

TERMAL RESIDUAL STRESSES AFTER MACHINING

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Abstract: In work the temperature tension arising at machining of axisymmetric cylindrical hardware is considered. Machining here is understood as different types of cutting: turning, drilling, milling, grinding, honingovaniye, polishing. These types of processing are accompanied by a number of the physical and chemical phenomena. In the deformed volume there is a complex stress condition of a material, elastic and plastic deformations take place.

KEYWORDS: TEMPERATURE RESIDUAL STRESSES, TURNING, HEATING, CYLINDRICAL HARDWARE, PARAMETERS OF PROCESS OF MACHINING

1. Introduction

The main objective of the manufacturing industry - available to the fast-growing world population, and metal goods required to meet the requirements. In this process by removing material is given special importance, since this method of treatment provides high accuracy. In the course of industrial development of treatments by removing material gained key positions. Production of a diverse range of goods is not possible without a focused and appropriate use of the various machining methods. Due to technical, economic and organizational change production facilities there is a need to comply with the higher standards of performance, efficiency and flexibility of manufacturing systems. Industrial value of machining should be evaluated in light of these aspects, as well as the interaction between the factors that influence the cutting process.

2. The state of stress during heating

Occur in the processing of non-uniform temperature field. In this case, an important characteristic of the surface layer are thermal residual stresses are formed due to plastic deformation and uneven heating of large surface layers. It is known that the geometry of the tool, part size, and various cutting parameters affect the sign and magnitude of such stresses. One of the causes of stress in the body is the uneven heating. Elements of the body expands with increasing temperature. Such an expansion in solid body usually can not be free, and stresses arise as a consequence of heating [1].

The equilibrium equation in cylindrical coordinates for the general case the stress state are

$$\begin{cases} \frac{\partial \sigma_r}{\partial r} + \frac{1}{r} \frac{\partial \tau_{r\theta}}{\partial \theta} + \frac{\partial \tau_{rz}}{\partial z} + \frac{\sigma_r - \sigma_\theta}{r} = 0; \\ \frac{\partial \tau_{r\theta}}{\partial r} + \frac{1}{r} \frac{\partial \sigma_\theta}{\partial \theta} + \frac{\partial \tau_{\theta z}}{\partial z} + 2 \frac{\tau_{r\theta}}{r} = 0; \\ \frac{\partial \tau_{rz}}{\partial r} + \frac{1}{r} \frac{\partial \tau_{\theta z}}{\partial \theta} + \frac{\partial \sigma_z}{\partial z} + \frac{\tau_{rz}}{r} = 0, \end{cases} \quad (1)$$

where $\sigma_r, \sigma_\theta, \sigma_z$ - the radial, circumferential and axial stresses respectively.

We restrict ourselves in this kind of deformation of bodies of revolution, in which the stress distribution is independent of the angle θ . Low in long circular cylinder is distributed symmetrically about an axis and independent of the axial coordinate Z . In the case of the plane strain stress have three components $\sigma_r, \sigma_\theta, \sigma_z$; all three shear and tangential stresses are equal to zero due to the symmetry axis and consistency conditions in the axial direction. Assume also that the axial movement w everywhere zero. The shear stress $\tau_{r\theta}$ is zero due to the symmetry of the deformation field.

In the article [2,3] - shows the accounting methods and the definition of thermo-elastic residual stress for axisymmetric cylindrical metal, where, after the solution of the thermoelastic stresses are determined depending on the heating of the surface layers of the workpiece after the passage of the cutting tool.

3. Thermoelastic stresses in hollow cylinders

Let's consider a cylindrical metal products radius R with through a circular hole of radius a . For hollow cylinders and tubes of expression for the radial, circumferential and axial stresses due to heating are:

$$\begin{aligned} \sigma_r &= \frac{\alpha E}{1-\mu} \frac{1}{r^2} \left(\frac{r^2 - a^2}{R^2 - a^2} \int_a^R T r dr - \int_a^r T r dr \right); \\ \sigma_\theta &= \frac{\alpha E}{1-\mu} \frac{1}{r^2} \left(\frac{r^2 + a^2}{R^2 - a^2} \int_a^R T r dr + \int_a^r T r dr - T r^2 \right); \\ \sigma_z &= \frac{\alpha E}{1-\mu} \left(\frac{2}{R^2 - a^2} \int_a^R T r dr - T \right), \end{aligned} \quad (2)$$

where α - the coefficient of linear expansion of the material, E - modulus - Poisson's ratio; r - current radius.

Temperature function - T the conditions of the causes heating of material, e.g. from the process and the various processing parameters. In the article [3] believed that due to the forces of friction in the deformation zone temperature distribution over the cross section of the details described by an exponential dependence

of the form. $T = T_0 e^{\frac{\beta r}{R}}$. Part surface temperature is denoted $T_1 = T_k$ the condition index $T/r=R=T_1$ found β and obtained a temperature function corresponding to the heating of the contact details in the process of cutting

$$T = T_0 \left(\frac{T_1}{T_0} \right)^{r/R}. \quad (3)$$

Solving the problem of thermal elasticity define the stresses induced by heat. Substituting the relation (2) into (3), after integration and transformation expressions for the stresses are defined as:

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$$\begin{aligned}\sigma_r &= \frac{\alpha E T_0}{(1-\mu)r^2} \left(\left(\frac{r^2 - a^2}{R^2 - a^2} \right) \cdot J + H + \frac{R^2 \Delta T^{a/R}}{\ln^2 \Delta T} \right); \\ \sigma_\theta &= \frac{\alpha E T_0}{(1-\mu)r^2} \left(\left(\frac{r^2 + a^2}{R^2 - a^2} \right) \cdot J - H + \frac{R^2 \Delta T^{a/R}}{\ln^2 \Delta T} - \Delta T^{r/R} r^2 \right); \\ \sigma_z &= \frac{\alpha E T_0}{1-\mu} \left(\left(\frac{2}{R^2 - a^2} \right) \cdot J - \Delta T^{r/R} \right),\end{aligned}$$

(4)

$$\text{where } \Delta T = \frac{T_1}{T_0};$$

$$\begin{aligned}J &= \frac{R^2 \Delta T^{r/R}}{\ln \Delta T} - \frac{a R \Delta T^{r/R}}{\ln \Delta T} - \frac{R^2 \Delta T}{\ln^2 \Delta T} + \frac{R^2 \Delta T^{a/R}}{\ln^2 \Delta T}; \\ H &= -\frac{r R \Delta T^{r/R}}{\ln \Delta T} + \frac{a R \Delta T^{r/R}}{\ln \Delta T} + \frac{R^2 \Delta T^{r/R}}{\ln^2 \Delta T}.\end{aligned}$$

Expressions (4) characterize the distribution of radial, circumferential and longitudinal thermal stresses on the pipe section. Numerical analysis of the relations (4) suggests that the highest thermal stresses occur in the surface layer part $R/r = 1$;

$$\sigma_r|_{r=R} = 0,$$

$$\sigma_z|_{r=R} = \sigma_\theta|_{r=R} =$$

$$= \frac{\alpha E T}{1-\mu} \left(\frac{2}{R^2 - a^2} \left(\frac{\Delta T (R^2 - aR)}{\ln \Delta T} - \frac{R^2 (\Delta T - \Delta T^{a/R})}{\ln^2 \Delta T} \right) - \Delta T \right).$$

4. The dependence of the temperature function of the cutting parameters

In relation (4) and (5) includes a temperature function, which in turn depends on the temperature of contact, which in turn depends on many factors that affect the temperature. In the literature, there is plenty of research to determine the temperature dependence of the contact temperature warming up on different parameters of the machining. In [5] using mathematical processing of the experimental data shows a simplified formula of temperature T_k of the contact layer is determined by the basic conditions of structural steel turning 40XH cutter:

$$T_k = T_0 + 148,8 v^{0.4} s^{0.24} t^{0.1}, \quad (5)$$

where T_0 - the temperature of the central layers of detail; v - speed in m / min; s - feed per revolution in mm / rev; t - depth of cut in mm.

5. Conclusions.

Thus the technique of fixed parameters of the machining process in determining the thermal stresses arising from the heating surface of the tubular products for turning. It is shown that for a high surface quality and durability of the parts necessary to select rational cutting conditions from the conservation of strength after machining. Knowing the distribution of thermal stresses generated during the processing of metal cutting conditions can prevent plastic deformation at the surface of the workpiece after the passage of the tool, define a rational ratio parameters of machining and the machining process to build such a way as to ensure the maximum allowable temperature.