ERRORS OF MECHANICAL TREATMENT PROVOKED BY THERMAL DEFORMATIONS OF TECHNOLOGICAL SYSTEM

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Abstract: The thermal deformations of a detail and boring bar during the cutting out precise slots were investigated by the means of modeling of compassing the method of final elements. The main factors, which define the magnitude of thermal errors and their influence on distortion of the profile of a detail were also established.

Keywords: *keywords list*

Introduction

One of the most widespread processes of casting machine detail slots remains the process of cutting of boring bar. The preciseness of slots is determined by the complex operation of a number of factors, which canse the emergence of systematic and casual errors of treatment.

The important factor of forming of macro-geometry of slots are the errors which arise due to the action of heat the springs up in the place cutting [1-4]. The most actual is the taking into account the thermal deformations of the cutting instrument as well as the surface of a detail during the final operations.

It is very difficult to calculate most analytically the defined errors, for the details having complex configuration or being heterogeneous as for their physical and mechanical peculiarities for example having functional coatings. For these cases it is very advisable to take into consideration the calculation of errors using the models based on the method of final elements and the realizations of them by the means using a computer.

Organization of a Task of Investigation

To the thermal deformations of the technological system, which influence the arising of treatment errors, they regard the deformation of machine mechanisms, a cutting edge of the instrument (a cutter, boring bar, etc) as well as a surface coat of the being treated allotment of a detail in the place of cutting under the influence of thermal currents.

In this paper the influence the current of heat, that appears during the cutting a slot in the details having different configuration.

The profile distortion is extremely undesirable while forming of cutting of the slot surfaces, which are the bases for the roller-bearings or those that operate conjugating with pistons, plungers etc [5-8].

The modeling was carried out with using the method of final elements. The algorithm of calculations made on a computer are described in the paper [9]. The preliminary results of modeling have shown that the thermal deformation of the detail surface being treated mechanically directly depends on general configuration of a detail.

In this paper the results of modeling of cutting of precise slots in the details having different thickness of a side are also brought into account.

Taking into consideration, that the distortion of a slot profile is the result of the combined action of such factors as: thermal deformation of a detail caused by a source of a thermal stream, that was arised by the process of cutting having intensity of q_d and moving along the slot axis with the sped of feeding (fig.1, a) and the thermal deformation of a instrument under the influence of the thermal stream having the intensity of q_i (fig.1, b).

For the simplification of the model such assumptions were made: thermal streams into the detail q_d and the instrument q_i are constant in time: the whole period of treating is divided into the steps periods during the next in turn step the certain new allotment of the detail is heated by the thermal stream caused by the process of cutting and if is being known that during each next step thermal influences of previous thermal inserting were taking into account.

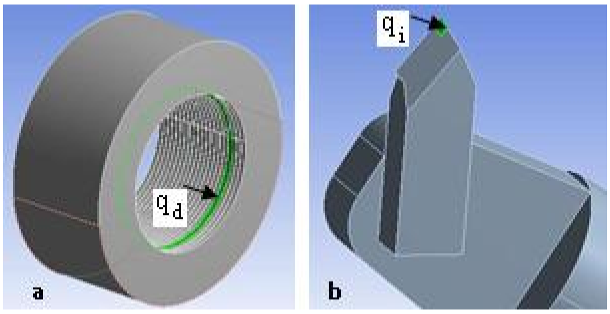

Figure 1: *Thermal streams in the slot cutting process: a) – a scheme of putting a thermal stream into a detail operation; b) – a schema of putting a thermal stream into a cutter into operation.*

The quantities of thermal streams, that influence the instrument and the detail, are calculated with the help of the well known dependences [1]. For example, in this paper the results of investigations used for cutting based on 0,5 mm/ feeding and 100 mm/min cutting sped are clearly shown.

Having aimed on determing the range of influence of the thermal heat capacity of a detail, that occur in the process of slot cutting, modeling for two types of details were carried out: 1 – details having relatively small thickness of sides, that makes possible of increase the temperature out the external surface during the cutting process; 2 – details having relatively big thickness of sides, that practically doesn’t allow to change the temperature on the external surface and that is quite typical for frame details.

If we call the detail of the first type a bush which is modeled by a cylinder having such parameters: the slot diameter d=60mm; the external diameter D=100mm; the length L=40mm; the material – steal 45. Let’s call the details of other type a frame which is modeled by a cylinder having such parameters: the slot diameter d=60mm; the external diameter D=300mm; the length L=40mm; the material – steal 45.

The results and their discussion

The positional of the thermal source q_d on the each step of thermal loading are corresponding to the position of the instrument during the slot treating. The character of the slot profile distortion caused by the thermal deformations of the detail will be determined by the movement of some points of material in the zone of cutting. Figure 2 and 3 show the radial shift of slot surface points in the process of treating under the influence of the thermal stream.

The investigation of the details having slots has shown that the macrogeometry of the treated slots depends on the their configuration and the thermal heat capacity of their sides.

For the models of a bushing type, i.e. when the thickness of the side is relatively small, the extention of the slot sizes due to the heating caused by cutting process is obviously seen and that leads to the diminution of metal layer, which is being cut. On account of this fact, the slot diameter of the cut detail appears to be smaller after cooling than it was calculated during the desposing the instrument to a certain size.

Absolutely another result is observed while slot cutting of frame details, and it is very characteristic or them that the thickness their slot sides is rather significant correlated to their diameter. As the thermal heat capacity and the hardness of their slots sides are rather big, external layers of details are almost never become deformed, and that’s why significant strain pressure is developed in the zone of cutting, and the deformation of the slot surface is directed to its axis.

As a result at this, the bigger than necessary layer of metal is cut off and that leads to the increasing of a slot after it’s treating and then cooling.

Residual distraction of the slot profile is the result of the total sum of the thermal shifting of slot surface points and of the instrument top. The distortion character of longitudinal slot profile achieved in the result of superposition of shifting is shown in figures 2 and 3 applied to the details such as the bushing and frame relatively.

The main component of the thermal deformation of a instrument is its lengthening in the direction perpendicular, to the axis of the treated slot which appears under the influence of the thermal stream, and has an effect on the operating part of the cutting edge.

The distortion of the slot profile in the process of treating owning to the lengthening of a instrument is shown in figure 2 and 3 and on curve 1. It is clearly seen that the maximum distortion of the slot radins caused by the tool instrument deformation makes up 0.022 mm.

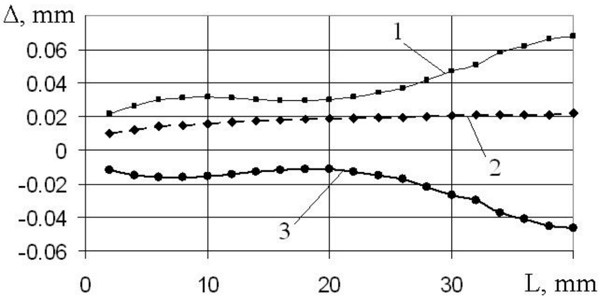

Figure 2: *Thermal deformations of the bushing in the process of cutting: 1 – cutter top shifting, 2 – slot surface points shifting in the zone of cutting, 3 – slot profile distortion after treating and cooling.*

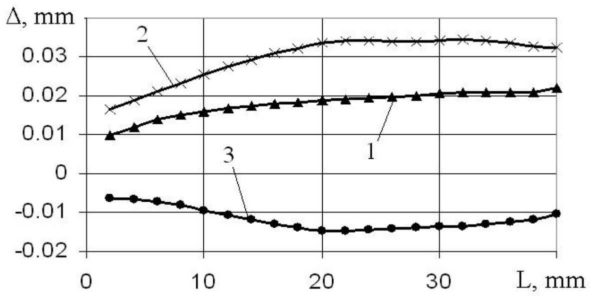

Figure 3: *Thermal frame deformations in the process of cutting: 1 – cutter top shifting, 2 – slot surface points shifting in the zone of cutting, 3 – slot profile distortion after treating and cooling.*

The maximum slot distortion for the details of the bushing tupe is twice bigger than the radial shifting and makes up 0,138 mm, and for the frame details it makes up 0,069 mm.

Conclusion

1. It is expedient to calculate the quantity of the error caused by the thermal deformation of the *instrument-detail* system using the models based on the method of the final elements.

2. The character and parameters of slot profile distortions appeared in the process of cutting depend on the construction and sizes of the detail as well as the sizes and physical and mechanical qualities of the cutting instrument.

3. To reduce the errors of mechanical treating appeared in the process of cutting, it is expedient to use the system of adaptive guidance together with adjusting the instruments accordingly to the results of model calculations.

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