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DETERMINATION OF THE INDUCED STRESS STATE IN AN ALUMINIUM ALLOY COUPLING BAR FOR ROAD VEHICLES BY USING FEM

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Abstract: *The work present the stress state analyzes in an aluminum coupling bar for the rear axle of the Mercedes Benz S320 model W140 car, with mass of 2500 kg, by using the finite element method and the program ANSYS. The results obtained by ruling the program lead to the conclusion that at the inferior part of the coupling bar curvature, the tension does not overcome 80 MPa which corresponds from the point of view of the car safety, because the value is smaller than the yield point of the material.*

Keywords: *aluminium alloy, coupling bar, stress*

1. Introduction

The use of light alloys, such as those based on aluminum, gain more and more ground in modern technology because their advantages, such as: small unit weight, good cast ability and easy to be work out [1], [2]. The essential characteristics of a rear axle are the compactness and the ability to maintain the vehicle stability. The role to maintain the wheels in permanent contact with the ground remain for the suspension and the axle [3]. To meet the above requirements, for luxury cars were adopted independent axles, allowing for each wheel to oscillate independent from the other ones. By the number of coupling rods (in our case 4) and their disposal, it was assured the desired comfort and stability as well as the reduction of the undesired liberty degrees for the wheels. By eliminating the mentioned negative effects, the movement of the car runs without perturbations, and the passengers have the sensation of “floating” over the road.

2. Researched material

The analyzed rod is a component of the Mercedes Benz S320 rear axle which, together with the steering knuckle sustains the car body fig. 1, position 92.

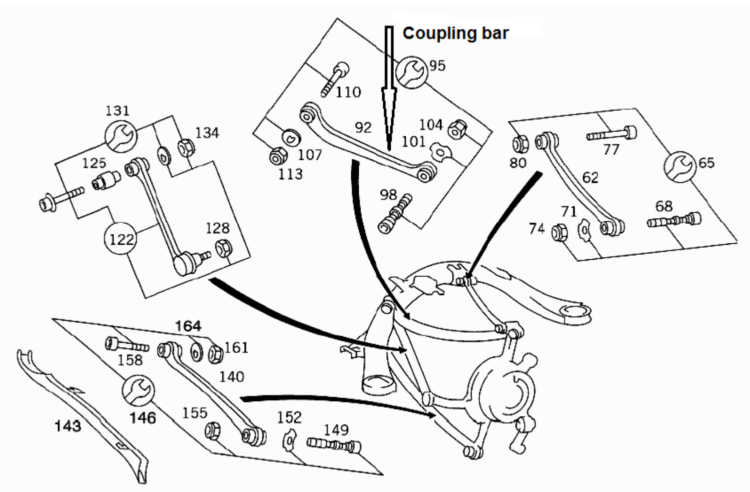


Fig. 1. The scheme of rear axle ensemble

The material from which the rod is manufactured is an aluminum alloy AlZn5.5MnCu with the following mecanical characteristics, determined in the Timisoara Polytechnic University Laboratory for Material Strength:
- Elastic module: $E = 71500\ MPa$
- Coefficient of transverse contraction: $\nu = 0{,}33$
- Yield limit: $R_{p\ 0,2} = 495\ MPa$
- Fracture strength: $R_m = 574\ MPa$
- Breaking tenacity: $K_{Ic} = 13{,}27\ MPa\sqrt{m} = 419{,}63\ MPa\sqrt{mm}$

3. Tension state analyze with FEM

The stress state analysis can be done by one of the following methods: analytical, numerical, and experimental [4, 5, 6, 7]. On a large scale is used the Finite Element Method (FEM) which, even providing approximate numeric solutions, is very accurate and the results are close to the real ones. The shape and dimensions of the aluminum rod is presented in fig. 2.

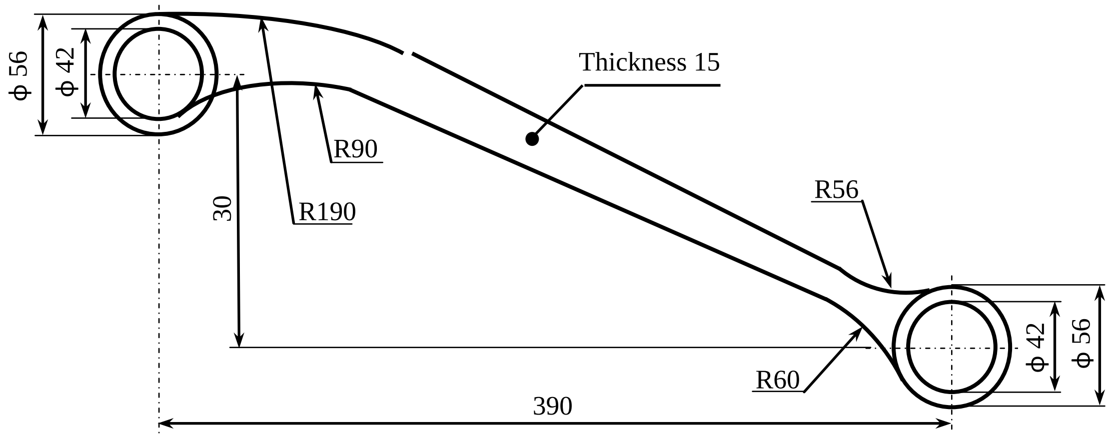


Fig. 2. The rod constructive solution

The rod numeric analyze was realized with the ANSYS FEM program [8]. For an accurate modeling of the load transmitted to the rod, we consider that it is realized through a bolt with distributed load. In conformity with [4] the load definition was done on the half of the orifice surface, being 0 (zero) for the extremities and p_{max} for the middle, fig. 3, and the maximum value is obtained with the relation (1).

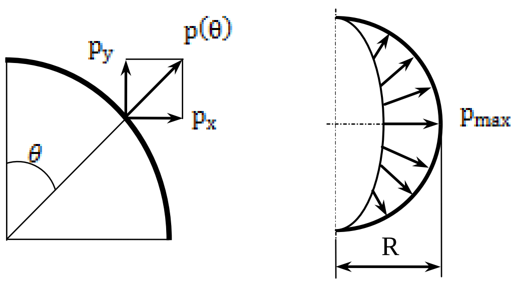


Fig. 3. Scheme of the load distribution

$$p_{max} = \frac{F \cdot \pi^2}{16 \cdot R \cdot t} = \frac{1000 \cdot \pi^2}{16 \cdot 21 \cdot 15} = 1{,}96\ MPa \qquad (1)$$

where:
F = the transmited force
R = radius of rod
t = rod thickness
The finite element meshing, fig. 4 was realized with 1872 SOLID elements, having 107703 finite elements nodes.

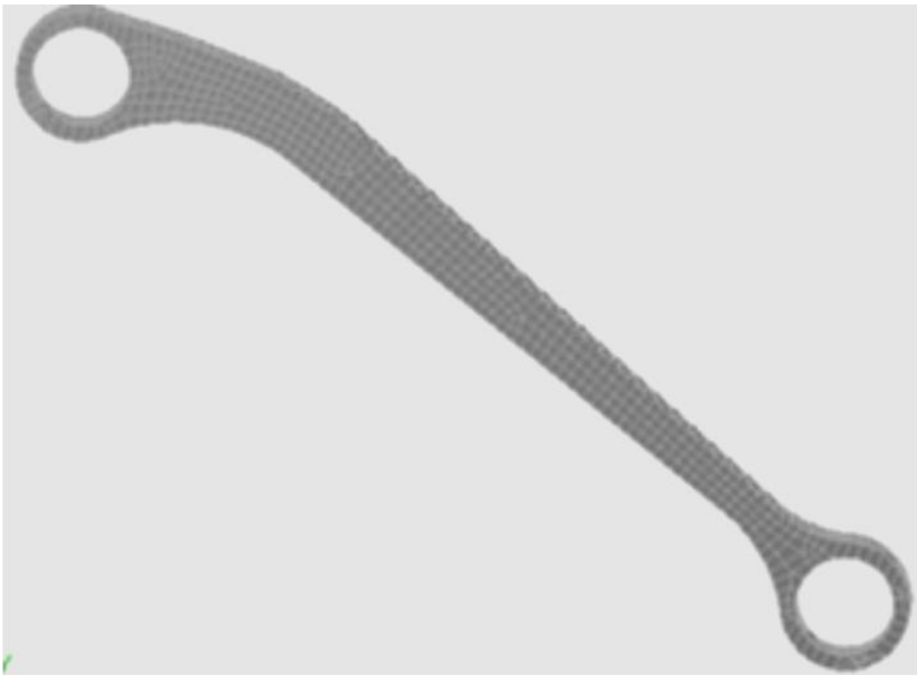


Fig. 4. Finite element meshing

The rod is mounted on the rear axle by two pins introduced in the fixing holes and the bearing conditions are presented in fig. 5.

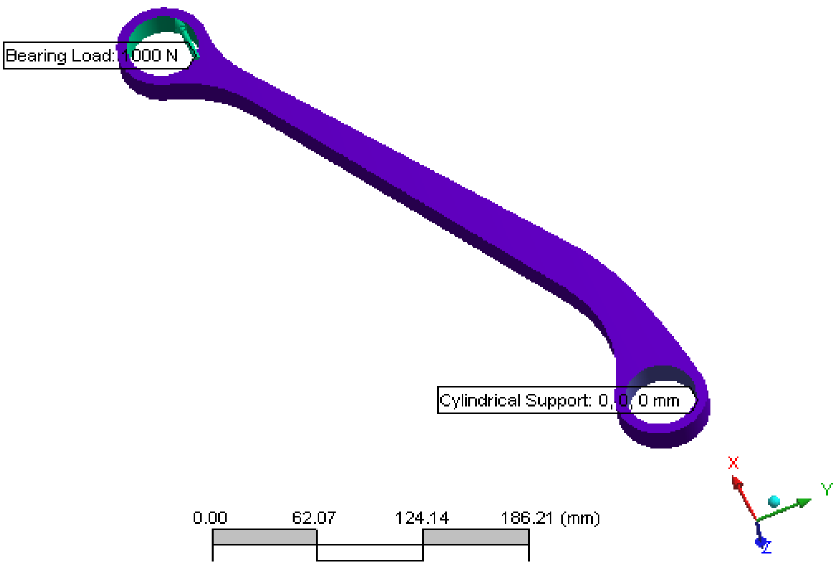
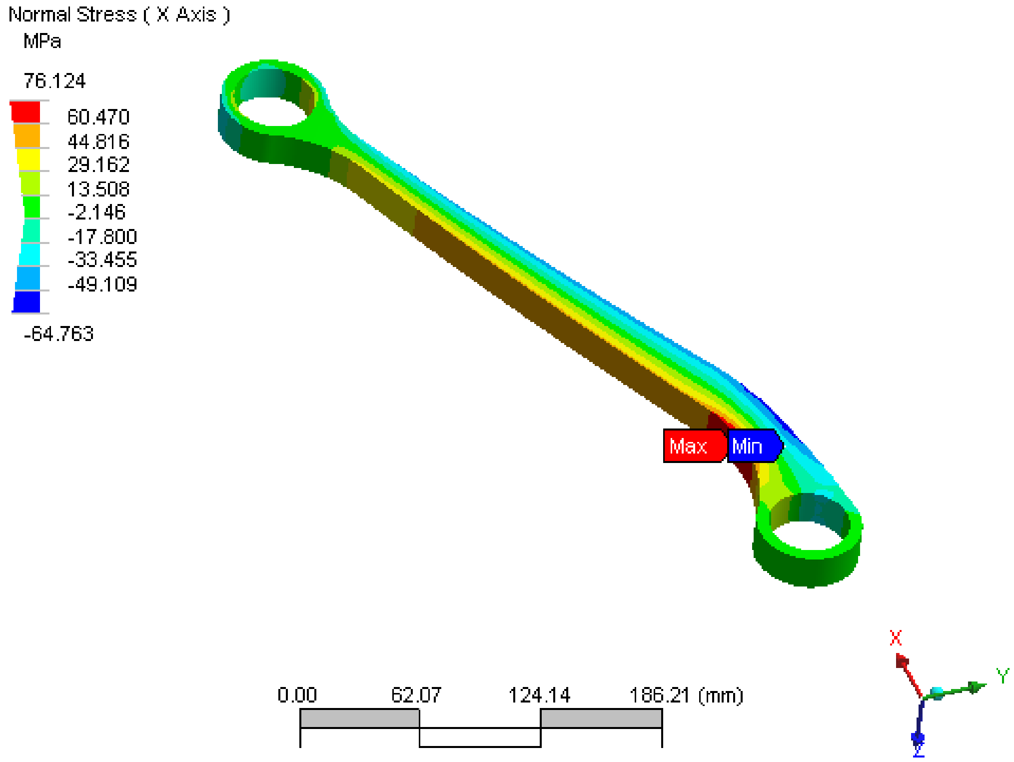
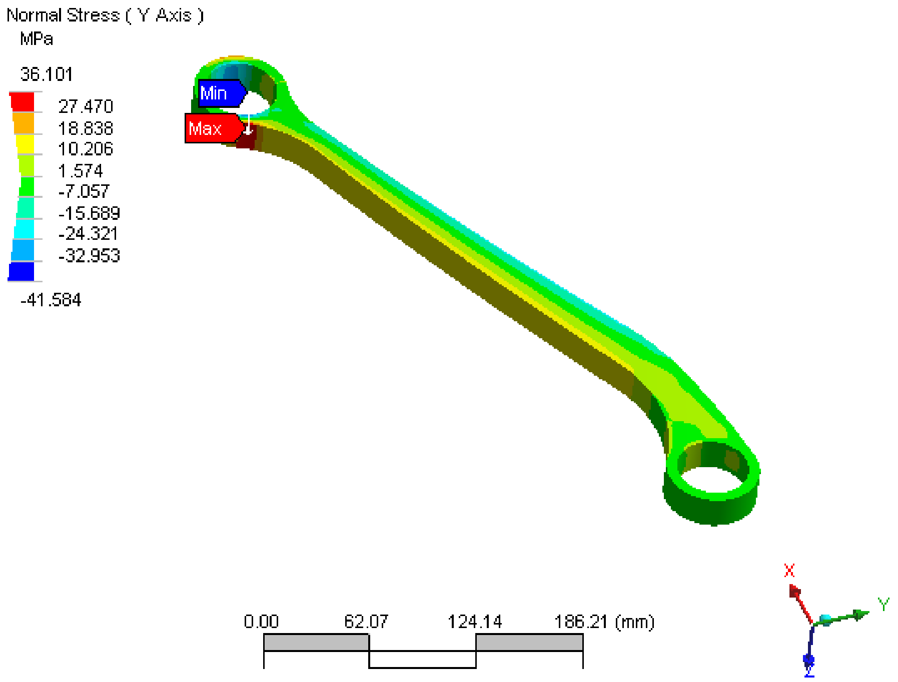


Fig. 5. Bearing conditions

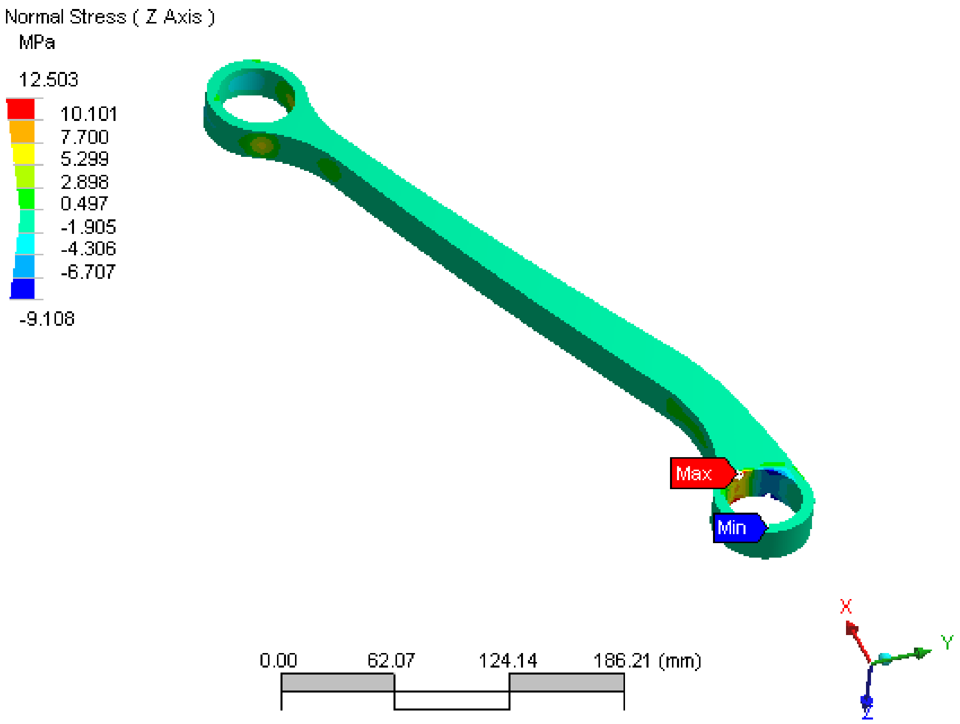
Running the computation program there were obtained the normal stresses after the three orthogonal directions $\sigma_x, \sigma_y, \sigma_z$ *and* $\sigma_{ech\,VM}$, which are presented in fig. 6.



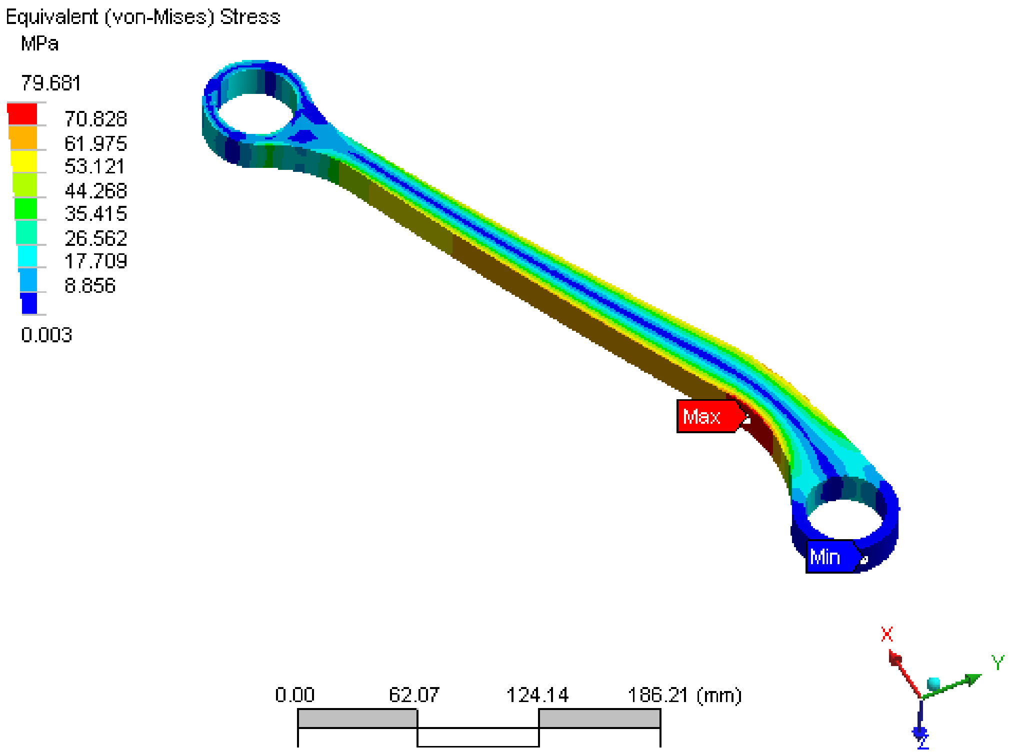
6a) Ox axes normal stresses



6b) Oy axes normal stresses



6c) Oz normal stresses



6d) Von Misses stresses

Fig. 6. Normal stresses and Equivalent (von-Mises) stress

The FEM analyze of the stress by using the ANSIS program, for the rear axle coupling bar of the Merced Benz S320 car, model WDB 140, gave the values presented Tab. 1.

Table 1: Numerical values of the stresses induced in the rod

Stress type	Measurement unit	Value
Normal σ_x	[MPa]	**76,12**
Normal σ_y	[MPa]	36,10
Normal σ_z	[MPa]	12,50
Normal $\sigma_{ech\ VM}$	[MPa]	**79,68**

From the data presented in Table 1 we can see that all the values are below the material characteristics, for both the flow limit ($R_{p\ 0.2}$ = 495 MPa) and, of course the fracture strength (R_m = 574 MPa).

4. Conclusions

- The finite element method permit the determination of the stresses $\sigma_x, \sigma_y, \sigma_z\ and\ \sigma_{ech\,VM}$ which allow to compute the principal tensions $\sigma_1\ and\ \sigma_2$ for the plan state of stresses and the displacements $u\ and\ v$ for the plan state of deformations.
- The application of the program for the analyze, using the ANSYS finite element method, in the study of the stress state for the rod of the car vehicles allow to determine both the critical points and also other values of the stresses occurring during the running.
- The FEM analyze of the model rod, used in the rear axle of Mercedes Benz S320 model W140 car show that theoretically there are fulfilled all the running condition as well as the running safety
- However, the coupling bar degradation is sometimes possible as the result of either fatigue or when important shocks occur during the car running.

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