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NUMERICAL ANALYSIS OF FORAGE TRAILER SUPPORTING STRUCTURE

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Abstract

The paper discusses issues of examination supporting structure of forage trailer. Tests were applied to supporting structure, lowered in order to adjust the height of mix feeding for younger cattle. Lowering obtained by spreading of supports caused increase of the structure effort and increase of stress exceeding acceptable values. The paper describes the manner of preparation of numerical model and results of tests performed with its application. Based upon the results modification of the structure in critical areas was proposed. Implementation of such modifications resulted in improvement of effort of forage trailer supporting structure..

Keywords: *agricultural machinery, forage trailer, structure tests, FEM, ANSYS*

1. Introduction

Forage trailer are widely used in particular on big farms which breed the cattle on large scale and intend to improve their stock efficiency through correct feeding of animals. Basic functions of forage trailer (Fig. 1) are: dosing correct feed dose, mixing and transportation to pasture.

Fig. 1. Forage trailer EVO

Special screw with knives is used for feed mixing and crushing. High and large capacity box allows for feed supply. Appropriately located gears transfer trailer supplied drive, move the screws and belt conveyors. Whole structure, additionally loaded by significant amount of feed is based on supporting frame. One of crucial parameters of forage trailer structure is the height at which animals take the mix – if its too high, shorter animals have difficulties with reaching the feed. The paper undertakes testing of lowered supporting frame structure. Such lowering was obtained by moving away of rear support which resulted in increase of deflecting moments acting on the frame. Numerical analyses were performed in order to set the structure strength and guidelines were specified for further modification of frame which was subsequently verified.

2. Object and testing conditions

Tested object was supporting frame of low EVO forage trailer. Characteristic dimensions of the object are presented at Fig. 2. On rear and front holders (Fig. 2) there is a basket containing the screw for feed mixing. Main supporting beams are made of closed sections 80 x160. The frame is made of S235JR steel.

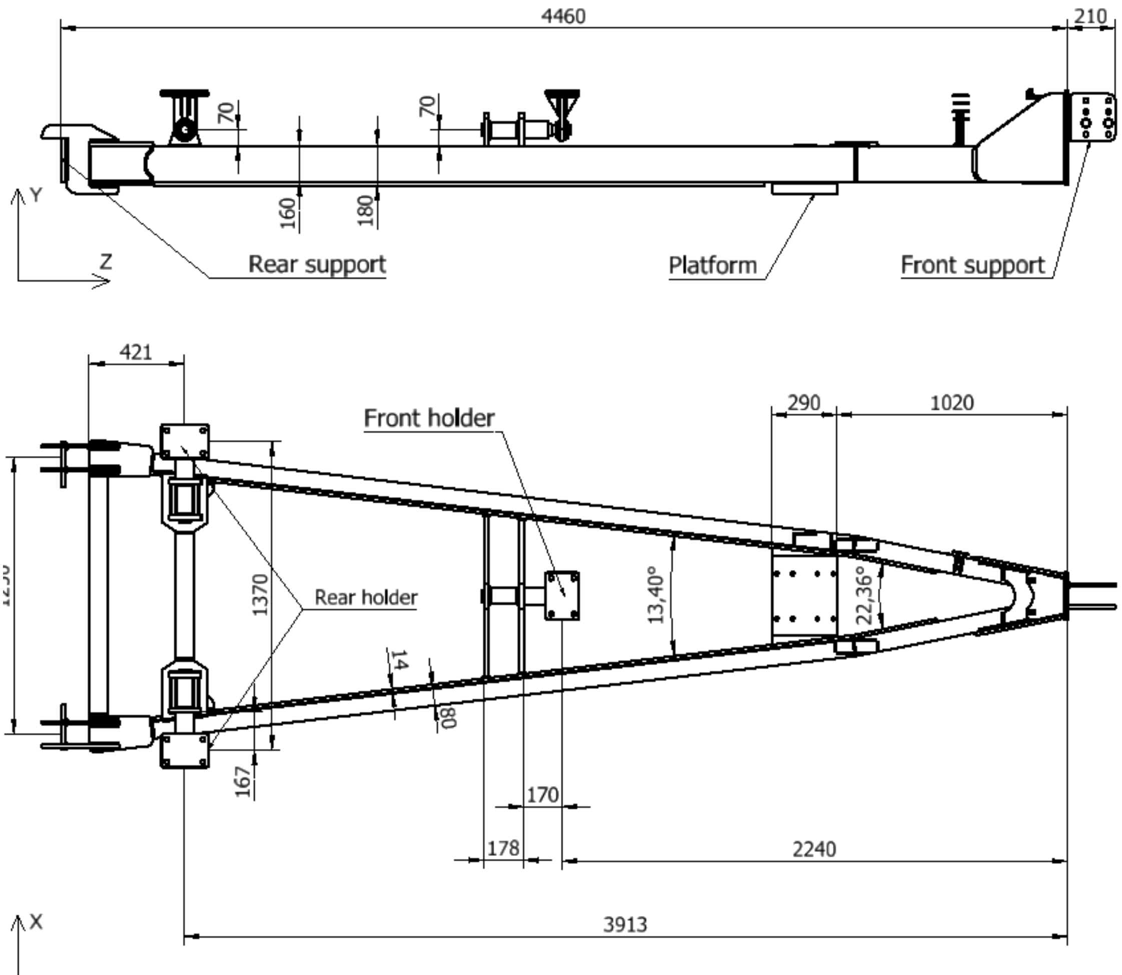

Fig. 2. Dimensional drawing of supporting frame of low EVO forage trailer

The frame is supported on two supports located in rear part at height of load bearing beam front. Rear supports are used for fixing of axis with wheels. Trailing hook acts as a front support. Total frame load resulting from founded basket results from masses: 2 000 kg –basket, 1 300 kg -

screw, 5 000 kg - feed, after summing up total mass - 8 300 kg. It was assumed for analyses that force of Q=81.5 kN will be applied to the frame. The force was divided into components: rear loads R_T operating in rear holders and front loads R_P operating in front holder. The form of both components is defined by set dependencies (1) and (2).

$$R_P = \mathrm{Q}\left(1 - \frac{\mathrm{R}}{\mathrm{H}}\right) \tag{1}$$

$$R_T = \mathrm{Q} \times \frac{\mathrm{R}}{2\mathrm{H}} \tag{2}$$

gdzie:
R – radius of a circle defined on points setting centres of supports.
H - distance between supports measured in direction 0Z acc. to Fig. 2.

Based upon measurements performed with supplied documentation values of R = 976.5 mm and H = 1672.5 mm were set resulting in the fact that the frame is loaded with three forces: at front holder with force of 33.9kN and at rear holders with forces of 23.8 kN.

3. Conditions for performing of numerical analyses

Numerical examinations were performed according to method of complete elements [2] in ANSYS Workbench environment. Based upon geometrical models of EVO frame, layer division grid was prepared. Threshold conditions for analyses were selected in such manner that at rear supports translation degrees of freedom in direction 0Y (Fig. 3a) were achieved. In front support condition of *Remote displacement* [3] type was defined which is presented schematically at Fig. 3b. In holders forces of *Remote force* [3] type were introduced of values specified in point 2, operating in direction 0Y (Fig. 4).

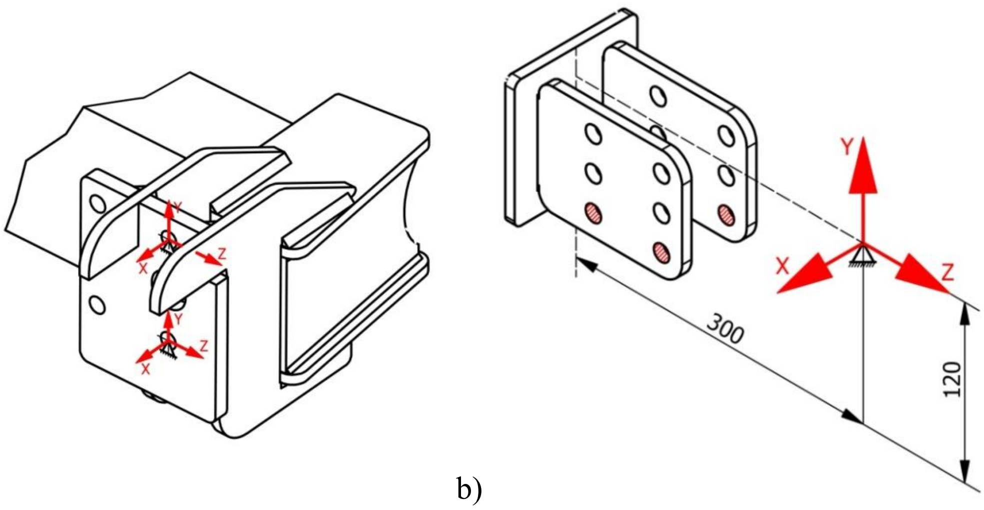

Fig. 3. Supports defining scheme: a) rear, b) front

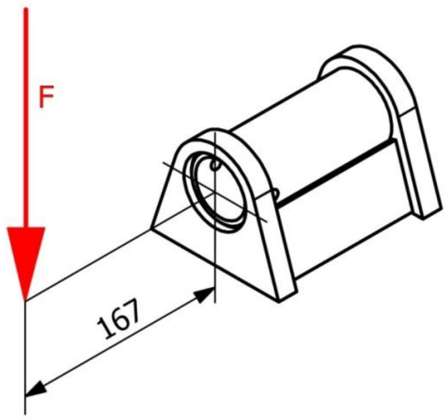

Fig. 4. Scheme of load application

4. Numerical tests and modification of supporting frame

After preparation of division grid and defining of threshold conditions numerical solution of the problem was obtained. Calculation results were presented in the form of distribution of stresses in the frame at Fig. 5.

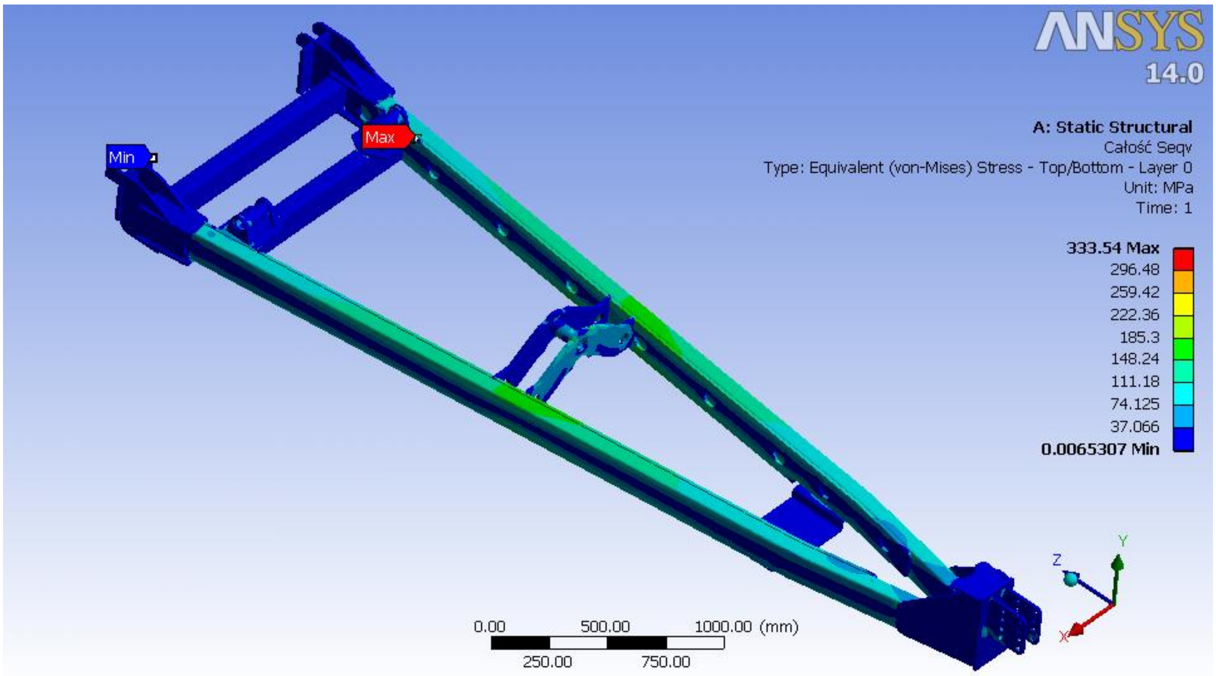

Fig. 5. Distribution of stresses reduced in EVO frame prior to modifications

It was stated that values of maximum stresses for the frame, identified with symbol Max at Fig. 5, which are present at the point of rear support fixing, significantly exceed acceptable stresses. In order to improve the state of frame effort in this area constructional changes were proposed. The changes would focus on introduction of ribs of 10mm thickness, supporting the support. Weld between rear support and main supporting beam was eliminated. The frame modified in this area is presented at Fig. 6.

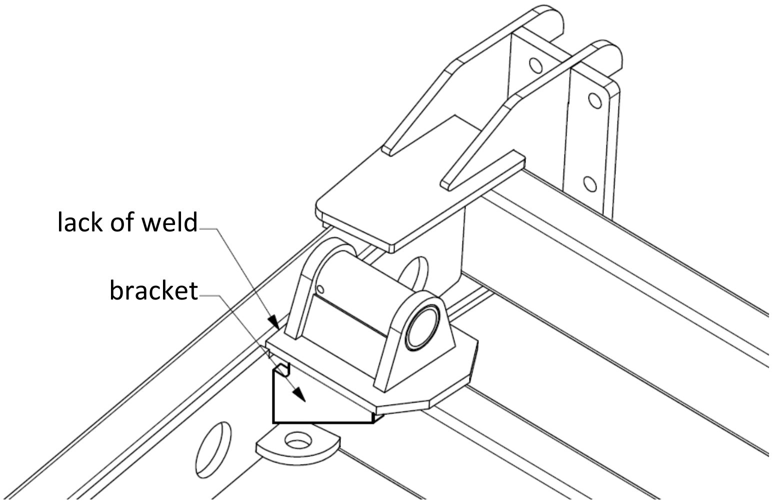

Fig. 6. Geometrical form of modified rear support

Moreover, a number of fine modifications was proposed leading to reduction of stresses at selected frame nodes. First modification was based on lowering down to 4mm of thickness of platform for drive gears (Fig. 2). In case of front bridge radius R55 was changed to radius R65 and the bridge thickness was increased to 24mm. Also, front holder height was increased from 210 mm to 380 mm (Fig. 7b). Geometrical form of modified bridge is presented at Fig. 7a, and modified holder at Fig. 7b.

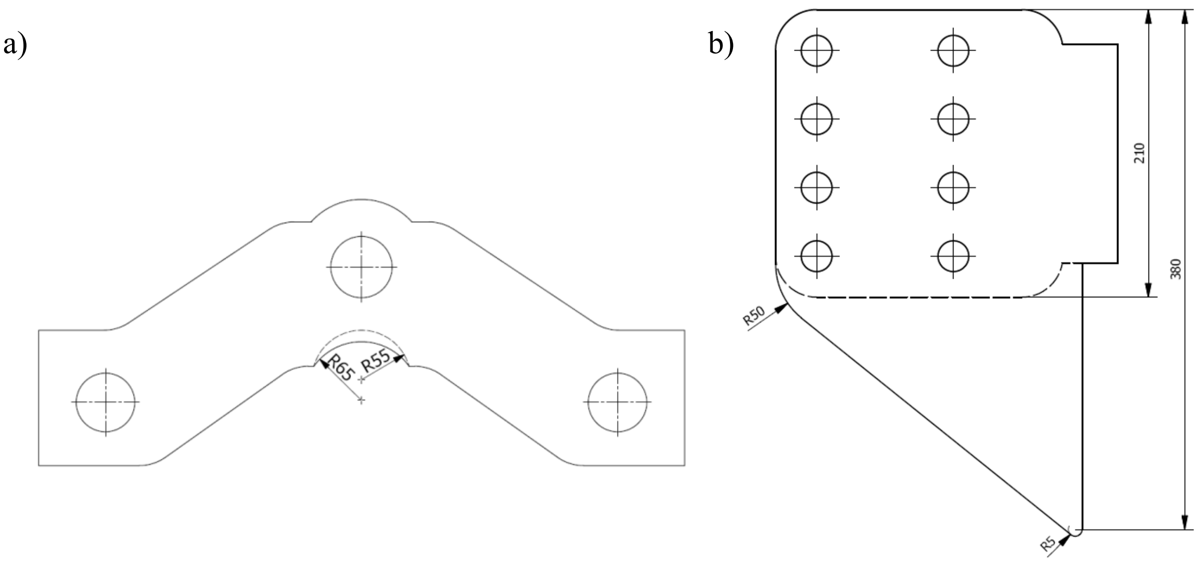

Fig. 7. Geometrical form of modified: a) front bridge, b) holder

After introduction of modifications of geometrical form for unchanged threshold conditions numerical solution to the problem was obtained. Calculation results are presented in the form of stress distribution in the frame at Fig. 8.

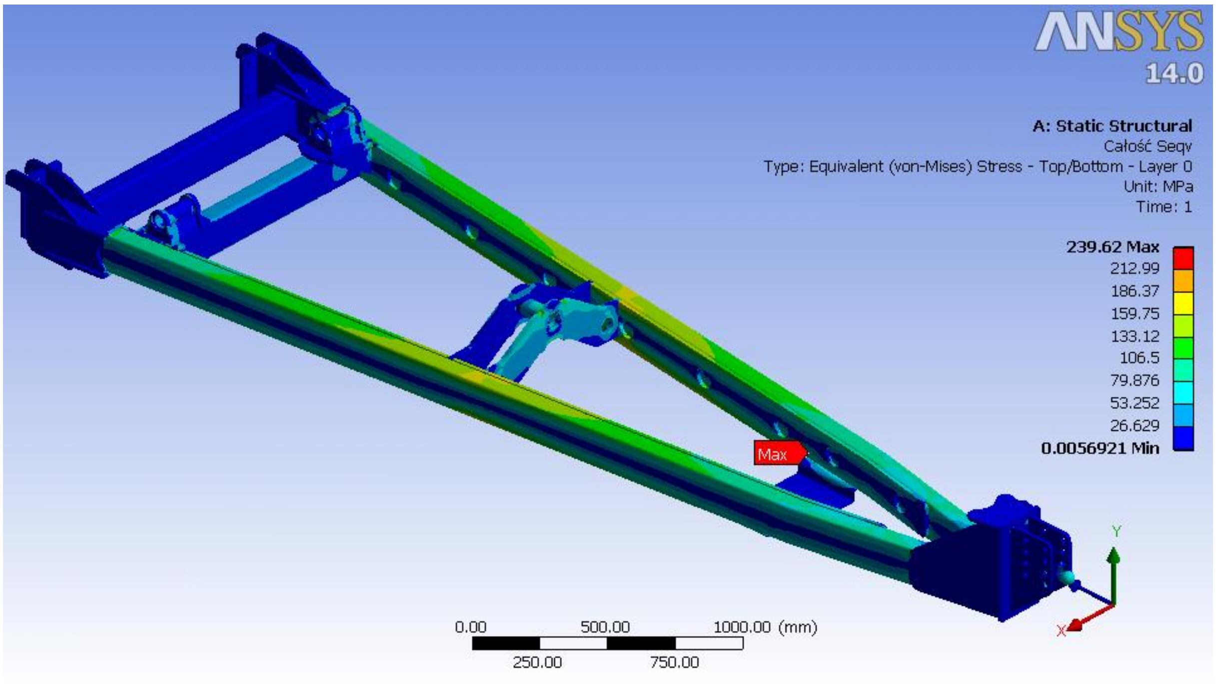

Fig. 8. Distribution of reduced stresses in EVO frame after modifications

5. Summary

The paper presents conditions for performance and results of numerical analyses of lowered supporting structure of forage trailer. After performing of calculations it was stated that values of acceptable stresses in the area of rear support were significantly exceeded. Moreover, it was stated that acceptable stresses were exceeded to a lesser degree in main supporting beam in the area of platform for drive gears and in holder and front bridge. In order to reduce stresses in critical nodes of the frame constructional changes were proposed. Their introduction led to improvement of the structure effort state.

In order to verify correctness of performance of numerical analyses one should compare their results with the results of analytical calculations performed for main supporting beams. Also, performance of experimental tests e.g. with strain gauge method at selected points of supporting structure, would allow for verification of assumptions applied for analyses.

References

[1] Sęk, P., *Wozy paszowe do żywienia krów w systemie TMR*, Journal of Research and Applications in Agricultural Engineering, Vol. 50, No. 4, 2005.

[2] Rakowski G., Kacprzyk Z., W., *Metoda Elementów Skończonych w mechanice konstrukcji*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2005.

[3] ANSYS Inc., *ANSYS Mechanical Appliction User's Guide*, ANSYS 14.0, 2011.