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200 HP Tractor - Zimbru Traction Bar Testing in Dynamic Regime and Modelling with Finite Element (MEF)

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Abstract: The paper follow up the traction bar testing in dynamic regime of a 200 HP tractor, using a tests installation in accelerated regime type hydro-pulse, with the goal of verifying the strength which it assures in transport. Also, it will be realized a model of the traction bar with finite elements, using COSMOS program in order to optimize its structure
Key words: testing, bar, tractor, regime, accelerated, finite elements

INTRODUCTION

The traction bar is a component part of the traction device mounted on the tractor and is used at towing the agricultural gear by the ZIMBRU tractor.

The main dimensions of the product are presented in table no. 1, and the measured ones in table no. 2.

Table 1.

No.	Dimensions according D 89/173/CEE and SR ISO 6489-3:1999	Dimensions according to technical documentation	Measured dimensions before test	Measured dimensions after test	Observations
1.	$d - \phi 33\ ^{+1}_{0}$	$\phi 33\ ^{+1}_{0}$	$\phi 33,10$	$\phi 33,15$	-
2.	min. 65	90	90	91	-
3.	H min. 105	150	152	157	-
4.	laţime	100	100	103,5	-
5.	R max. 80	65	65	64,57	-

***NOTE:** the dimensions are in mm.

Table 2.

No.	Parameter denomination	Min. value according D 89/173/CEE	Measured value
1.	Steering angle	min. ± 60°	±78°
2.	Pitch angle	min. ± 20°	±20°48'
3.	Rolling angle	min. ± 20°	±28°5'

TESTING METHOD

The product test was effectuated according to Directive 89/173/CEE regarding the unification of the legal prescriptions of the member states, referring to some constructive elements and characteristics of the forestry and agricultural tractors on wheels, modified by the SEE Accord from 1992.

Connective documents and of internal reference (procedures), harmonized to the EU norms, according to which were realized the traction bar tests:

- SR ISO 6489/3:1999;
- SR ISO 5692:1996;
- PSpI - 01.00.37;
- IL SM 01.04;

TESTING CONDITIONS

The traction bar test was performed in mounted state on the traction device of which is a component part.

The traction device was fixed on the testing platform through the medium of a system of universal and specific devices, according the fitting presented in figures 1-3.

For tests it was used a hydraulic cylinder of 100 kN.

The testing parameters and their values are presented in table no. 3 and they were established in conformity with the technical documentation of the product and with the annex IV of Directive 89/173/CEE.

Figure 1.

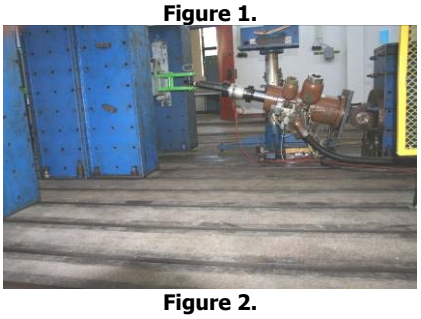

Figure 2.

Figure 3. The fitting realized on the hydropulse installation for the mechanical test of the tractor's traction bar

Table 3

No.	Parameter denomination	M.U.	Values
1.	Maximum towing weight	kg	25.000
2.	Total technical admissible weight of the tractor	kg	12.500
3.	Maximum vertical static load on bar	kg	1.500
4.	Dynamic testing load, **D**	kN	81,75
5.	Horizontal force, $\mathbf{F_h}$	kN	81,75
6.	Vertical force, $\mathbf{F_v}$	kN	22,50
7.	Testing force, **F**	kN	84,79
8.	Maximum force, $\mathbf{F_{max}}$	kN	84,79
9.	Medium force, $\mathbf{F_{med}}$	kN	44,51
10.	Minimum force, $\mathbf{F_{min}}$	kN	4,24
11.	Testing angle	°	15,38°
12.	Testing frequency, **f**	Hz	1 Hz
13.	No. of cycles of pulsating solicitation	no	2000000

INSTALLATIONS AND MEASURING DEVICES USED

- Hydropulse installation with the following components:
  - Dynamometer (force cell);
  - Control board for the hydraulic cylinder;
  - Displacement measuring system with inductive transducer 0-500 mm;
- Laptop type Notebook 486 professional equipped with data acquisition board DAP 2400 – Microstar Laboratories;
- Calculator Pentium equipped with data acquisition board DAP 3200 E – Microstar Laboratories;
- Caliper 0-150 mm;
- Measuring tape 3 m;
- Level with microscope.

TEST RESULTS

The traction bar assures the mobility grades requested by Directive 89/173/CEE according to table no. 4.

The values were obtained using a trailer hitch fitted with a draw-bar eye, according to SR ISO 5692:1996 with the width of the bar of 85 mm and the thickness of 50 mm, measured at a distance of 80 mm from the draw-bar eye axle.

Table 4.

No.	Parameter denomination	Min. value accord. D 89/173/CEE	Measured value
1.	Steering angle	min. ± 60°	±78°
2.	Pitch angle	min. ± 20°	±20°48'
3.	Rolling angle	min. ± 20°	±28°5'

The effective values of the applied force and the corresponding measured displacements on the hydraulic cylinder axle direction during the test are presented in table no. 5.

Table 5.

Nro.	Realized number of cycles	Maximum force [kN]	Maximum displacement [mm]
1.	10.000	84,79	5 mm
2.	100.000	84,78	5 mm
3.	250.000	84,80	5 mm
4.	427.200	84,79	5 mm

The force-time diagrams are represented in figures 4-7.

Figure 4.

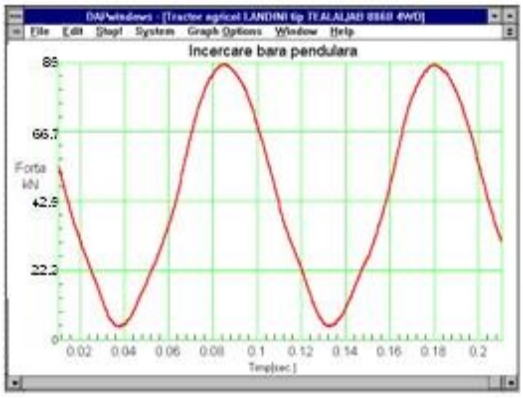

Figure 5. The force-time diagram for the traction bar fig. 4 - at 10.000 cycles; fig. 5 - at 100.000 cycles

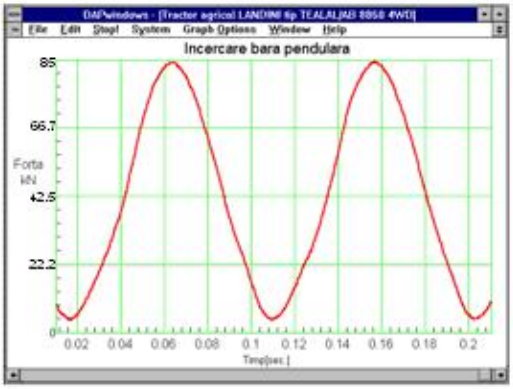

Figure 6.

Figure 7. The force-time diagram for the traction bar

fig. 6 - at 250.000 cycles fig. 7 - at 427.000 cycles

After realizing a number of 427.200 cycles at the amplitudes and frequency indicated in table no. 5, it was discovered the breakage of the connection bolt. (figures 8 ÷ 10).

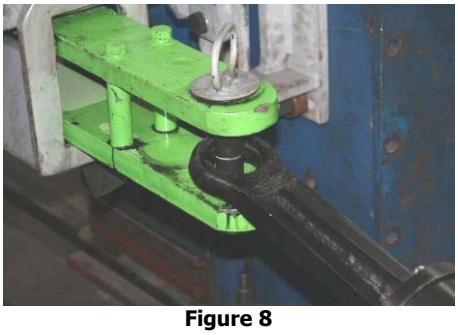

Figure 8

Figure 9

Figure 10. Breakage of the connection bolt for the mechanical test of the traction bar from the ZIMBRU 2200 tractor (after 427.000 cycles)

fig. 8 - bolt breakage, total view
fig. 9 - bolt breakage, detail
fig. 10 - bolt breakage section

NUMERICAL SIMULATION FOR THE SOLICITATIONS STUDY TO FOR THE TRACTION BAR (MEF)

Conditions:

- *Loading* with a force leaning with 24,9 degrees from the horizontal, applied after a pulsating cycle with the asymmetry grade R_s=0,06; Fmax=84,9 KN; Fmin=5 KN.
- Identical *support* with the one realized on the INMA stand.
- *The geometric model* was realized based on the documentation supplied by INMA. It was realized the assembly Traction bar based on all the execution drawings, using the SOLIDWORKS 2007 software.

The calculus model for the finite elements analysis

For the finite elements analysis it was used the software package COSMOS WORKS 2007.

There were used tridimensional finite elements of tetrahedron type with four nodes on element.

- Total number of elements =280.493.
- Total number of nodes=429.459.
- Total number of equations, after imposing the contour conditions = 1.287.369.

The calculus model used with the presentation of quantization and contour conditions is presented in Fig. 11, Fig. 12, Fig 13.

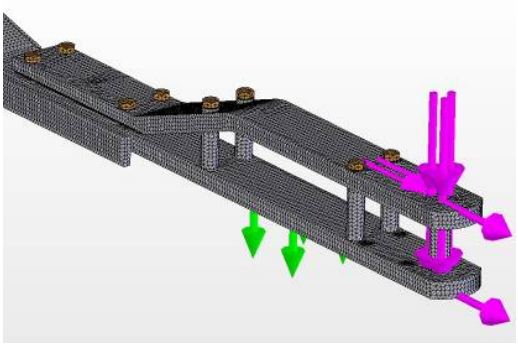

Figure 11 - Calculus model (traction end detail)

Figure 12 - Calculus model (central area detail)

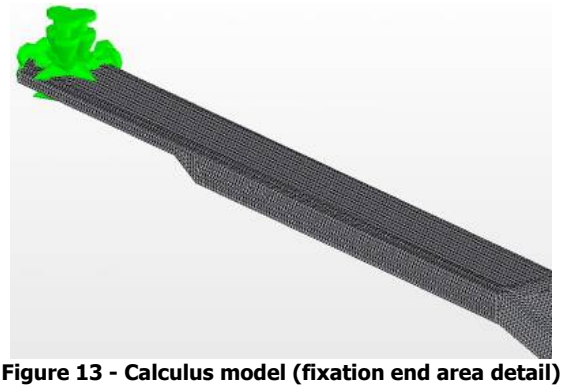

Figure 13 - Calculus model (fixation end area detail)

The elaborated calculus model was conceived both for the static analysis of the tension and deforming states from the assembly Traction bar and for its variable solicitation.

RESULTS

The deforming and tension state distribution in *case of static solicitation* at the maximum force level of 84,5 KN, (applied according to the presented loading conditions), is presented in Fig. 14, 15, 16, 17, 18.

Based on the simulation effectuated in variable solicitation regime, it was established the weariness comportment of *the assembly traction bar.*

The obtained results are synthetic presented in Fig. 19, and 20.

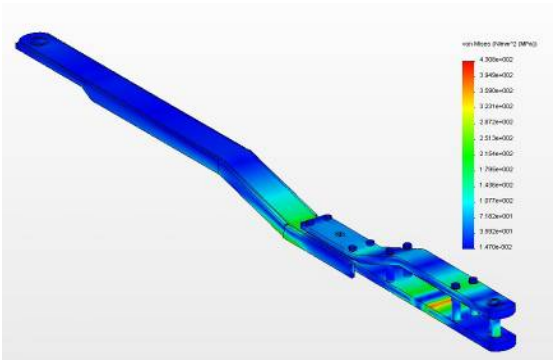

Figure 14 - The equivalent tension state distribution calculated after the theory of specific energy of maximum deformation, Von Mises (total view picture)

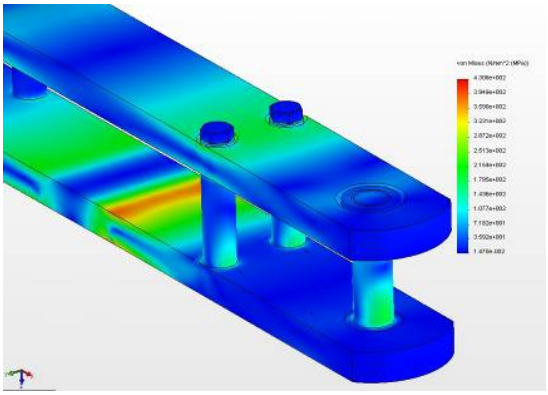

Figure 15 The equivalent tension state distribution calculated after the theory of specific energy of maximum deformation, Von Mises (end of traction detail picture)

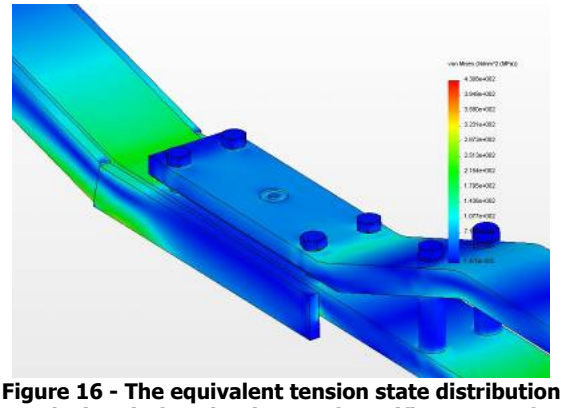

Figure 16 - The equivalent tension state distribution calculated after the theory of specific energy of maximum deformation, Von Mises (central area detail picture)

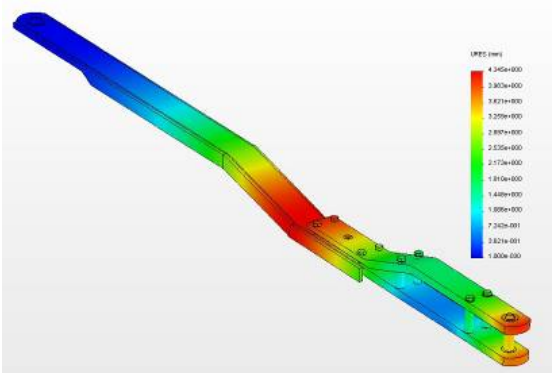

Figure 17 - The total deformation state distribution, in undistorted state (total view picture)

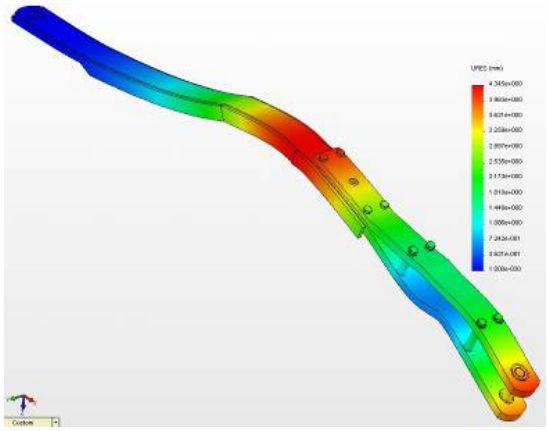

Figure 18 - The total deformation state distribution, in deformed state (total view picture)

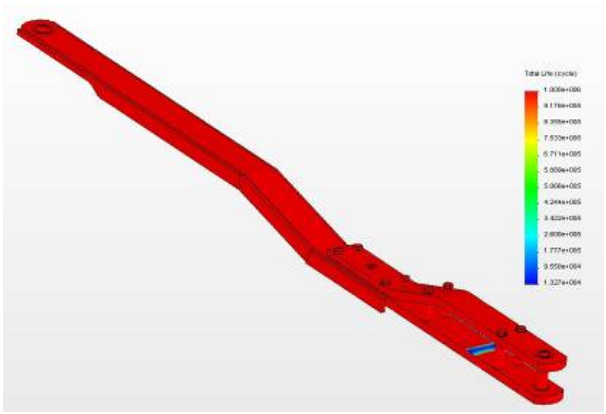

Figure 19 - The general representation of the solicitation number of cycles at which the assembly *traction bar* resists at weariness

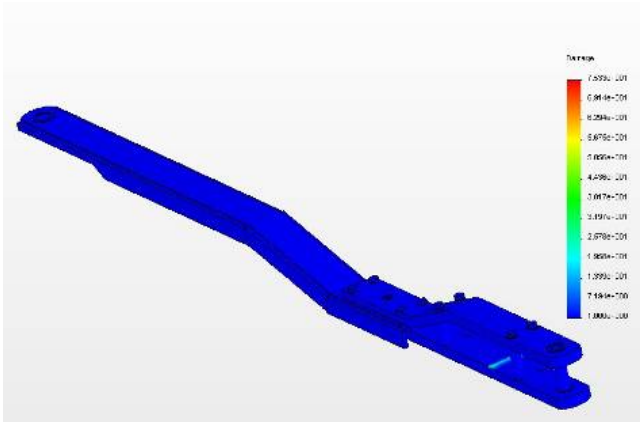

Figure 20 - The degrading stadium recorded for the assembly *traction bar* for a number of 13270 solicitation cycles

CONCLUSIONS

The traction bar which equips the tractor is designed to towing the agricultural gear with which this one works in tandem.

The necessary data for the determination of the dynamical solicitations, at which the product was subjected, were specified by the beneficiary in the technical documentation transmitted together with the product for test.

Throughout the test the bar was fixed in the traction device, which at its turn was rigidly fixed by four pylons, simulating this way the mounting of the tractor's chassis.

The tests were executed on the installation of dynamical testing hydropulse type, and after 427.200 cycles the connection bolt has broken.

At the end of tests, it was observed that the connection bolt has broken, resulting that the constructor has to recalculate it for a bigger dimension because in this case the bar cannot be used for towing the gear with which it works in tandem without endangering the safety and security of those nearby.

After bolt redimensioning, the traction bar has to be tested again until 2000000 cycles (as the D 89/173/CEE stipulates), for seeing if both the bar and the bolt are resisting to solicitations, without breaking, for being homologated for endowing the tractor when it works in tandem with agricultural gears.

From the analysis of the bar solicitations (MEF) it is remarked that in the imposed conditions, after a number of 13.270 solicitation cycles there appears a high endangered area - the guidance area of the assembly *traction bar* , Fig. 19, which should be redimendioned (strengthened).

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