SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2020 **Issue:** 05 **Volume:** 85

Published: 30.05.2020 **http://T-Science.org**

QR – Issue **QR – Article**

Denis Chemezov
Vladimir Industrial College
M.Sc.Eng., Corresponding Member of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
vic-science@yandex.ru

Alexandr Petrenko
Vladimir Industrial College
Master of Industrial Training, Russian Federation

Irina Medvedeva
Vladimir Industrial College
Master of Industrial Training, Russian Federation

Evgeniy Vakhromeev
Vladimir Industrial College
Student, Russian Federation

Leonid Khripkov
Vladimir Industrial College
Student, Russian Federation

Kirill Filatov
Vladimir Industrial College
Student, Russian Federation

Evgeniy Varavin
Vladimir Industrial College
Student, Russian Federation

SOME ADDITIONS TO THE ROD TORSION CALCULATIONS

Abstract*: The calculated contours and vectors of stress, strain, strain energy and other parameters on the cross section area of the cylindrical metal rod subjected to torsion are presented in the article. These results are recommended for determining total stress and strain state of material in the conditions of solving the torsion problems.*

Key words*: the rod, torsion, strain, stress, the cross section.*
Language*: English*
Citation: Chemezov, D., et al. (2020). Some additions to the rod torsion calculations. *ISJ Theoretical & Applied Science, 05 (85),* 420-423.
Soi: http://s-o-i.org/1.1/TAS-05-85-78 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2020.05.85.78
Scopus ASCC*: 2210.*

Introduction

The shafts are subjected to various deformations during operation, including torsion. For normal operation of the shafts, it is necessary that resulting stresses in material do not exceed maximum allowable stresses. The torsion tests [1-10] are performed to determine the quality evaluation, strength, and ductility of materials. Nature of deformation (destruction) of material during torsion can be visually seen and evaluated in the laboratory after the test. The numerical values of material stress along the entire length, taking into account the circular or annular cross sections of the shaft (the rod), can be obtained by substituting the pre-known and calculated parameters values in the analytical formulas. The purpose of this research was to obtain the visual displays of the some parameters of material strain, which would be addition to the calculations of stress state of the rod.

Materials and methods

The rod torsion calculation was performed in the Ansys program. The rod model with the length of 200 mm and the outer diameter of 25 mm was proposed in the experiment. The rod model was made of structural steel. One end of the rod was rigidly fixed to the wall, and the clockwise moment was applied to the free end of the rod. Application of the moment and rigid fixation of the rod model are presented in the Fig. 1. The remaining conditions for implementing the rod torsion calculation are presented in the table 1.

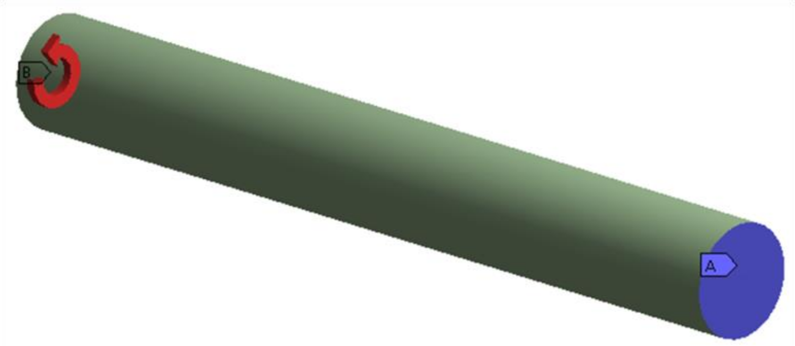

Figure 1 – The initial conditions for the calculation: A – rigid fixation in the wall; B – the applied moment.

Table 1. The conditions for implementing the calculation.

The solution options	
The problem dimensionality	3-D
The degrees of freedom	UX, UY, UZ, ROTX, ROTY, ROTZ
The analysis type	Transient
The solution method	Full
The offset temperature from absolute zero	273.15
The nonlinear geometric effects	On
The equation solver option	PCG
The tolerance	1×10^{-8}
The Newton-Raphson option	Program chosen
The globally assembled matrix	Symmetric
The load step options	
The load step number	1
Time at end of the load step	1
The starting time step size	0.1
The minimum time step size	0.1
The maximum time step size	0.2
The maximum number of the equilibrium iterations	15
Gamma	0.1
Alpha	0.3025
Delta	0.6
AlphaF	0.1
AlphaM	0

Results and discussion

Stresses and strains of material were considered in the cross section of the rod. The cross section was taken at the point where the moment were applied. The visual display of stress and strain state of material was presented by the color contours and vectors. The values of stresses, strains and strains energies were not indicated near the scale, so only the overall evaluation of the calculated parameters was presented. State of material in the cross section of the cylindrical rod after removing load is presented in the Fig. 2.

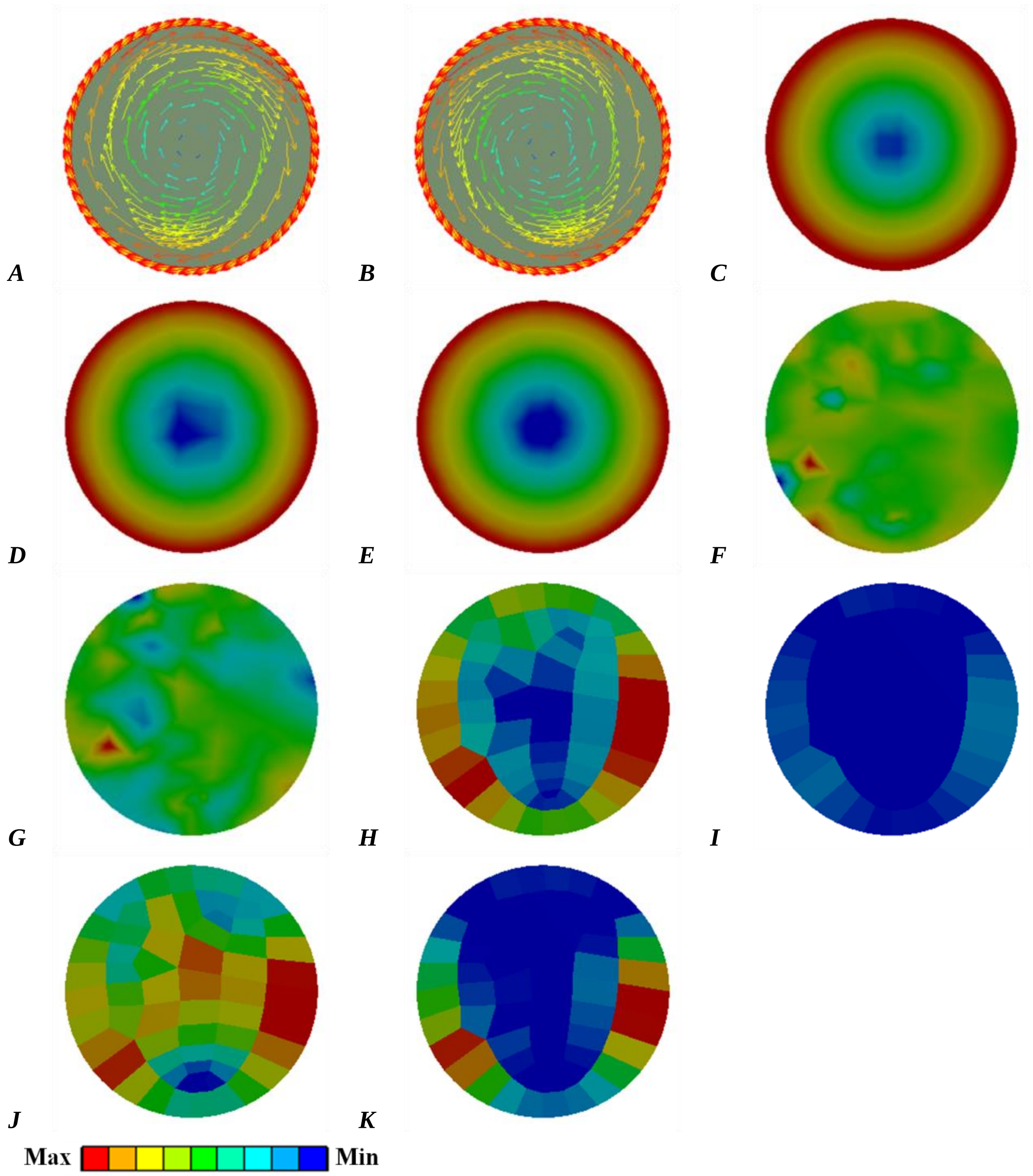

Figure 2 – State of material in the cross section of the cylindrical rod after removing load: *A* – total deformation; *B* – total velocity; *C* – displacement; *D* – equivalent elastic strain; *E* – elastic strain intensity and stress intensity and equivalent stress; *F* – shear elastic strain and shear stress; *G* – pressure; *H* – potential energy; *I* – kinetic energy; *J* – the volume; *K* – the structural error.

The direction of total deformation of the rod material coincides with the direction of the moment (clockwise). The rod material near the axial line is practically not deformed. Total deformation increases to the maximum value in the surface layers of the rod material. Total velocity of deformation of the rod material is directed in the opposite direction of the action of the moment. Displacement, equivalent elastic strain, equivalent stress, and intensity of strain and stress have same nature of changing during torsion. The degree of strain increases from the axial line to the rod periphery. The contours of shear elastic strain and shear stress show that the dangerous local volumes of material subject to cracks can occur in the cross section of the rod. The compressed or stretched volumes of the rod material can be determined by the pressure contours. Material compression occurs in the range of the red-green colors, material stretching occurs in the range of the green-blue colors. The rod shape changes during torsion. This change can be considered on the potential and kinetic energies contours. Maximum energy spent on material deformation is calculated on two opposite sides of the cross section of the rod. Changing the volume of material is observed in the middle part and in the elements associated with the outer diameter of the rod (the element size depends on the quality of splitting the solid model). The structural error shows where the calculations accuracy is high and where it is not. The volumes filled in blue have the most accurate results. Reducing the element size when splitting the model is recommended for the remaining volumes.

Conclusion

Based on the calculated vector and gradient fields of strains and stresses of material, it is determined that the round cross section of the rod changes to the elliptical cross section. The research results can be useful in selecting the overall dimensions of the cylindrical rods in the conditions of application of the moments on them. The results will be valid when the problems solving the rods torsion made from the number of structural steels with the Young's modulus equal to 200 GPa.

References:

1. (1981). GOST 3565-80. *Metals. Method of Testing in Torsion. Introduced 06.07.81*.
2. Noritsyn, I. A., & Kislyi, P. E. (1973). Determination of the true stresses from the results of tests of specimens of circular cross section in torsion. *Zavod. Lab., 39, No. 3*, 329-333.
3. Anarova, Sh. A. (2016). Algorithm of solution of the problem of bending torsion of the rod based on r-function method. *International Journal of Current Research, 8, (09)*, 37807-37819.
4. Konovalov, A. V. (2001). Torsion of Cylindrical Rods and Pipes with Large Plastic Strains. *Izv. Akad. Nauk. Mekh. Tverd. Tela, No. 3*, 102-111.
5. Chemezov, D. A. (2015). The choice of the optimal round/ring cross-section steel rods running torsion. *ISJ Theoretical & Applied Science, 03 (23)*, 44-48.
6. Themis, Yu. M., Lazarev, A. A., & Malanova, O. L. (2012). The generalized method of additional deformations in the problem of rod torsion. *Izvestiya MSTU "MAMI", No. 2 (14), Vol. 2*, 336-341.
7. Nurimbetov, A. U. (2015). Stress-strain state of layered composite rods and blades during torsion. *Construction mechanics of engineering structures and structures, No. 1*, 59-66.
8. Kashaev, R. M. (2018). On tension-torsion testing of solid cylindrical specimens. *Lett. Mater., 8(3)*, 346-352.
9. Matveenko, V. P., Tashkinov, A. A., & Chinakhov, D. A. (2015). Experimental Study of Nonlinear Effects under Torsion of the Uniform Cylinder with Initially Circular Cross Section. *Solid State Phenomena, Volume 243*, 29-34.
10. Freeman, N. J., & Keer, L. M. (1964). Torsion of a cylindrical rod welded to an elastic half space. *Journal of Applied Mechanics, Transactions ASME, Vol. 34, No. 3*, 687-692.