings of the cutting tool, possess dual functions as can strongly enough change superficial characteristics of a tool material (frictional properties, heat conductivity, propensity of a tool material to physical and chemical interaction with a processed material etc.), and simultaneously influence contact processes. Thus, multifunctionality of the intermediate technological environment what the covering is, allows to predict possibility of the directed management in temperature of cutting [1, 6].

On the one hand the covering is capable to lower essentially friction factor in system "tool-preparation" and to reduce capacity of frictional sources of heat. On the other hand, the covering possesses shielding function and is capable to reduce essentially intensity of thermal streams in cutting wedge of the tool and to increase, thus, a temperature threshold of the beginning of adhesive interaction in system "preparation-tool" and to lower intensity of diffusion between them [6].

In the course of cutting under the influence of temperature there are structurally-phase transformations into blankets of the tool materials and preparation that means change of physicomechanical properties of boundary layers of contacting surfaces. As a result conditions of formation of contact temperatures and maintenance of optimum temperature of cutting change. Therefore the important problem at designing of functional coverings for the cutting tool is forecasting of changing contact conditions.

Decision of the coverings creation problem taking into account the specified factor is application of multilayered architecture of a covering in which each layer will carry out strictly certain functions answering to certain conditions of tool functioning.

2. Technique of researches

Software «DeForm3D» were used for cutting simulation. Thus movements it is informed the rigid body simulating cutting tool, and to preparation it is put only forces, therefore the tool moves concerning preparation. Using reference processing it was set the basic conditions of cutting: processing modes, tool and preparation geometry, parametres of tool coverings etc. Preparation geometry set in the form of the cylinder with a diameter 120 mm. Cutting modes corresponded to following parameters: spindle rotation speed 1600 rpm, feed rate 0.11 mm/rev, cutting depth 0.7 mm. A material of tool substratum is High-Alloy Steel.

Applying computer simulation it is possible to vary in heat-physical parametres and tribological properties of a contact zone, simulating characteristics of wearproof coverings on border "tool-detail". As such parametre can be not only heat conductivity of the covering, but also entry conditions of a pre-contact zone (for example, friction factor) which in turn influence formation of sources of warmth and their intensity. On fig. 1 results of calculations in a software «DeForm 3D» are shown at use various wearproof coverings both on a chemical compound, and on a thickness of a layer.

For an estimation of influence degree specified above factors on efficiency of process of cutting following experimental researches are executed. The analysis of tribo-technical characteristics at various temperatures which made on an adhesion measuring instrument at use spherical indenters from High-Speed Steel without a covering and with coverings (TiCr)N and (TiCr)N, and also indenters from High-Alloy Steel with coverings TiN, (TiCr)N, (TiAl)N, (AlTi)N, (TiAlCr)N, (AlTiCr)N. In quality of pair a friction special samples from a Constructional Steel with hardness 20 HRC used.

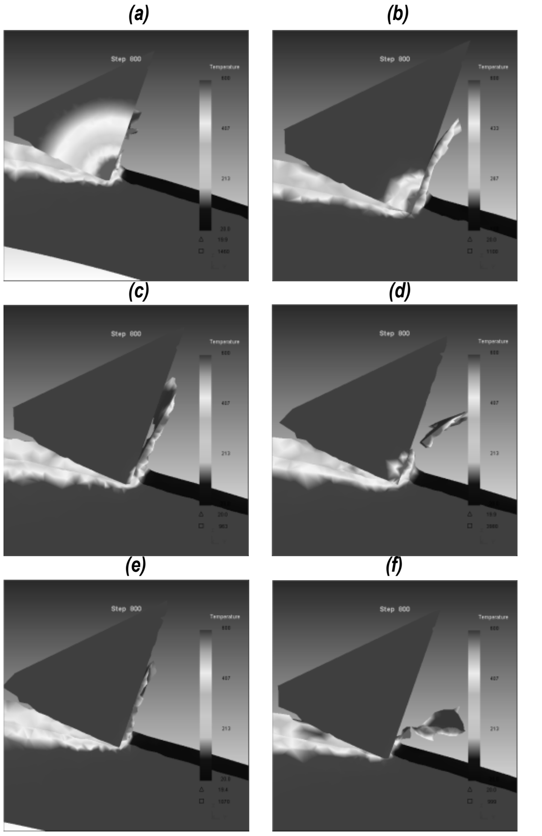

Fig. 1 Calculation of temperature fields at the cutting in the software «DeForm 3D»
(a) - without a covering;
(b) - TiN in the thickness 5 μm;
(c) - TiCN in the thickness 5 μm;
(d) - TiN in the thickness 5 μm and Al_2O_3 in the thickness 5 μm;
(e) - Al_2O_3 in the thickness 5 μm and TiCN in the thickness 5 μm and TiN in the thickness 5 μm;
(f) - Al_2O_3 in the thickness 5 μm and TiN in the thickness 5 μm.

3. RESULTS AND DISCUSSION

In experiments at milling and turning investigated wear of the tool on a back surface, temperature and force of cutting, a roughness of the processed surface. On fig.2 results both settlement, and experimental values of temperature of cutting for various conditions of processing by the tool with a covering at the turning are resulted. Cutting modes corresponded to following parameters: cutting speed 450 m/min, feed rate 0.11 mm/rev, cutting depth 0.5 mm.

Tests were conducted at milling on vertically-milling machine tool HECKERT of Constructional Steel and Stainless Steel by end mills (d=12 mm, z=4) and face mills (d=90 mm, z=1) with replaceable tetrahedral plates from High-Alloy Steel without coverings and High-Alloy Steel with covering TiN, (TiCr)N, (TiAl)N, (AlTi)N, (TiAlCr)N, (AlTiCr)N, having various percentage of each of elements with the general thickness to 15 μm. Milling modes: spindle rotation speed 500-900 rpm; feed 60-100 mm/min; cutting depth of 1-3 mm;

Coverings on tools have been received on the process equipment of the basic manufacturers of the tool with a covering («Balcers», «Sandvik Caromant», «Carbide», «Rimet») on factory technologies about use of processes CVD and PVD, and also with use of filtered.

The fig. 2 shows good enough coincidence of experimental and settlement data, and also the most effective role of coverings on the basis of system Ti-Al-N, received at use of filtering processes.

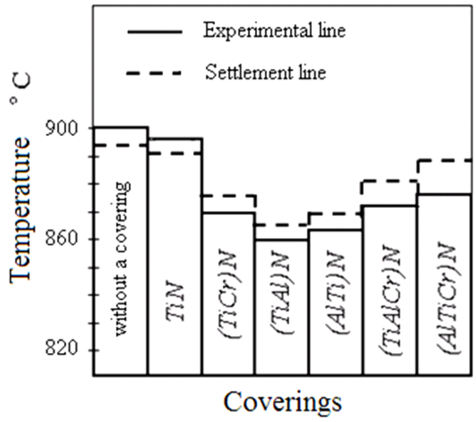

Fig. 2 Influence of a covering on cutting temperature at the turning

4. CONCLUSION

As a result of researches the role of an arrangement of various layers of coverings of the multilayered architecture synthesised at use of thermochemical processes CVD is defined. It has been revealed, that the greatest temperature of cutting corresponds to processing by the tool without a covering. The maximum decrease in intensity of thermal streams in system "tool-preparation" is provided with the coverings having multilayered architecture, and intensity of a thermal stream considerably depends on sequence of making layers of a multilayered covering. In particular more favorable thermal condition of a cutting wedge of the tool the two-layer system of a covering provides a «substratum of alloy - Al_2O_3 (5 μm) - TiN (5 μm)» in comparison with two-layer system «an alloy-TiN substratum (5 μm) - Al_2O_3 (5 μm)».

The maximum improvement of a thermal condition of a cutting wedge of the High-Alloy tool three-layer system provides an «alloy substratum - Al_2O_3 (5 μm) - TiCN (5μm) - TiN (5 μm)», that the combination of layers of a multilayered covering is caused favorable. In particular, at such covering the top layer TiN provides the maximum decrease in adhesive activity of a substrate in relation to a processed material. Transitive layer TiCN carries out strong adhesion between top TiN and bottom Al_2O_3 layers, and bottom layer Al_2O_3 effectively shields action of a thermal stream from a frictional source of heat on forward and back contacting surfaces of the tool.

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