



FINITE ELEMENT METHOD

AEF-A.2.11

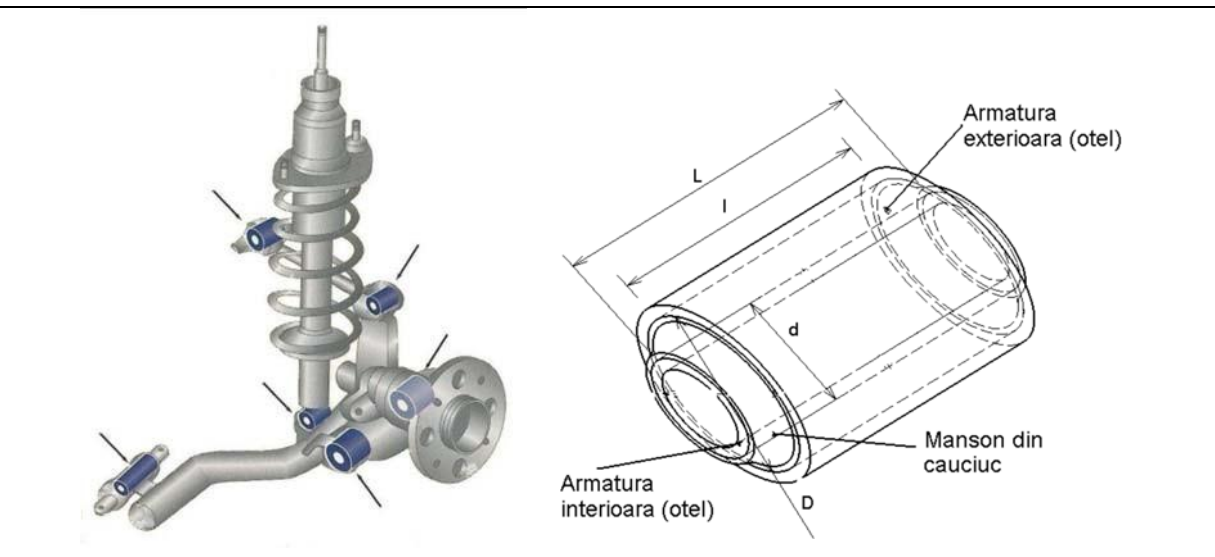
LINEAR STATIC ANALYSIS OF NON - METAL ELASTIC ELEMENTS

INTRODUCTION

There are many technical products in mechanical components that have distinct compact structures required by the main function to perform. Representative of this group of components are elastic elements (springs), damping elements, supporting elements (housings), etc. The specificity of these elements, as a rule, is given by their fixed or quasi-fixed links with adjacent parts. The finite element analysis of these components for accurate results requires accurate definition of the solid model, the constraints imposed by the links with the adjacent elements, as well as the loads.

DESCRIPTION OF THE APPLICATION

Rubber elastic elements are frequently used in the construction of mechanical systems due to their elastic capacity and, in particular, damping and, in many cases, due to lower cost. The flexible bush (flexiblock) consists of a cylindrical outer rubber sleeve and two metal cylindrical reinforcements. Flexiblocks are frequently introduced into the vehicle's suspension and steering subsystems as elastic cushioned dampers, bringing the following benefits: eliminates wear and tear, cushions vibrations, moderate costs, and unpredictable maintenance. On the other hand, these elements have a shorter operating life than steel ones due to the decrease in the tire strength and elastic properties with time (aging process).



PURPOSE OF THE APPLICATION

In this paper we aim to determine the fields of displacements, deformations and tensions in the structure of the rubber sleeve of the flexiblock, type 77 00 514 109, composed of the lower arm of the Dacia 1300. The rubber sleeve has the following dimensions: $D = 28 \text{ mm}$, $d = 18 \text{ mm}$, $l = 38 \text{ mm}$, $L = 46 \text{ mm}$. The load of the rubber structure is made by means of metal armatures with force vectors, $F = [F_{ax} \ F_{rad1} \ F_{rad2}] = [20 \ 20 \ 200] \text{ N}$, and torque, $M = [M_{axial} \ M_{radial1} \ M_{radial2}] = [2 \ 5 \ 2] \text{ Nm}$.

Application AEF-A.2.11

LINEAR STATIC ANALYSIS OF NON-METALLIC ELASTIC ELEMENTS

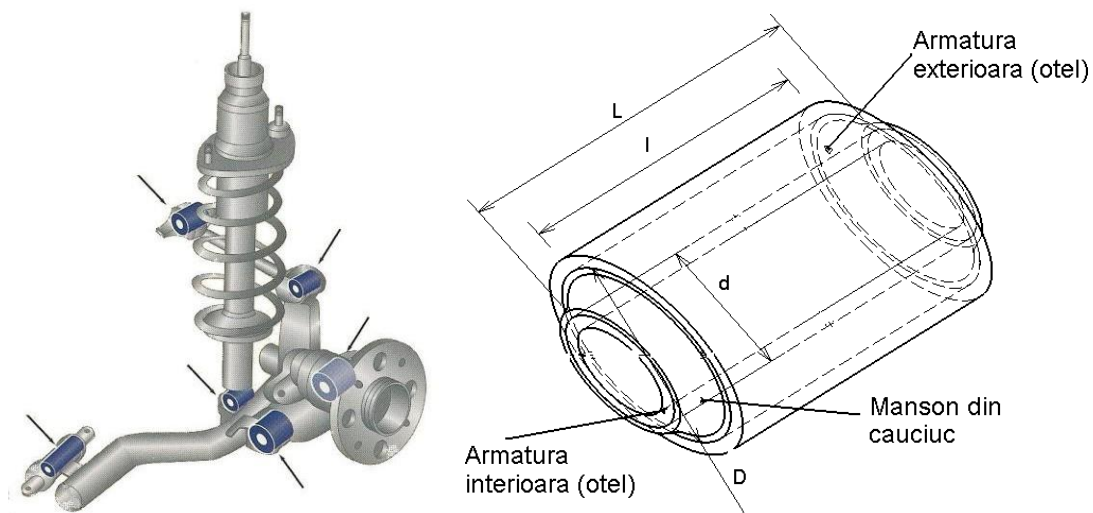
A. DEFINITION OF THE APPLICATION

A.1. Introduction

Many technical products contain mechanical components that have distinct compact structures required by the main function to be performed. Representatives of this group of components are elastic elements (springs), damping elements, supporting elements (housings), etc. The specificity of these elements is generally given by their fixed or quasi-fixed links with adjacent parts. To obtain precise results, the finite element analysis of these components requires an accurate definition of the solid model, the constraints imposed by links with adjacent elements, and the loads.

A.2. Description of the application

Rubber elastic elements are frequently used in the construction of mechanical systems due to their elastic capacity and, in particular, damping, and in many cases due to lower cost. The flexible bush (flexiblock) consists of a cylindrical outer rubber sleeve and two metal cylindrical reinforcements (armatures). Flexiblocks are frequently introduced into vehicle suspension and steering subsystems as elastic cushioned dampers, bringing the following benefits: they eliminate wear and noise, cushion vibrations, have moderate costs, and require low maintenance. On the other hand, these elements have a shorter operating life than steel ones due to the decrease in strength and elastic properties of the rubber over time (aging process).



A.3. Purpose of the application

In this paper, we aim to determine the fields of displacements, deformations, and tensions in the structure of the rubber sleeve of the flexiblock, type 77 00 514 109, composed of the lower arm of the Dacia 1300. The rubber sleeve has the following dimensions: $D=28$ mm, $d=18$ mm, $l=38$ mm, $L=46$ mm. The load of the rubber structure is applied via the metal armatures with force vectors $F = [F_{axial} \ F_{radial1} \ F_{radial2}] = [20 \ 20 \ 200]$ N and torque $M = [M_{axial} \ M_{radial1} \ M_{radial2}] = [2 \ 5 \ 2]$ Nm.

B. PREPARATION OF THE ANALYSIS MODEL

B.1. Defining the analysis model

To prepare the finite element analysis model associated with the application above, the following must be identified:

- Geometric shape and dimensions.
- Restrictions induced by connections with adjacent elements.
- External loads.
- Material characteristics.

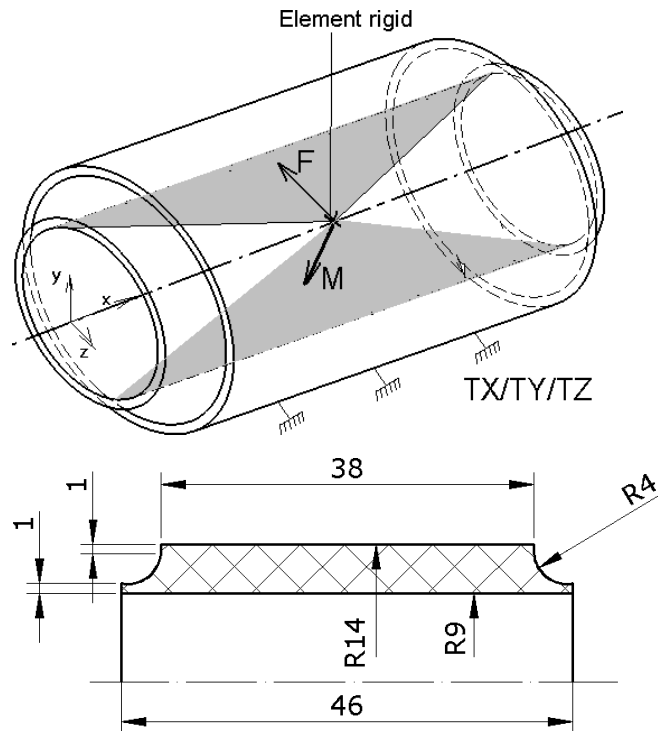
B.2. Description of the analysis model

The geometric shape and dimensions of the rubber sleeve are presented in the figure below. For the analysis, the sleeve structure is modeled with 3D finite elements, so the geometric model is identical to the solid model.

To simulate the sleeve's behavior as close to reality as possible—considering it is loaded via a bolt and the inner armature made of steel, which are characterized by high stiffness—a rigid element associated with them is introduced. This element has its master point at the center of symmetry and the slave part as the inner surface of the sleeve.

To simulate the connection with the exterior via the outer armature, boundary conditions are introduced that imply translation restrictions along the three directions of the XYZ coordinate system for all points on the outer surface.

Also, for behavior as close as possible to the real model, the load is applied at the master point of the rigid element with force vectors $F = [F_x \ F_y \ F_z] = [20 \ 20 \ 200] \text{ N}$ and torque $M = [M_x \ M_y \ M_z] = [2 \ 5 \ 2] \text{ Nm}$.



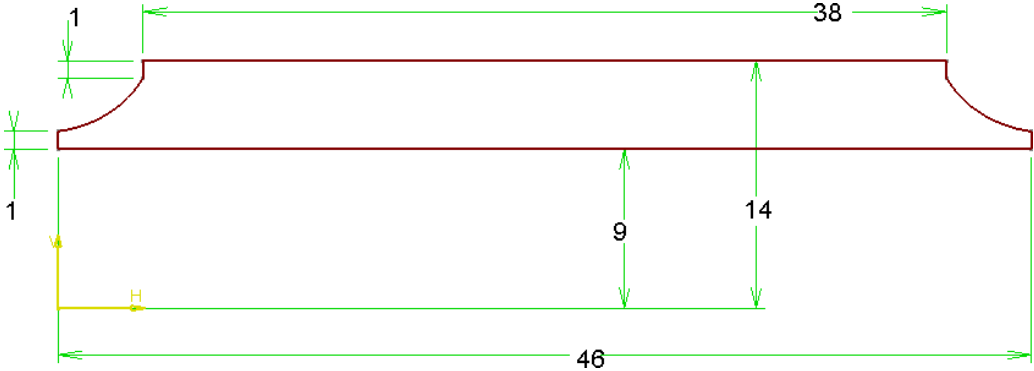
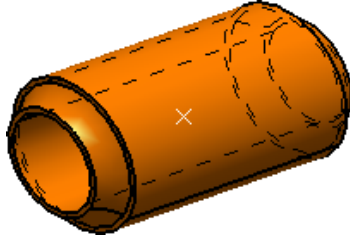
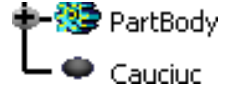
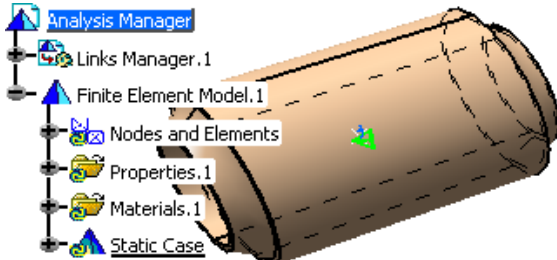
B.3. Establishing material characteristics

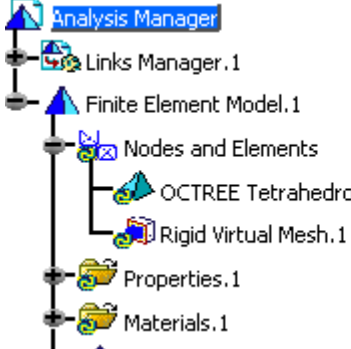
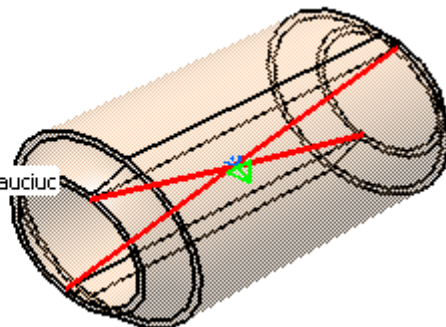
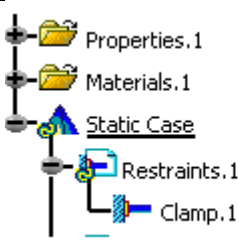
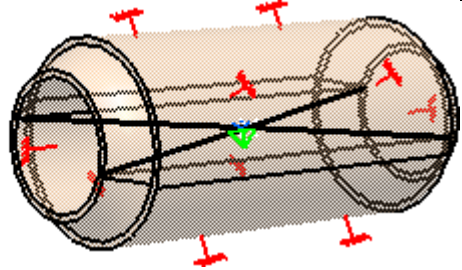
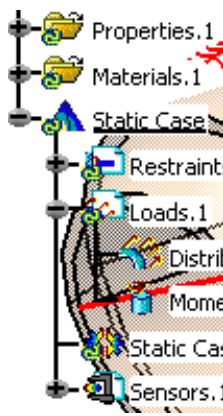
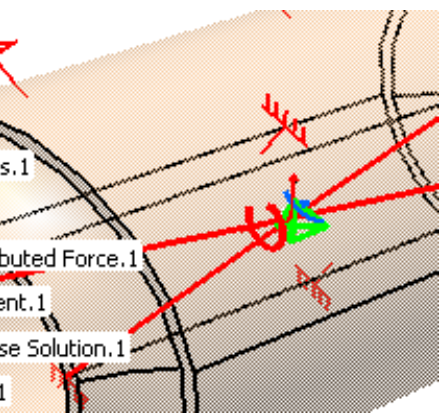
The analyzed element is made of neoprene rubber, with a hardness of 70 Sh and the following deformation constants: $A_{10} = 0,177 \text{ N/mm}^2$, $A_{01} = 0,045 \text{ N/mm}^2$ and $D_1 = 333 \text{ N/mm}^2$. For small deformations, the following physical analysis parameters correspond to these characteristics:

Longitudinal modulus of elasticity (Young's Modulus): $E = 2 \text{ N/mm}^2$

Transverse contraction coefficient (Poisson's Ratio): $\nu = 0,5$.

C. PRE-PROCESSING OF THE ANALYSIS MODEL

C.1. Geometric modeling	
<i>Activating the solid generation module and setting the unit of measurement for lengths</i>	
Start → <u>M</u> echanical Design → <u>P</u> art Design → New part : New part name: Manson. <u>T</u> ools → <u>O</u> ptions... → Options : Parameters and Measure; Units; Length, Milimeter (mm); ↵OK.	
<i>Generating the reference sketch</i>	
Sketcher) → xy plane → (Profile) → [draw the longitudinal section contour] → (Constraint) [enter dimensions successively by selecting entities, using the Ctrl key for multiple selection], (Exit Workbench)	
	
<i>Generating the solid model and a central point</i>	
 (Shaft) → Shaft Definition : First angle 360deg, Profile Selection [select Sketch.1], ↵OK.  (Point) → Point Definition : Point Type: Coordinates, X 23 mm, Y 0 mm, Z 0 mm; ↵ OK.	
C.2. Modeling material characteristics	
<i>Rubber Sleeve</i>	
[Select the PartBody specification in the tree structure] →  (Apply Material) → Library (ReadOnly) : Other, Rubber → Apply Material, ↵OK. [Select the Rubber specification in the tree structure] → Properties : Feature Properties, Feature Name: Cauciuc (Rubber); Analysis, Young Modulus 2 N/mm ² , Poisson Ratio 0,5, Apply, ↵OK.	 
C.3. Finite element modeling	
<i>Activating the finite element analysis module</i>	
Start → <u>A</u> nalysis & Simulation → <u>G</u> enerative Structural Analysis → New Analysis Case Static Analysis, ↵ OK.	

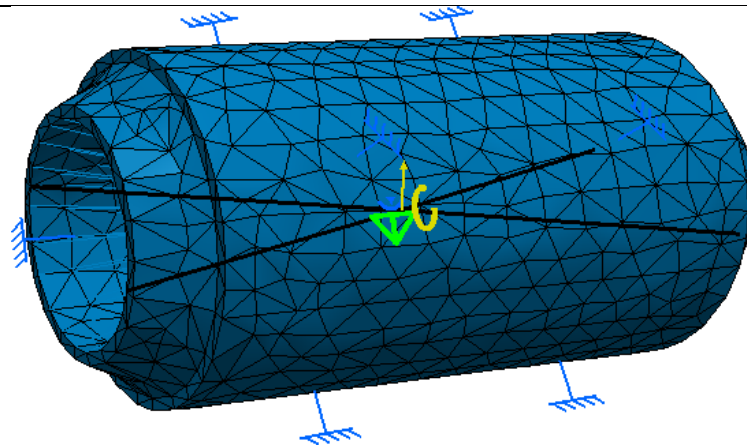
<i>Generating the virtual rigid element</i>	
 (Rigid Virtual Part) → Rigid Virtual Part: Supports [select the inner cylindrical surface with the mouse], Handler: [select Point.1], ↵ OK.	
	
C.4. Modeling geometric constraints	
<i>Introducing displacement restrictions</i>	
 (Clamp) → Clamp: Supports [select the outer cylindrical surface with the mouse], ↵OK.	 
C.5. Modeling loads	
<i>Introducing forces</i>	
 (Distributed Force) → Distributed Force: Supports [select the virtual rigid element with the mouse]; Force vector X 20N, Y 20N, Z 200N; ↵ OK.  (Moment) → Moment: Support [select the virtual rigid element with the mouse]; Force vector X 2 Nxm, Y 5 Nxm, Z 2 Nxm; ↵ OK.	 

D. SOLVING THE FINITE ELEMENT MODEL

D.1. Launching the calculation module	
 (Compute) → Compute: ↵ All, ↵OK → Computation Resources Estimation , ↵Yes → Computation Status .	

E. POST-PROCESSING OF RESULTS

E.1. Visualizing the deformed state / Animation	
 (Deformation).  (Animate) → Animate: Steps number: 5 (other parameters can be modified) ↵Close.	

**Observation**

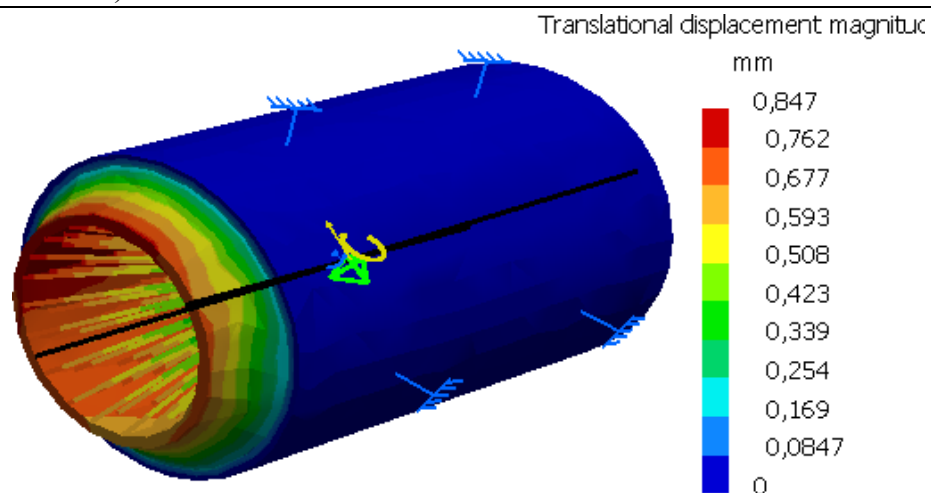
To modify the amplitude of displacements during animation for better visualization, follow the sequence:



→ **Amplification magnitude:** Factor: 1 (other parameters can be set), **OK**.

E.2. Visualizing the displacement field

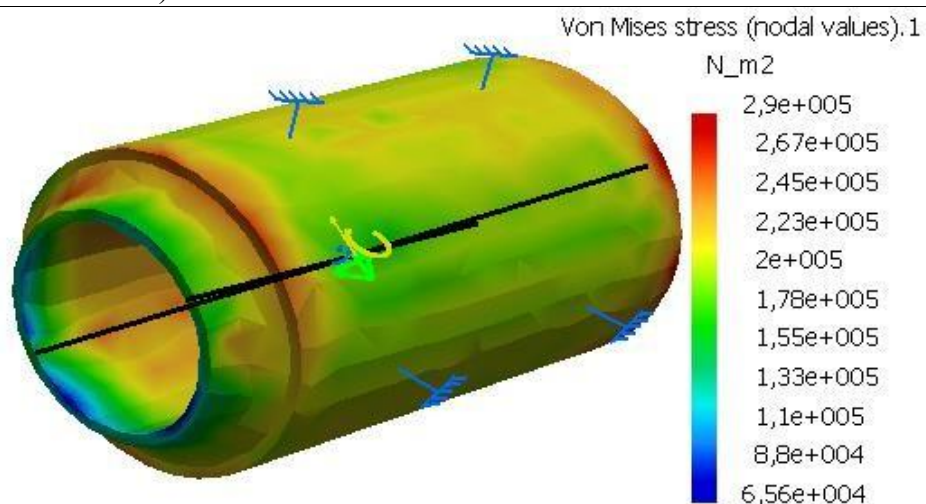
(Displacement).

**E.3 Visualizing the stress field**

Visualizing the Von Mises stress field in isometric view



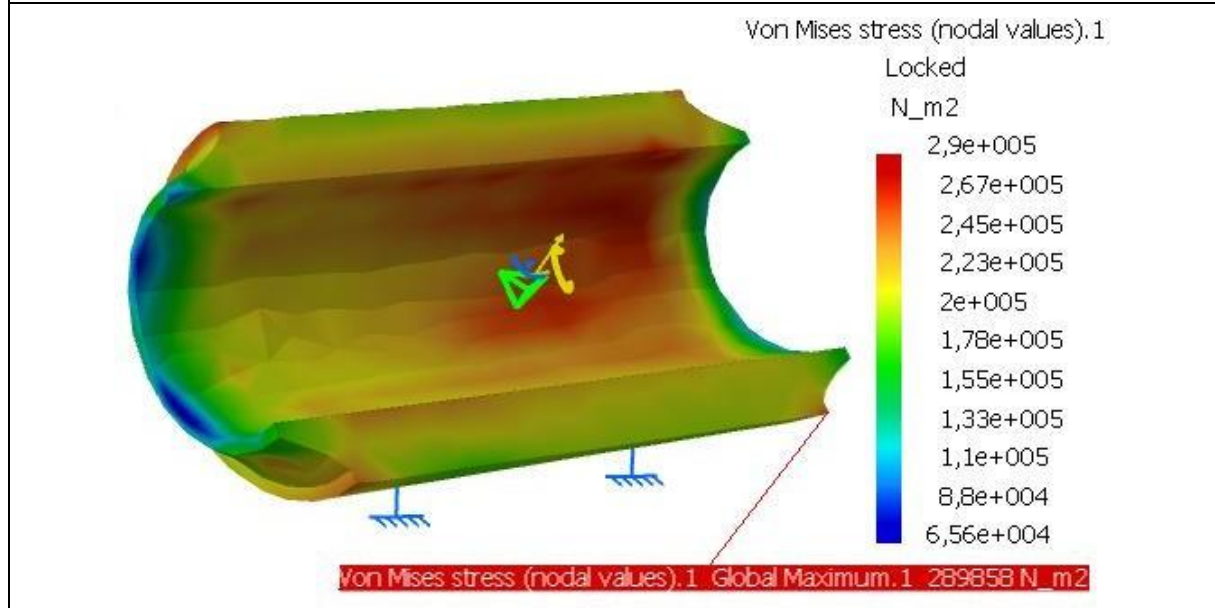
(Von Mises Stress).



Visualizing the Von Mises stress field in axial section



(Cut) → [orient the cutting plane with the mouse].



F. CONCLUSIONS

The analysis of the displacement and stress fields highlights that the analyzed part is a quasi-rigid structure (maximum displacement is 0.847 mm). Maximum stress (1 MPa) is highlighted in the connection areas with the outer metal armature towards the edges of the rubber sleeve. If the maximum stress is greater than the admissible limit, the structure is under-dimensioned, and dimensional modifications are required.

G. EXERCISE

Perform the finite element analysis of the neoprene rubber brake shoe part from a bicycle braking system. The geometric and mounting dimensions are $l=50$ mm, $h=12$ mm, $m=8$ mm, $R1=3$ mm, $h=2$ mm, $g=10$ mm, $b=15$ mm.

The braking force, $F_t = 800$ N, is equal to the friction force between the shoe and the metal rim of the wheel. To obtain this force, the shoe must be pressed against the rim with a normal force, $F_n = F_t / \mu$ cu $\mu = 0,35$ is the friction coefficient between rubber and steel.

