Impact Factor:	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 0.191	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.100	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

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: 2024 **Issue:** 11 **Volume:** 139

Published: 19.11.2024 **http://T-Science.org**

Issue **Article**

Denis Chemezov
Vladimir Polytechnic College
MEng, Honorary Worker of the Education Field of the Russian Federation, Academician of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
vpk-science@yandex.ru

Aleksandr Popov
Vladimir Polytechnic College
Student, Russian Federation

Nikita Rybin
Vladimir Polytechnic College
Student, Russian Federation

Dmitriy Bychkov
Vladimir Polytechnic College
Student, Russian Federation

Aleksandr Klyauzov
Vladimir Polytechnic College
Student, Russian Federation

Kirill Branchukov
Vladimir Polytechnic College
Student, Russian Federation

Denis Korkunov
Vladimir Polytechnic College
Student, Russian Federation

Abubakr Khasanov
Vladimir Polytechnic College
Student, Russian Federation

EQUIVALENT AND SHEAR STRESSES IN A DEFORMED THIN-WALLED STEEL RING

Abstract: *The analysis of the stress-strain state of a thin-walled metal ring under the influence of concentrated constant forces is carried out in the article. The degree of equivalent and shear stresses of the ring material at the initial moment and after 1 s of application of the load on the outer surface is investigated.*

Key words: *load, strain, ring, stress, compression, stretching.*

Language: *English*

Citation: Chemezov, D., et al. (2024). Equivalent and shear stresses in a deformed thin-walled steel ring. *ISJ Theoretical & Applied Science, 11 (139),* 199-202.

Soi: http://s-o-i.org/1.1/TAS-11-139-25 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.11.139.25

Scopus ASCC: *2210.*

Introduction

Metal rings in the assembly are subjected to various deformations [1] caused by loads. As a result of static or dynamic action, the ring changes its geometric shape, which affects its functionality. This is especially pronounced in thin-walled rings.

Deviations from the geometric shape in the cross section (in this case, the deviation from roundness) can be calculated by measuring the actual dimensions at several contact points of the ring surfaces with special tools and devices and then comparing these data with the dimensions of ideal circles. The measurement process may carry errors due to the inaccuracy of the measuring instrument and the measurement methodology carried out by the performer. At the same time, the degree and nature of deformation of the ring material (for example, von Mises stress [2-5] and shear stress [6-10]) in real conditions can be calculated only by indirect measurement methods.

The use of special computer applications for engineering analysis makes it possible to evaluate the degree of strain of the material and deviations from the geometric shape of hollow parts with high reliability of the results obtained and in a short time. The article presents the results of calculating the stress-strain state of a thin-walled steel ring under the action of symmetrical constant loads.

Materials and methods

The calculation of equivalent and shear stresses of the thin-walled steel ring under point loading by concentrated forces on the outer surface was performed in Comsol Multiphysics 5.6. The ring model was built on a plane with an outer diameter of 400 mm and an inner diameter of 300 mm. The ring model was given the properties of 1006 structural steel. A constant load acted on the outer surface of the ring, in the form of four concentrated forces of 5 kN, shown in the Fig. 1.

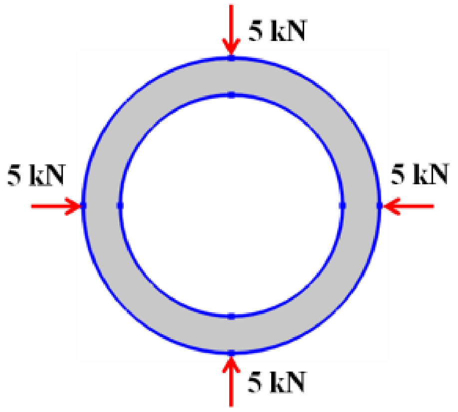

Figure 1. Applied forces to the outer surface of the ring model.

Applied forces acted on the ring for a duration of 1 s. The accuracy of splitting the ring model into finite elements is assumed to be average.

Results and discussions

The calculation results are shown in the Fig. 2.

The color scheme applied to the two-dimensional model characterizes the deformed state of the ring under the action of four concentrated forces. Contours of the circles characterize the initial shape of the ring model. The colors, from blue to red, determine the degree of strain of the ring model, i.e. from minimum to maximum magnitudes, respectively. Due to the symmetry of the action of loads, the deformation of the ring model has the same nature in the cross section of each quarter of the circle. Changes in the magnitudes of von Mises stress, volumetric strain and shear stress of the ring material were determined along the circumference of the outer and inner surfaces of the model. In the graphs, the blue dependences characterize the magnitude of the stress-strain state of the ring material at the initial moment of the load action, and accordingly, the green dependences indicate the stress-strain state of the ring material at the first second of the load action. It is noted that the strain along the outer surface of the model is characterized to a greater extent by compression and stretching (negative and positive magnitudes of the volumetric strain coefficient) at the time of application of forces. Before removing the load (in the first second), the compression of the material increases slightly, and there is practically no tensile strain. At the same time, stretching and compression strains are halved on the inner surface of the ring model. It is also noted that on the inner surface, the layers of the material are subjected to stretching and compression to the same degree. Shear stress of the layers of the ring material has almost the same nature. Along the outer surface, the layer shift is expressed in an instantaneous increase in stress in the local area, both at the time of exposure to the load and before removing it. On the inner surface, the shear stress is distributed more evenly over the circumference.

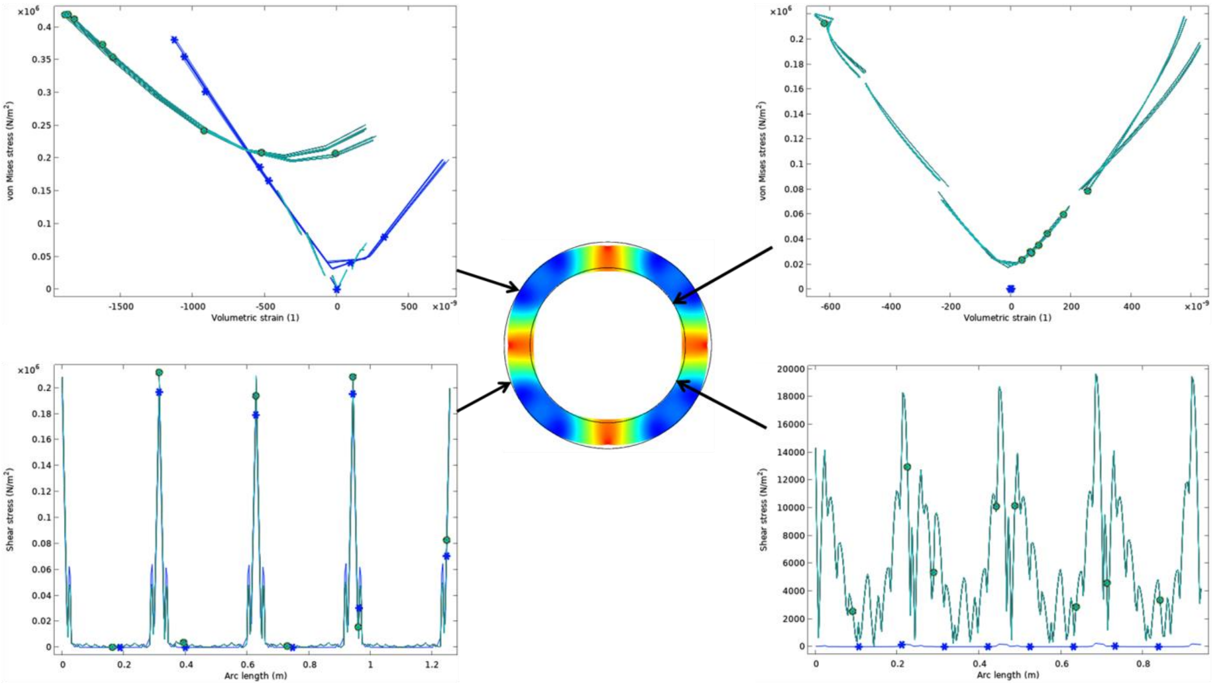

Figure 2. Calculation results: in the middle are the contours of the displacement of the ring material during deformation; the graphs on the left show von Mises stress from volumetric strain of the material and shear stress from the circumference along the outer surface of the ring; the graphs on the right show von Mises stress from volumetric strain of the material and shear stress from the circumference along the inner surface of the ring.

Conclusion

Thus, based on the analysis of the calculation results, the following conclusions can be drawn:

1. Under the action of a concentrated load, the layers of the ring material on the outer surface are mainly compressed, and on the inner surface, the layers of the material experience strains and compressions and stretches to the same extent.

2. The duration of the load affects the amount of equivalent stress of the material with a predominance of compression strains of the thin-walled ring.

3. Shear stress of the ring material during the action of a concentrated load on the outer surface is greater than the shear stress of the material measured on the inner surface. If peak shifts of the ring material are noted in the load application zone, then from the inner surface the shear stress is more evenly distributed along the circumference of the ring.

References:

1. Mao-hong, Yu. (2002). Advances in strength theories for materials under complex stress state in the 20th century. *Appl. Mech. Rev., 55(3)*, 169-218.
2. von Mises, R. (1913). Mechanik der festen Körper im plastisch-deformablen Zustand. *Göttin. Nachr. Math. Phys., 1*.
3. (2024). *von Mises yield criterion*. Retrieved 31.10.2024 from https://en.wikipedia.org/wiki/Von_Mises_yield_criterion
4. 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.
5. Sunte, J. (2022). The Material Failure by Von-Mise’s Stress and Resonance Concept. *International Journal of Scientific Research in*

Mechanical and Materials Engineering, 6 (4), 44-51.

6. Millett, J. C. F., et al. (1997). Shear stress measurements in copper, iron, and mild steel under shock loading conditions. *Journal of Applied Physics*, *81*, 2579-2583.
7. Volkov, A. V., Golubkin, K. S., & Solyaev, Y. O. (2024). Refined Analysis of Shear Stress Distribution in Tapered Rods Accounting for Gradient Effects. *Lobachevskii J. Math.*, *45*, 2421-2428.
8. Whiteman, G., & Millett, J. C. F. (2012). Shear Stress Measurements in Stainless Steel 2169 under 1D Shock Loading. *Exp. Mech.*, *52*, 265-273.
9. Gustafsson, E., et al. (2017). Strain and stress conditions at crack initiation during shearing of medium- and high-strength steel sheet. *Int. J. Mech. Mater. Eng.*, *12*, 10.
10. Mlikota, M., & Schmauder, S. (2018). On the Critical Resolved Shear Stress and Its Importance in the Fatigue Performance of Steels and Other Metals with Different Crystallographic Structures. *Metals*, *8(11)*, 883.