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NUMERICAL ANALYSIS OF FRAME STRUCTURE OF SINGLE AXIS MANURE SPREADER

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Abstract

The study describes issues of research of frame structure of single axis manure spreader of loading capacity 14t. During the tests state of stress in frame structure and manure box have been specified. Manner of preparation of numerical model and results of tests performed with its use have also been described. On the basis of the results modification of the construction in critical areas has been proposed. Introduction of modifications resulted in improvement of frame structure of manure spreader strength state.

Keywords: *agricultural machinery, manure spreader, construction testing, FEM, ANSYS,*

1. Introduction

One of the most crucial factors having impact on frame structure of manure spreader is a number of axis of driving system. The most common are single and double axis solutions, more rare triple axis solutions applied when huge loading capacity is required. In case of single axis spreaders (Fig. 1) significant portion of load is transmitted by rear axis of a tractor resulting in increase of vehicle thrust force due to reduction of sliding of driving wheels [2].

Fig. 1. The tested manure spreader

Lower load present in case of a single spreader allows for application of smaller driving wheels. The advantages of such solutions are, connected with tyre diameter, lesser resistances of rolling, and, connected with tyre width, reduced soil compaction. As for spreader rolling on the field greater portion of tractor power is used, reduction of specified movement losses results in reduction of tractor fuel consumption [1].

2. Obiekt i warunki badań

The tested object was frame structure of a single axis manure spreader of loading capacity 14t. The main element of spreader equipment is a double drum manure spreading adapter. Mounted in rear part of manure box, the adapter with vertical system of drums is driven by mechanical gear. Characteristic dimensions of the analysed object are specified in Fig. 2. The welded frame is made of steel S235JR.

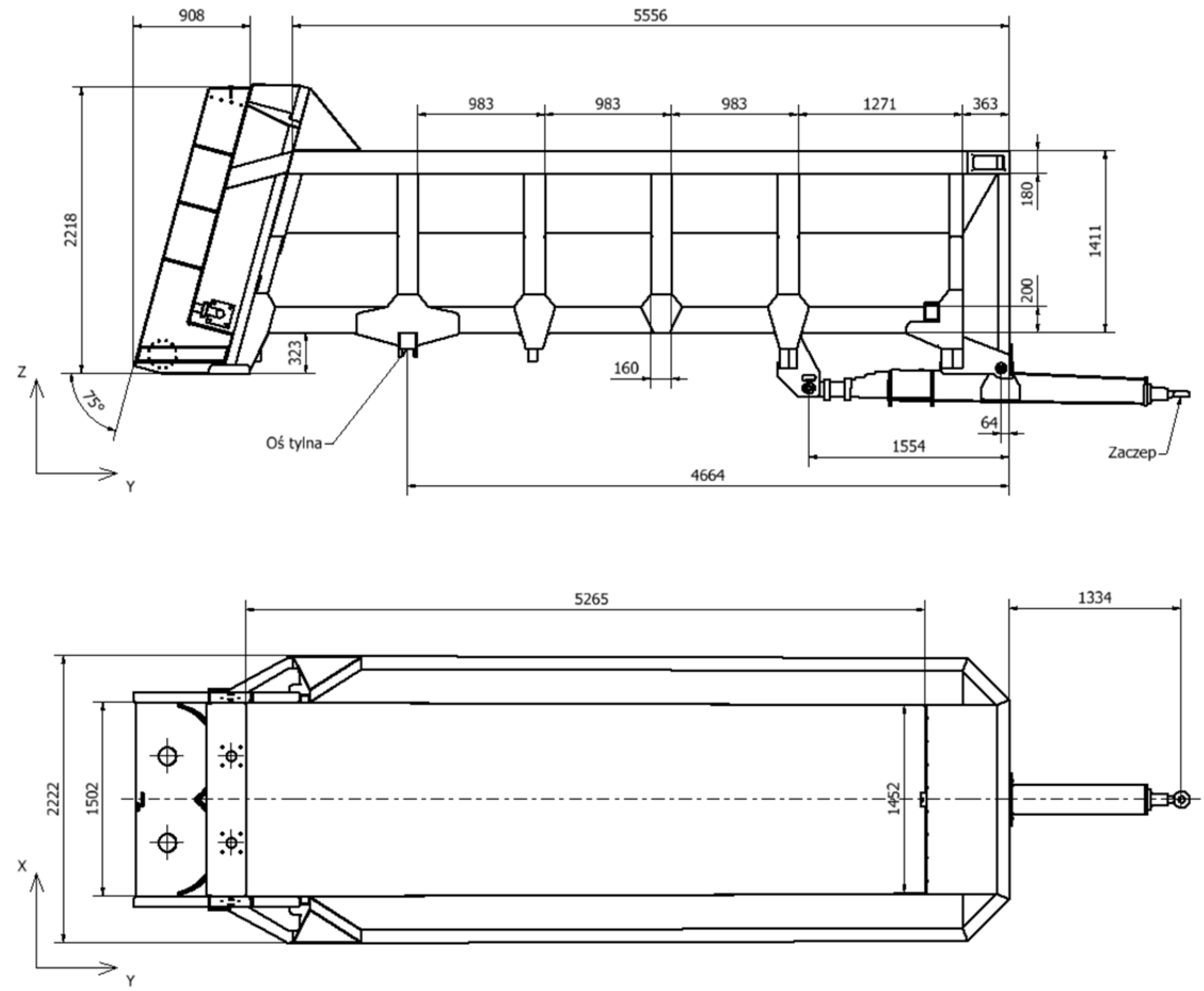

Fig. 2. Size dimensions of manure spreader

In its rear part spreader is supported in two points located on both ends of rear axis. To this axis the wheels are mounted. In its front part spreader is supported in one point, corresponding with joint for single axis trailers. Total load of frame structure of manure spreader consists of: manure mass 14 000 kg, mass of two manure spreading adapters 2x160 kg and mass of two gears for adapters driving 2x250 kg. The analyses take into account the frame structure weight of its own.

3. Conditions of performance of numerical analyses

Numerical tests were performed with a method of finite elements [3] in ANSYS Workbench environment. On the basis of geometric models of frame structure of manure spreader, shell mesh was prepared. For analyses boundary conditions were selected in such manner that at rear supports translation degrees of freedom were fixed in direction 0Y (Fig. 3). At front support the condition of *Remote displacement* [4] type was specified, fixing all three degrees of freedom. Main load resulting from manure mass was distributed on the whole floor surface.

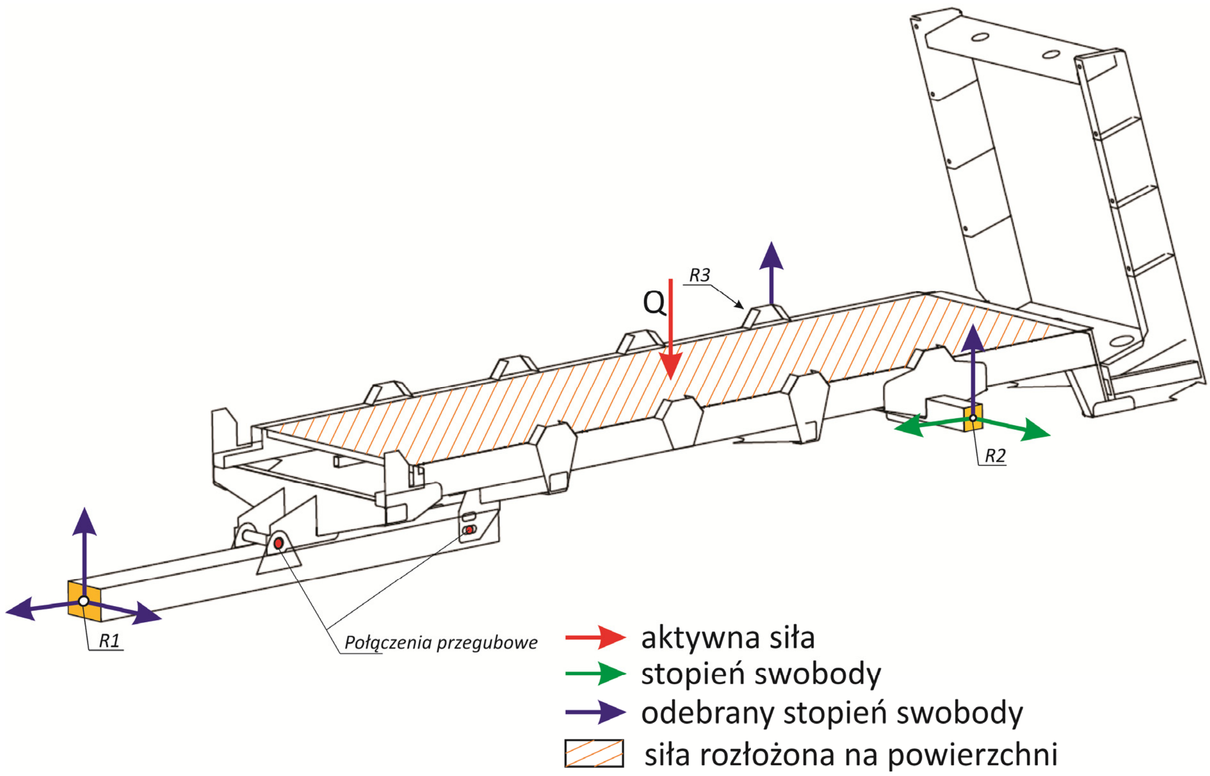

Fig. 3. Diagram of selection of threshold conditions for manure spreader

For the analyses it was assumed that in bottom part of applicator frame there should be two forces applied *P*=2.5 kN representing transmission gears. The forces were applied to right and left side of applicator frame assigning them appropriate index on Fig. 4. Applicator rotors were mapped by forces *W*=1.6 kN with appropriate index on Fig. 4. It was assumed that forces *W* should be applied at points of rotors bearing mounting locations.

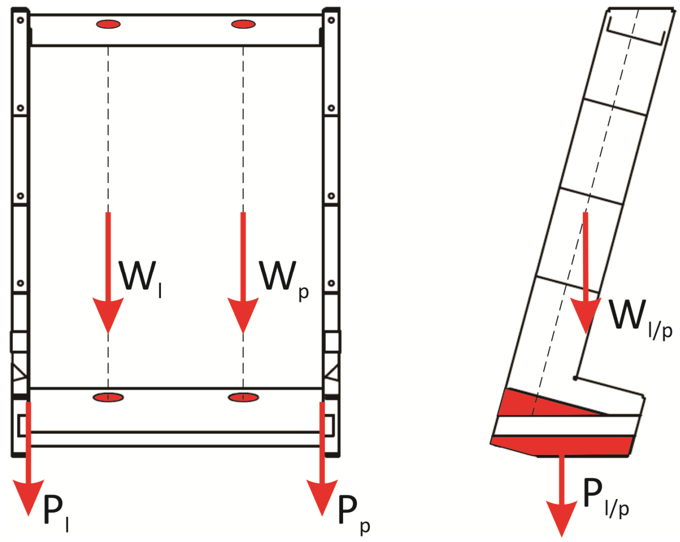

Fig. 4. Diagram of distribution of load on applicator frame

4. Numerical tests and modification of frame structure

After preparation of mesh and defining of material properties and boundary conditions numerical solution of the problem was achieved. Calculation results were presented in the form of stress distribution on frame structure in Fig. 5.

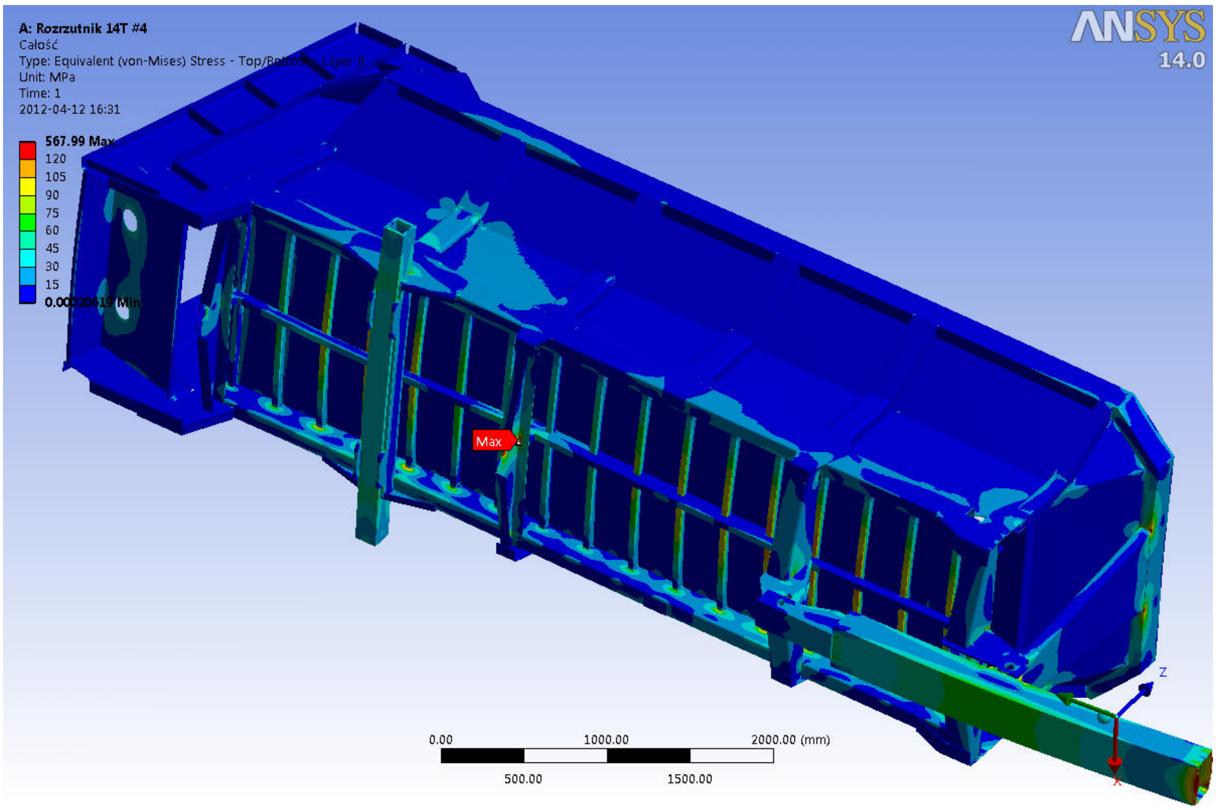

Fig. 5. Distribution of reduced stresses on spreader frame prior to modifications

It was noted that specified values of maximum stresses significantly exceed permitted stresses for the frame. Extreme stress identified with symbol Max in Fig. 5 is present in support of third horizontal beam, numbered in sequence from tow bar side. Also, exceeding of permitted stresses was noted on supports of remaining beams and on the very beams. In order to improve the condition of frame strength state modifications of elements, in which the highest stress was noted, were proposed. For the purpose of analyses the following were changed:

- supports of horizontal beams (Fig. 6, item 1). Their thickness was increased to 6mm. To 10 mm thickness of support located over third horizontal beam, numbered in sequence from tow bar side, was changed;
- first horizontal beam, numbered in sequence from tow bar side (Fig. 6, item 2). Thickness was increased to 8mm;
- second horizontal beam, numbered in sequence from tow bar side (Fig. 6, item 3). Thickness was increased to 7mm;
- third horizontal beam, numbered in sequence from tow bar side (Fig. 6, item 4). Thickness was increased to 9mm;
- main beam bottom(Fig. 6, item 5). Thickness was increased to 7mm;
- top front beam (Fig. 6, item 6). Thickness was increased to 7mm;
- front tow bar support (Fig. 6, item 7). Thickness was increased to 16mm.

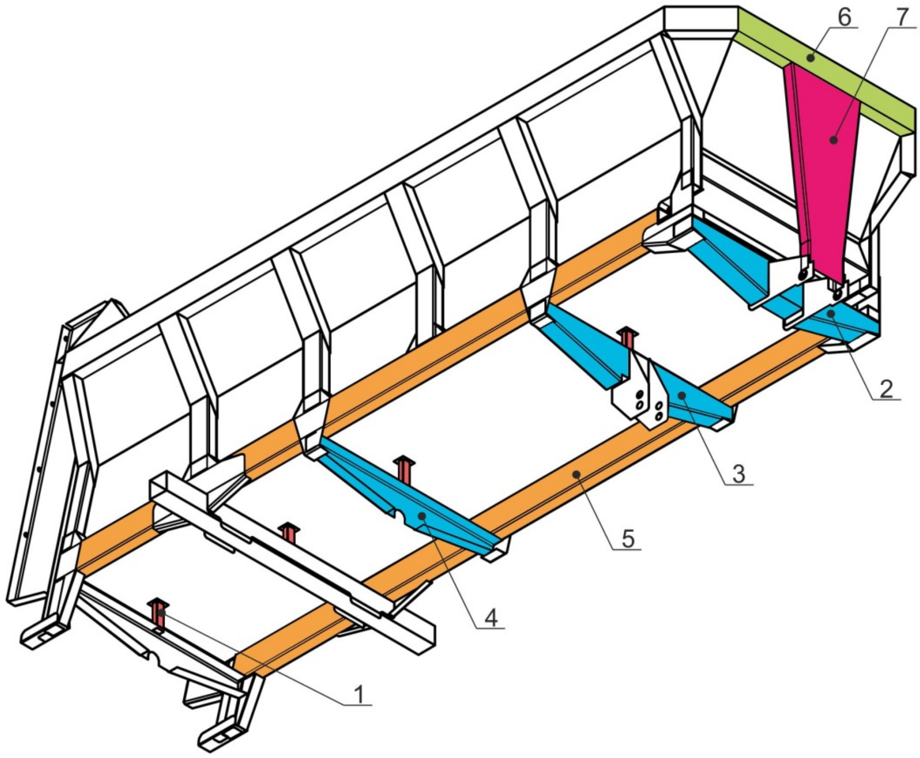

Fig. 6. Modified elements

After introduction of modifications of geometric form for unchanged bundary conditions, numerical analyses were repeated. Calculation results were presented in the form of distribution of stresses in frame in Fig. 7.

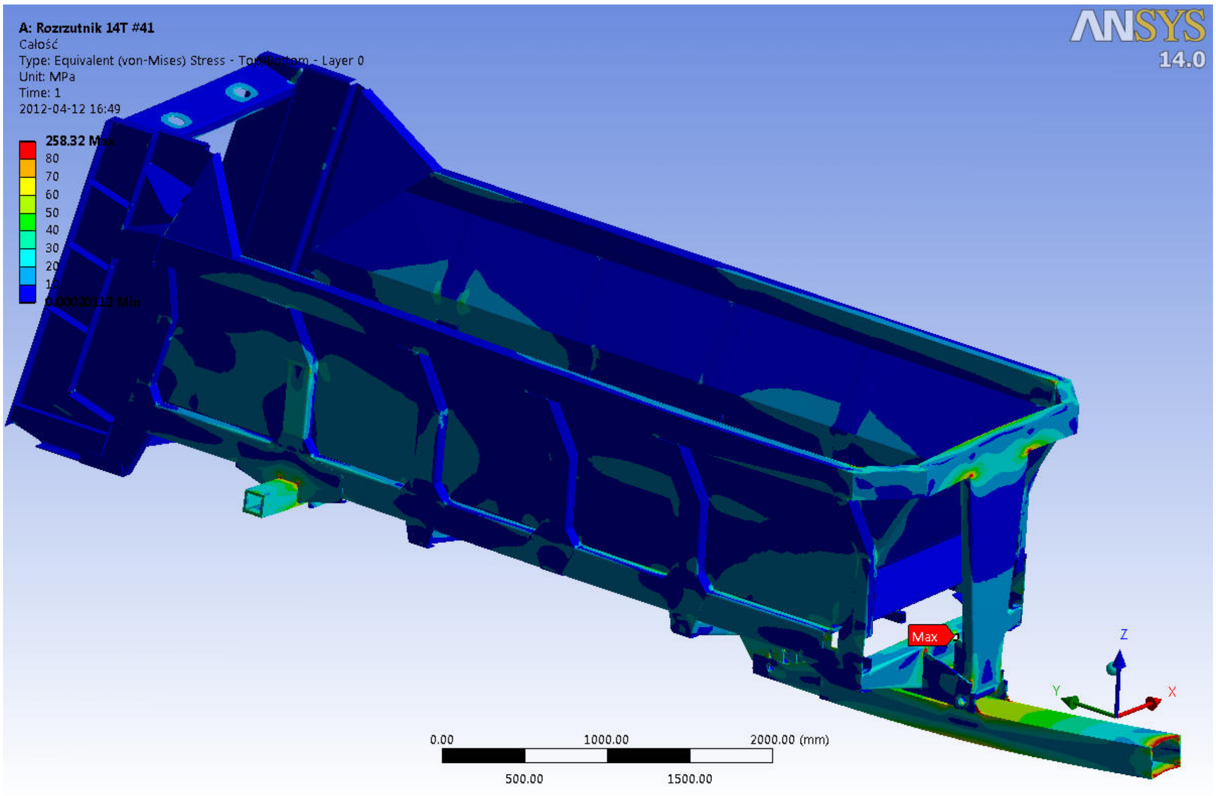

Fig. 7. Distribution of reduced stresses on spreader frame after modifications

5. Summary

The study presents conditions of conducting and results of numerical analyses of frame structure of a single axis manure spreader. After performing of calculations significant exceeding of values of permitted stress on horizontal beams and their supports were noted. Also exceeding of permitted stresses on main load bearing beam and on tow bar support and cooperating top front beam were stated. In order to reduce stresses on critical frame joints constructional modifications were proposed. Introduction of such modifications resulted in improvement of the construction strength state.

As a result of performed calculations information on stresses, which due to degree of construction complexity could not be determined analytically, was obtained. In order to verify correctness of performance of numerical analyses, in the scope of model preparation and estimation of boundary conditions, one should perform experimental verification of the construction e.g. by tensometric method at selected points of frame structure.

References

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