ASPECTS REGARDING THE BEHAVIOR OF THE SEAT BELT SIMPLE GUIDE SUBJECTED TO TRACTION

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ABSTRACT: This paper presents the determination of the tension state for the simple ear component of the safety belt when subjected to external traction forces transmitted by the webbing. The aims of these determinations are to determine the dangerous zones at the orifice where the webbing is applied, to correct the dimensions for the webbing and ear positioning and to determine the optimal material type. The tension state is determined by the finite element method and it is confirmed experimentally by using the photo-elasticity method. In the same time, the force necessary to break the simple ear by traction is determined and compared to the FEM simulation, this information being necessary for homologation. The dimension for the breaking force is found to be within normal requested range. The experimental and numerical data are found to correspond.

Keywords: seatbelt, photo elasticity, finite element, simple guide

1. INTORODUCTION

Design, manufacturing and homologation of the safety belts require resistant components that are to provide good functionality and user safety. The simple ear guide (fig.1) is one of the components of the safety belt ensemble. In order for the tension state of the simple ear when subjected to loading to be observed clearly, a theoretical and experimental study was designed. The theoretical study of the tension states was performed on more samples and the numerical results were used to determine the shape and the recordation angle for the webbing ring. After determination of the ear shape, this was analyzed with the finite element method to determine the tension state. The FEM results were experimentally verified with the photo elasticity method. The finite element model was used to simulate breaking by subjection to traction until the break point. The results were verified experimentally by determining the traction force necessary to break the ear[3, 7].

2. ANALYSIS OF THE DEFORMATION AND OF THE TENSION STATE

We will present first how the samples were analyzed with the finite element method. In the same way other pieces were analyzed by subjecting them to various recordation angles in order to obtain a minimal tension state corresponding to the angle value. Let us consider one optimized the safety belt guide as shown in figure 1. This piece is fixed on the internal rim at an angle of 120^o; the internal diameter on a bolt is 14 *mm* (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, type 95 solid, 170 target and 174 contact elements were used. The total number of solid type elements is 2700 having 13500 nodes. The figure 2 presents the discretization of the piece in finite elements and the placing for the sections positioning for the stress state analysis used.

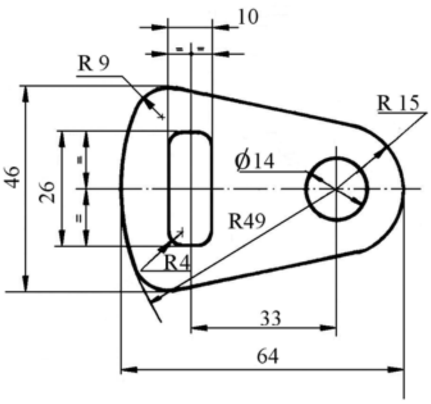

Fig. 1 The simple belt, structural element of the safety belt; design

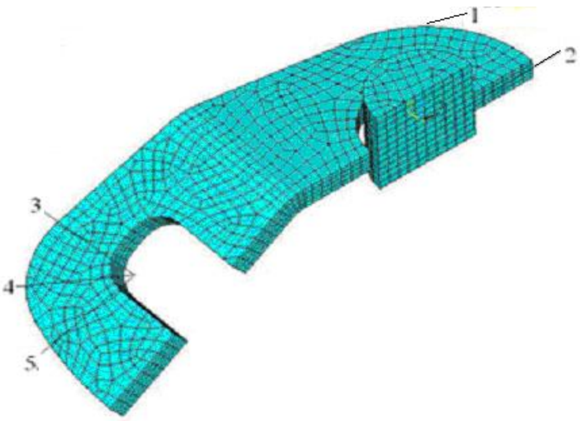

Fig. 2 The sections positioning for the stress state analysis

Due to symmetry, only half of the model was considered. The tension state for a 1500 N for half of the piece is shown in figure 3. One can observe that the tension state distribution in the piece is symmetrical. The largest equivalent tension is placed at the contact point between the ear and the steel bolt. The value for this equivalent tension is large, as it represents a contact tension.

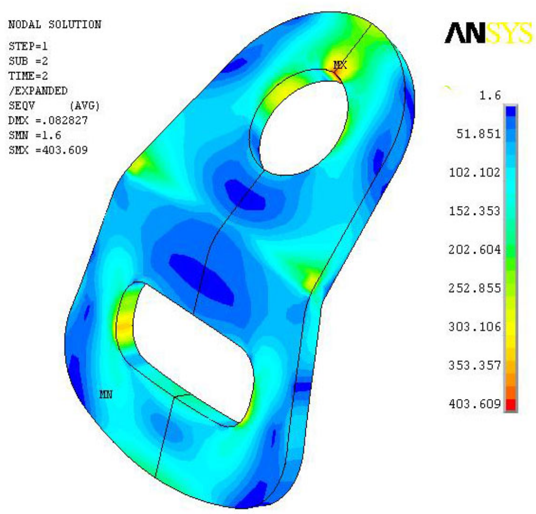

Fig.3 Equivalent Von Misses tensions for the step 2, corresponding to a 1500 N force.

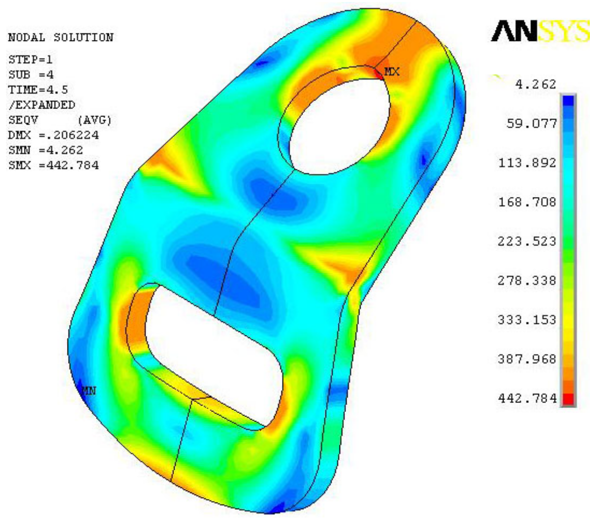

Fig.4 Equivalent Von Misses tensions for the step 4 corresponding to a 3375 N force.

Analysis of the tension state was performed in step 7, taking also into consideration the contact (the piece steel bolt) and material nonlinearity (photoelastic material).The force was simulated by using an uniformly distributed pressure having a resultant value for the entire model up to 15000 *N*. Thus, the material was considered to be elasto-plastic bilinear kinematics Von Mises with the following characteristics: $E = 2\cdot 10^5$ *MPa*, $E_t = 2000$ *MPa* , $\sigma_c = 400$ *MPa*. Figure 3 and 4 present the tension state for the steps 2 and 4. The equivalent tension for step 2 at the steel bolt level is 403 *MPa* and for step 4 is 442 *MPa*. The large dimensions for the tension are explained by the fact that these are contact tensions. Figure 5 presents the tension state corresponding to step 5 and figure 6 presents the deformation state corresponding to step 7 for the steel bolt model and solicitation model as shown in figure 2. Large contact stress appears on the contact surface between bolt and hole. Their stress magnitude decreased when the contact point is further located from the contact surface.

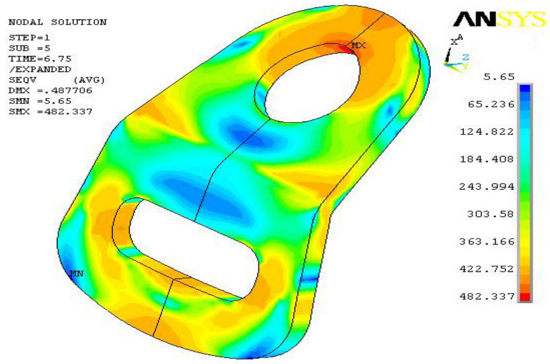

Fig. 5 Equivalent Von Misses tensions for the step 5 corresponding to a 5062N force

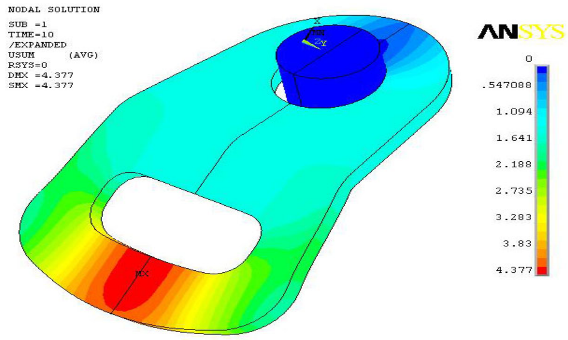

Fig. 6 Displacements resulted at maximal load (step 7). All elements are displayed.

5. EXPERIMENTAL STUDIES

The photoelastic determinations were performed on plane (bidimensional) models. The photoelastic model (fig.7) was manufactured from a Araldit D plate. Since the point of interest was the hole and the orifice and the tension values corresponding to them, no special attention was granted to the piece bending. The piece was placed in a device shown in figure 9.

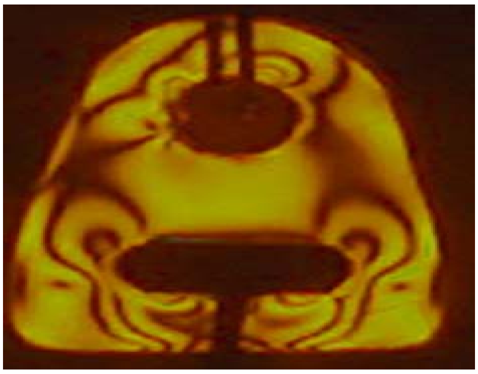

Fig. 7 Photoelastic model with fringe

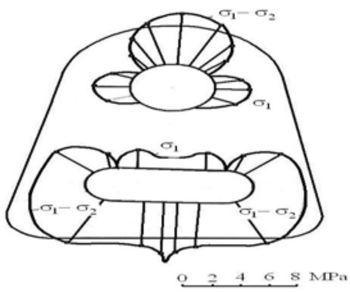

Fig. 8 Isochromatic levels

The traction force transmitted to the model is 717,24 *N* (fig.9). The force F_1 is transmitted to the model through rubber pieces (3) that simulate the webbing and steel bolt actions. The examination was performed in monochromatic light with 6oo *μm* wavelength in a polariscope with circular polarized light.
The following Isochromatic descriptions were obtainning (fig.7), by using the relation

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

where f_σ = 0,182 N/mm^2 is the photoelasticity constant of the material and N is the band order as read at the contour level. Based on these recordings tension variation curves were drawn (fig.8) and by applying the similitude law the results were expanded from the model to the prototype. To perform the experimental traction tests, a special device was manufactured to allow for the double ear to function in conditions similar to these in which it would function in the safety belt ensemble. The testing was performed until the break point on a loading device, by using from each 50 pieces lot 6% of the pieces. Figure 10 presents graphically the break point forces for four samples in comparison to the 15000 *N* requested by the safety belt safety reglementations.

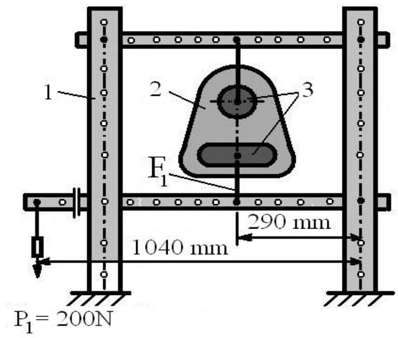

Fig.9 The loading device (1 device, 2 piece, 3 rubber)

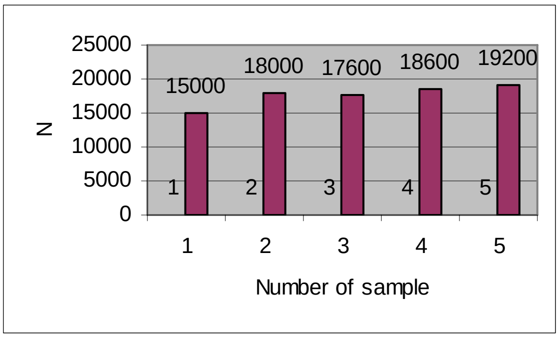

Fig.10 Breaking forces diagram

The breaking pattern for the four discussed samples is presented in figure 11.

a. b. c. d.

Fig. 11 Breaking pattern for the double ear guide

6. CONCLUSIONS

The analysis of the behaviour by the finite element method, by performing traction loading and by photo-elasticity measurements lead to the following conclusions: the most dangerous areas are those corresponding to the orifices through which the textile webbing pass and the bolt region; the breaking of the pieces occurred especially in the orifice area; the pieces' dimensions were 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 analyses performed by the authors were based on the practical necessities and were used to design the shape of the safety belt guide.

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