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ON THE DETERMINATION OF THE TENSION STATE IN THE SIMPLE BELT GUIDE

Vasile Ciofoaia, Florin Dogaru
Luciu Alexandrescu, Mariana Stanciu
Transylvania University
Eroilor 29 Avanue, 500036 Brasov 1
Romania

ABSTRACT
In this paper the authors determine the stress state of the belt guide (the constituting part of the safety seatbelt) when subjected to external forces transmitted by the textile webbing. The purpose of this paper is to determine the dangerous areas near the orifice where the webbing is placed and to optimize the dimensions according to the material type in order to obtain a better cost. The tension state is determined with the help of the finite element method; thus the danger zones are determined and also the material type and the orifice dimension-range. With the material type and the dimensions set, an experimental check-up of the tension state is performed with the help of photoelastic analysis.
Keywords: safety belt, finite element method, photoelastic analysis

1. INTRODUCTION
The design, the manufacturing and the homologation process of safety belts require using resistant components in order to guarantee good operation and the user's safety. The simple belt guide (fig.1) is a component of the safety belt assembles. This paper provides an analysis of the behavior of the simple belt guide when subjected to traction stress by using the finite element method and photoelasticity measurements. Furthermore, the results of the traction tests to guide belt break point are also presented.

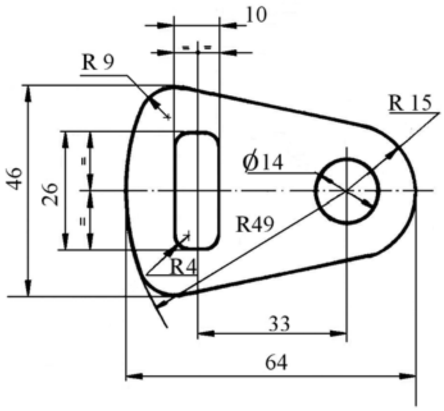


Figure 1 The simple belt, structural element of the safety belt; design

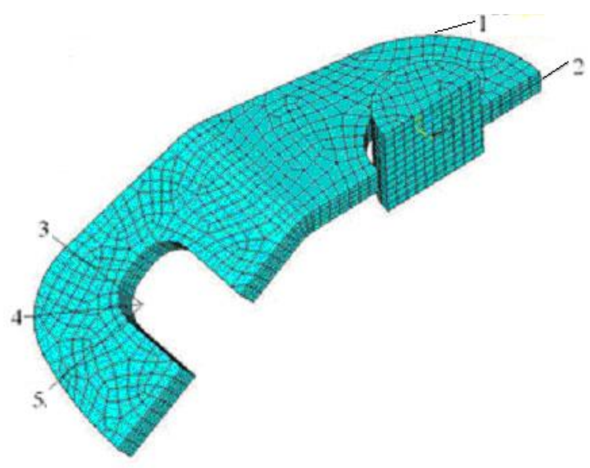


Figure 2 The sections positioning for the stress state analysis

2. ANALYSIS OF THE STRESS AND DEFORMATION STATE
Let us consider one safety belt guide as shown in figure 1. This piece is fixed on the internal rim at an angle of 120°; the internal diameter is 14 mm on a bolt (fig.2). On the surface of the internal orifice,

the loading force is applied and it represents the traction in the textile webbing. In analyzing the behavior of the piece when subjected to traction, solid type 95, target 170 and contact 174 elements were used. The total number of solid type elements is 8512 having 10618 nodes. The figure 2 presents the discretization of the piece in finite elements and the putting of the sections positioning for the stress state analysis used. Due to symmetry, only half of the model was used. The analysis was performed in one step and the force was simulated by using an uniformly distributed force having a resultant value on the entire model of 15.000 N. For the bolt fixed model, 21562 elements with 8 nodes were used. The equivalent stress and deformation state were analyzed in more sections, as presented in figure 2. For the first piece, the stress state was presented in figure 4. The results obtained for the analyzed case were compared and are presented in figures 4 and 8. The most representative numeric results are also presented. The figure 10 shows the rim conditions and the discretization for the screw fixed model. The figures 3 and 7 present the stress values; it can be observed that significant values were obtained for the positions near the hole and orifice corresponding to the loading step.

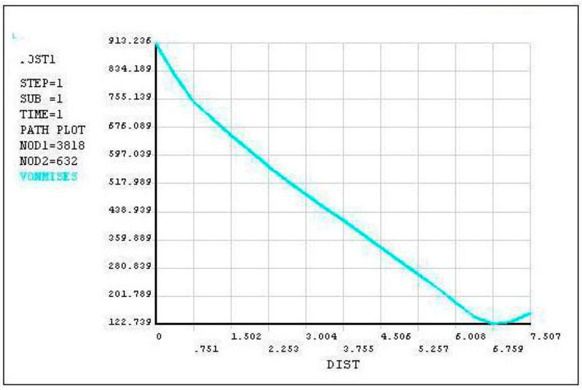


Figure 3 Von Mises stress on the direction 1;

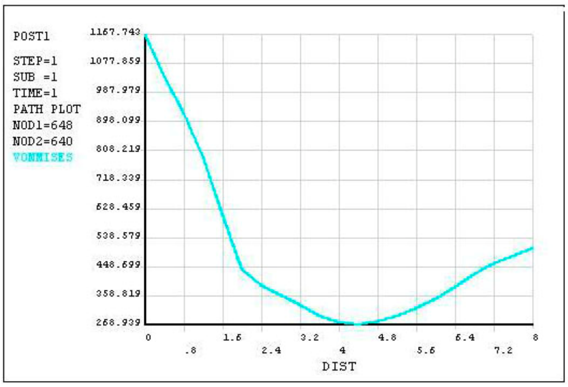


Figure 4 Stress state on the direction 2;

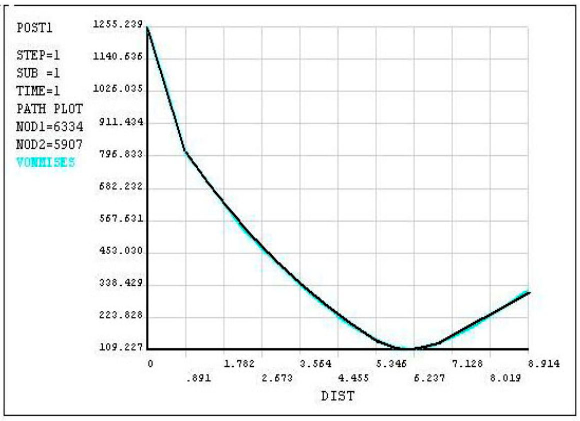


Figure 5 Stress state on the direction 3;

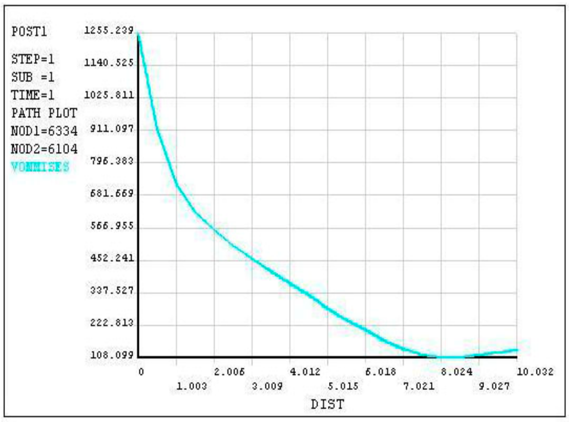


Figure 6 Stress state on the direction 4;

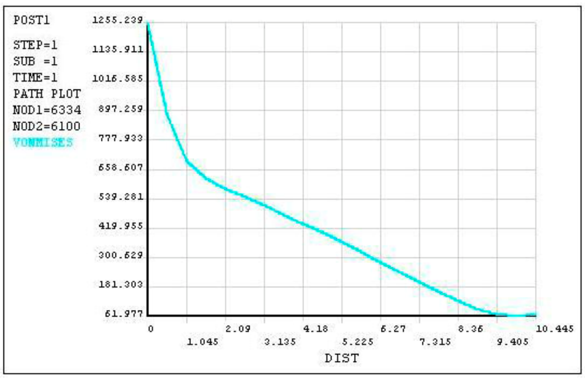


Figure 7 Stress state on the direction 5

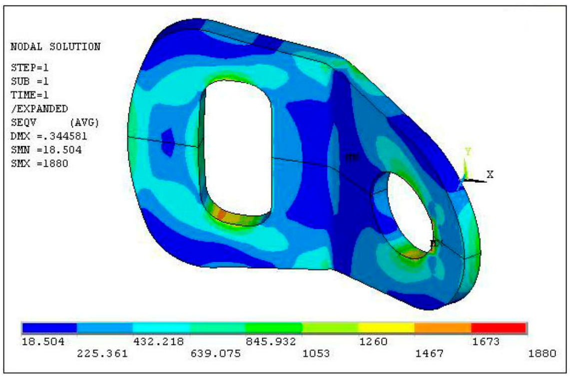


Figure 8 Von Mises stress state

The figures 8 and 9 present the stress state for the whole piece. The figure 10 presents the deformation state.

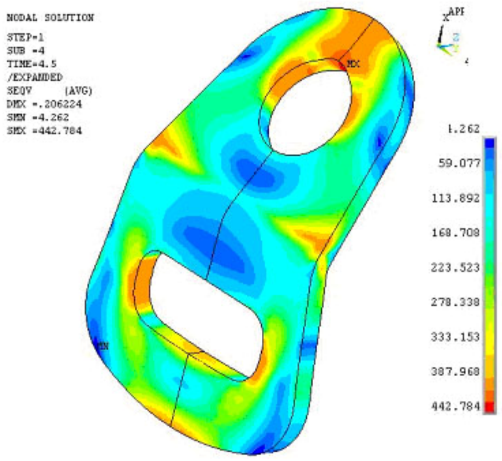


Figure 9 Stress state on behind face.

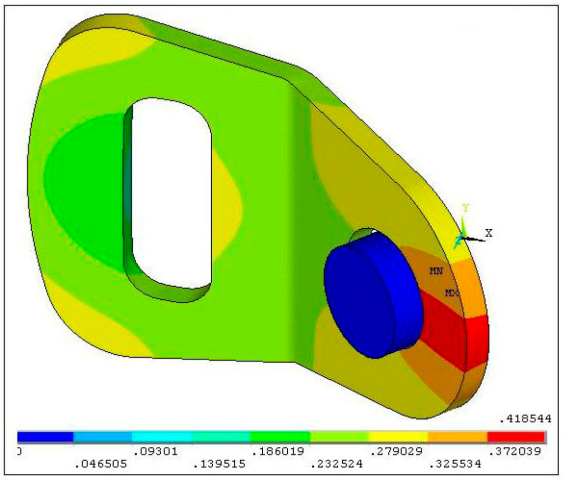


Figure 10 Deformation state

On the contact surface between bolt and hole appears large contact stress. Their stress magnitude decreased when the point is further located from the contact surface.

3. EXPERIMENTAL DETERMINATIONS

The photo-elastic model (fig.11) was manufactured by casting. After casting, the resulting model was not subjected to further processing. After placing in a fixing device, it was subjected to a 717.24 N force with the help of a rubber support that simulated the webbing and the screw.

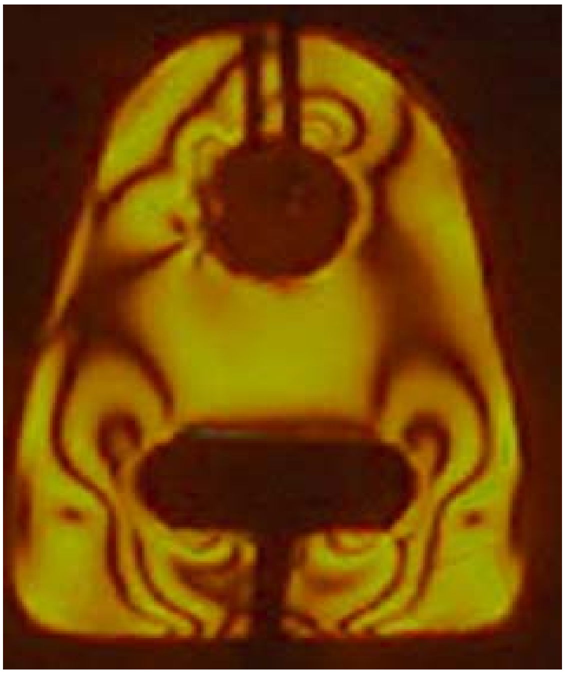


Figure 11 The photo-elastic model with the manifested fringes

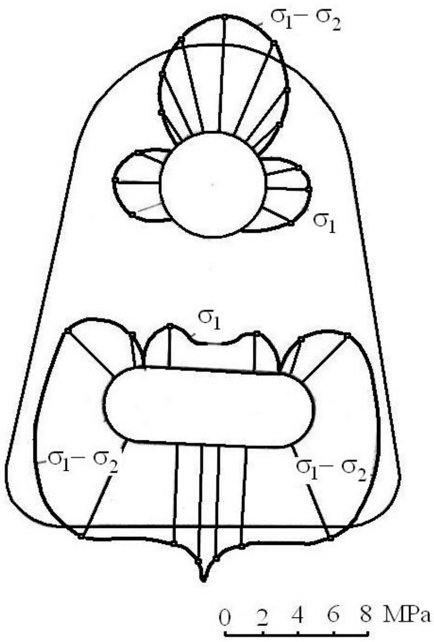
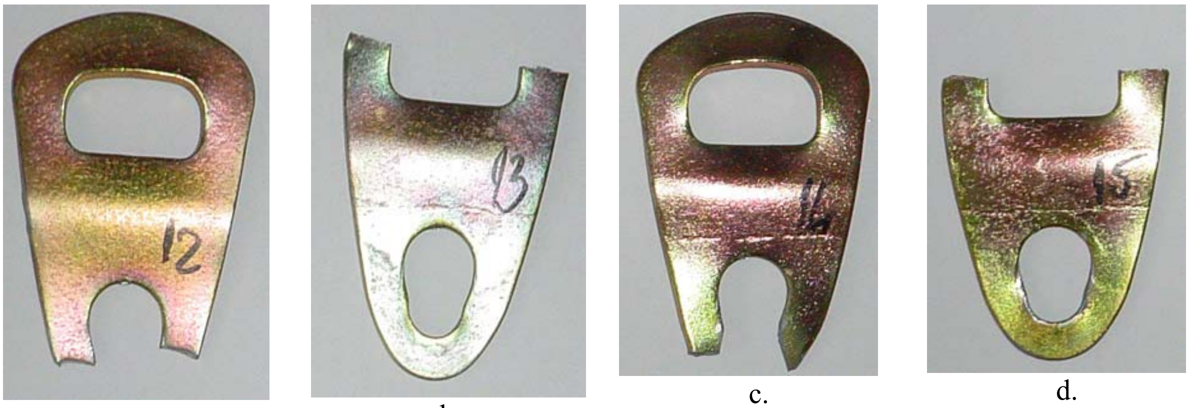


Figure 12 Determination of the tension state

The isochromatic fringes were obtained by using the following formula:

$$\sigma_1 - \sigma_2 = f_\sigma N \qquad (1)$$

where $f_\sigma = 0,182$ N/mm^2 is the photoelastic constant of the material and *N* is the contour band order. Based on these recordings, the stress state variation curves were drawn (fig.12). By applying the similitude law, the same results were extrapolated from the model to the prototype.
The tensile breaking strength can be determined by subjecting the piece to traction forces in real conditions; this value is set by the user to a certain value. The tensile testing is performed on a statistically selected set of pieces together with the user. In order to perform the experimental loading traction tests, a special device was designed in order to attain the functioning conditions for the double belt in the safety belt ensemble. The loading tests were performed by a loading machine by traction to the break point. The experimental and theoretical results are compared and the discrepancies are traced to the generating cause.



a. b. c. d.

Figure 13 Breaking possibilities for the belt guide

4. CONCLUSIONS

The analysis of the behavior by the finite element method, by performing traction loading and by photo-elasticity measurements lead to the following conclusions:

- the most dangerous areas are corresponding to the orifices through which the textile webbing pass and for the bolt;
- breaking of the pieces occurred most in the orifice area;
- the pieces dimensions was corrected according numerical analysis results;
- the experimental and numerical results are in agreement with the finite element method and have been used to determine the dangerous area;
- the results obtained were used to correct the belt guide shape;
- the numerical and experimental results are in concordance.

The analyses performed by the authors were based on the practical necessities and it used to design the form of the safety belt guide.

5. REFERENCES

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