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VOLUMETRIC MECHANICAL STRESSES IN A STEEL BUSHING AFTER REMOVING OF RADIAL LOAD

Abstract*: Stress-strain condition of a steel bushing in a vector form along axes of the Cartesian coordinate system after removing of constant radial load is presented in the article. It is determined that mechanical stresses in a longitudinal section of the bushing material are caused by compression deformation, and in the cross section mechanical stresses are caused by tensile deformation.*

Key words*: a bushing, principal stress volume, a model, a vector, deformation.*
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Introduction

Stress-strain condition of hollow parts having a shape of rotating bodies at the action of different in direction, a method of application and pattern of changing in time of loads has been described in the works [1 – 10]. Axial, radial and combined loads act on elements of technological equipment during machining. These loads cause plastic deformation of the elements material of technological equipment, i.e. changing of a geometric shape and sizes of the part, formation of microcracks in material and etc. High degree of material deformation is observed in the thin-walled parts of technological equipment. Active forces and torques along three coordinate axes are applied to the parts in three-dimensional space. Prediction of a workpiece machining error can be obtained at a calculation of material deformations of the technological equipment elements, which lead to changing of the linear and diametrical sizes of the part at the action of axial or radial forces.

Materials and methods

The calculation of stress condition of the deformed metal bushing was performed by the numerical simulation. The three-dimensional model of the bushing (the Fig. 1) was imported into the *Comsol Multiphysics* software environment.

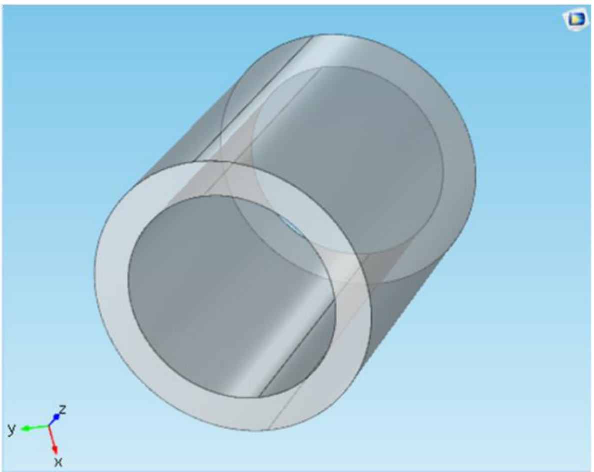


Figure 1 – The solid model of the bushing.

Constant distributed force along the *X* and *Y* coordinate axes acted on an outer cylindrical surface of the model. The bushing was based and fixed for the inner surface. The bushing does not move and does not rotate along the *Z*-axis. The bushing material is steel 1045 (solid, annealed). Changing of the basic properties of the bushing material depended on temperature. The computer write of the properties of the bushing material is presented in the table 1.

Table 1. The basic properties of the bushing material.

Description	Value
dL	(dL(T[1/K]) - dL(Tempref[1/K]))/(1 + dL(Tempref[1/K]))
CTE	CTE(T[1/K])[1/K]
Thermal conductivity	{{k(T[1/K])[W/(m*K)], 0, 0}, {0, k(T[1/K])[W/(m*K)], 0}, {0, 0, k(T[1/K])[W/(m*K)]}}
Resistivity	{{res(T[1/K])[ohm*m], 0, 0}, {0, res(T[1/K])[ohm*m], 0}, {0, 0, res(T[1/K])[ohm*m]}}
Syt	Syt_solid_annealed_1(T[1/K])[Pa]
Coefficient of thermal expansion	{{(alpha(T[1/K])[1/K] + (Tempref - 293[K])*if(abs(T - Tempref)>1e-3, (alpha(T[1/K])[1/K] - alpha(Tempref[1/K])[1/K])/(T - Tempref), d(alpha(T[1/K]), T)[1/K]))/(1 + alpha(Tempref[1/K])[1/K]*(Tempref - 293[K])), 0, 0}, {0, (alpha(T[1/K])[1/K] + (Tempref - 293[K])*if(abs(T - Tempref)>1e-3, (alpha(T[1/K])[1/K] - alpha(Tempref[1/K])[1/K])/(T - Tempref), d(alpha(T[1/K]), T)[1/K]))/(1 + alpha(Tempref[1/K])[1/K]*(Tempref - 293[K])), 0}, {0, 0, (alpha(T[1/K])[1/K] + (Tempref - 293[K])*if(abs(T - Tempref)>1e-3, (alpha(T[1/K])[1/K] - alpha(Tempref[1/K])[1/K])/(T - Tempref), d(alpha(T[1/K]), T)[1/K]))/(1 + alpha(Tempref[1/K])[1/K]*(Tempref - 293[K]))}}
Heat capacity at constant pressure	C(T[1/K])[J/(kg*K)]
Electrical conductivity	{{sigma(T[1/K])[S/m], 0, 0}, {0, sigma(T[1/K])[S/m], 0}, {0, 0, sigma(T[1/K])[S/m]}}
Density	rho(T[1/K])[kg/m^3]

Description	Value
TD	TD(T[1/K])[m^2/s]

Results and discussion

Stress condition at a point of the volumetric deformed body can be presented by a set of normal and tangential stresses acting along the coordinate axes. The visual model of mechanical stress of material is obtained by the computer simulation of the plastic deformation process of the bushing model. The vector field of principal stress volume in the bushing model after removing of load is presented in the Fig. 2. The vectors of principal stress volume directed from the each finite element of the bushing model. The vectors distribution of principal stress volume of the bushing material along the *X*, *Y* and *Z* coordinate axes after plastic deformation is presented in the Fig. 3.

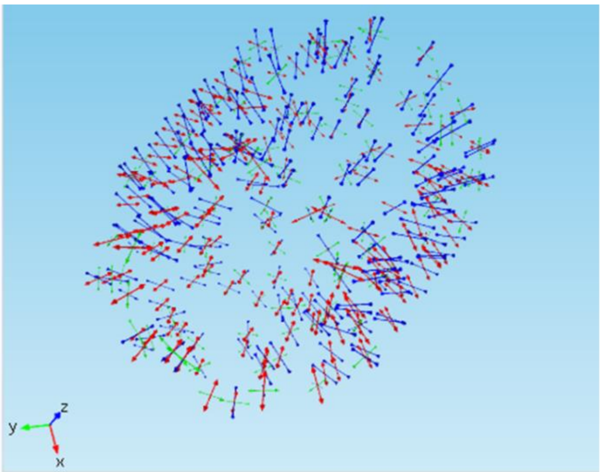
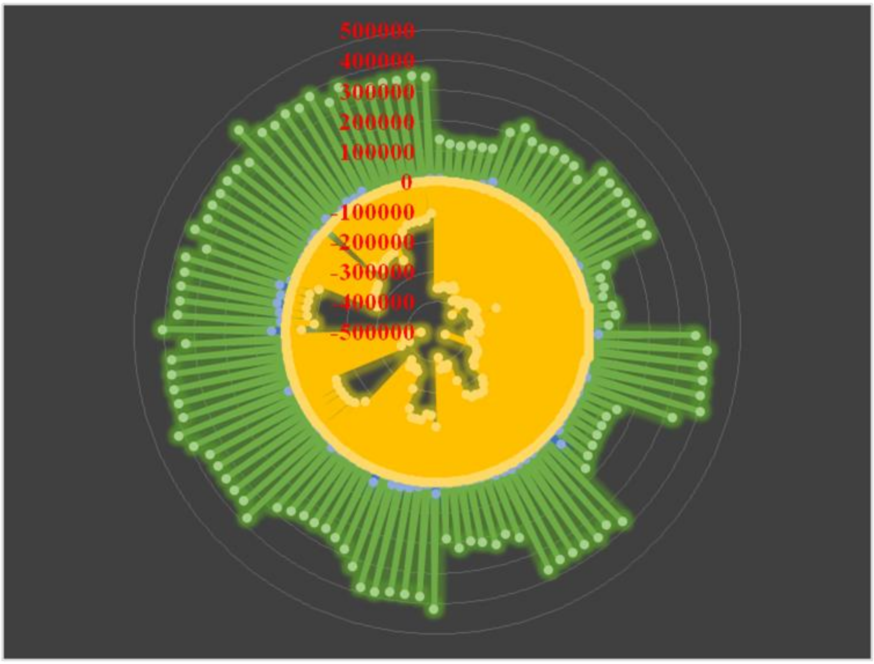


Figure 2 – The vector field of principal stress volume in the deformed bushing model.



— **vector *X*** — **vector *Y*** — **vector *Z***

Figure 3 – The vectors distribution of principal stress volume of the bushing material along the coordinate axes.

The vectors of principal stress volume of material along the *X* and *Y* axes act in the coordinate plane, which it is perpendicular to the axis of the bushing model (the diametrical sizes). The vectors of principal stress volume of material along the *Z*-axis act in the coordinate plane, which it is parallel to the axis of the bushing model (the linear size is length). Tensile deformation of material occurs at positive values of principal stress volume along the *X*-axis. Material is compressed at negative values of principal stress volume along the *Z*-axis. Stretching and compression of the bushing material are observed along the *Y*-axis. Significant values deviations of stress along the *Z*-axis and vice versa were observed in the volume of the bushing model material, where uniform stress distribution along the *X*-axis was determined.

Conclusion

1. The bushing material along the *X*-axis is subjected to stretching, and material along the *Z*-axis is subjected to compression. This indicates about increasing of the diametrical size and decreasing of the bushing length. In this case, these types of deformation are not uniform in value in all volume of the bushing material.

2. The values ratio of the stress vectors along the *X* and *Z* coordinate axes corresponding to maximum stretching (compression) is 8:10. The values ratio of the stress vectors is 9:10 at minimum stretching (compression) on the same coordinate axes.

References:

1. Hodge, P. G. (1955). Impact pressure loading of rigid-plastic cylindrical shells. *Journal of the Mechanics and Physics of Solids, vol. 3*, 176-188.
2. Symonds, P. S. (1968). Plastic shear deformations in dynamic load problems. *In Engineering Plasticity, Cambridge University Press, Cambridge, UK*, 647-664.
3. Wierzbicki, T., & Suh, M. S. (1988). Indentation of tubes under combined loading. *International Journal of Mechanical Sciences, vol. 30, no. 3-4*, 229-248.
4. Watson, A. R., Reid, S. R., & Johnson, W. (1976). Large deformations of thin-walled circular tubes under transverse loading-III: further experiments on the bending of simply supported tubes. *International Journal of Mechanical Sciences, vol. 18, no. 9-10*, 501-502.
5. Watson, A. R., Reid, S. R., Johnson, W., & Thomas, S. G. (1976). Large deformations of thin-walled circular tubes under transverse loading-II. Experimental study of the crushing of circular tubes by centrally applied opposed wedge-shaped indenters. *International Journal of Mechanical Sciences, vol. 18, no. 7-8*, 387-IN14.
6. Jones, N., Birch, S. E., Birch, R. S., Zhu, L., & Brown, M. (1992). An experimental study on the lateral impact of clamped mild steel pipes. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, vol. 206*, 111-127.
7. Shen, W. Q., & Shu, D. W. (2002). A theoretical analysis on the failure of unpressurized and pressurized pipelines. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, vol. 216, no. 3*, 151-165.
8. Karman, T., & Duwez, P. (1950). The Propagation of Plastic Deformation in Solids. *Journal of Applied Physics, vol. 21*, 987-994.
9. Chemezov, D., Tyurina, S., Pavluhina, I., Gorbatenko, O., & Medvedeva, I. (2018). Calculation of von Mises stress at plastic deformation of a steel bushing. *ISJ Theoretical & Applied Science, 09 (65)*, 201-203. soi: http://s-o-i.org/1.1/TAS-09-65-35 doi: https://dx.doi.org/10.15863/TAS.2018.09.65.35
10. Rees, D. (2006). Basic Engineering Plasticity: An Introduction with Engineering and Manufacturing Applications. *Butterworth-Heinemann*, 41.