2013
51th conference on experimental stress analysis

# Evaluation of Operational Testing of Agricultural Trailer

ROMAN UHLÍŘ[1, a], PAVEL MOSSÓCZY[2,b] and PAVEL MALÝ [3,c]

[1] Czech Technical University in Prague – Faculty of Mechanical Engineering – Department of Designing and Machine Components, Technická 4, 16607 Praha 6, Czech Republic

[2] Czech Technical University in Prague – Faculty of Mechanical Engineering – Department of Designing and machine components, Technická 4, 16607 Praha 6, Czech Republic

[3] Czech Technical University in Prague – Faculty of Mechanical Engineering – Department of Design and Machine Components, Technická 4, 16607 Praha 6, Czech Republic

[a]roman.uhlir@fs.cvut.cz, [b]pavel.mossoczy@fs.cvut.cz, [c]pavel.maly@fs.cvut.cz

**Keywords:** Gauge, Welded Steel Frame, Transport Device, Towing Attachment.

**Abstract.** Article summarizes evaluation of operational testing of developed agricultural trailer. Measurement was made to determine operating load of trailer. Experiment was made in static and dynamic mode. Sensors were installed on front hitch and selected components of axle and frame of trailer. Furthermore, this report describes comparison of results of FEM analysis and experimental measurement.

## Introduction

Developed agricultural trailer serve to transportation of selected agricultural products. It is designed as self-loading transporter and it is independent of the operator. Main mechanical parts of trailer are: steel welded frame, front trailer hitch, hydraulic lifting mechanism and transport holders of cargo (Fig. 1). Effective weight of the trailer is about 4,600 kg.

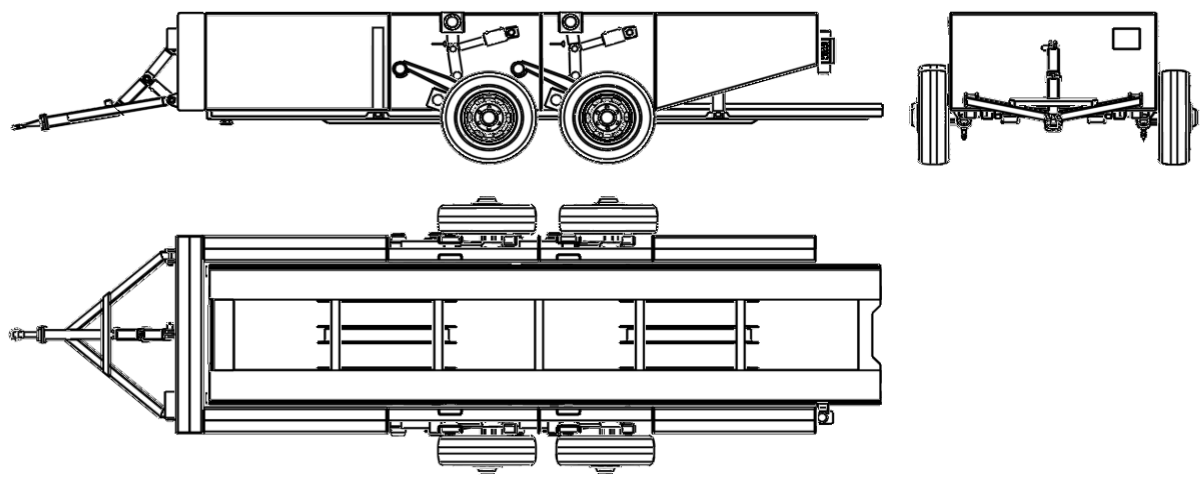

Fig. 1 – Developed agricultural self-loading trailer

## FEM Analysis

During trailer development some experiments and FEM analyses were performed. The main objects of interests were trailer frame and selected mechanical parts of lifting mechanism. Input values for setting of boundary conditions were captured from experimental measurement. Each part of trailer was described and force acting has been identified. Acting forces and resulting reactions on front trailer hitch are shown in Fig. 2.

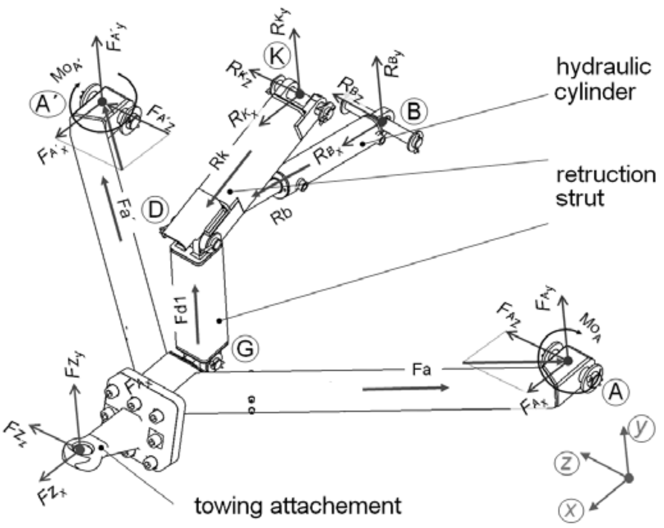


Fig. 2 – Application forces and reactions on trailer hitch

Other parts of trailer were described similarly (Fig. 3).

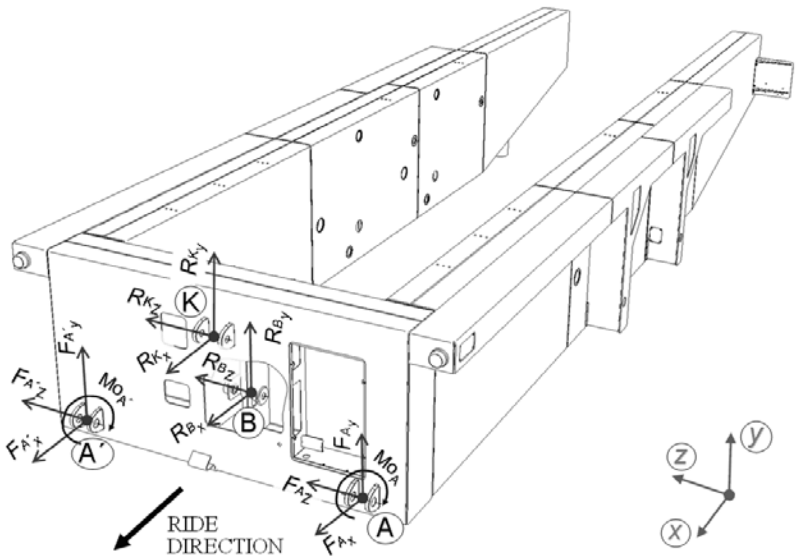


Fig. 3 – Applied reactions on part of trailer frame

FEM calculations were solved for many settings and for many modes of operation conditions. Selected boundary conditions reflected real conditions which had been detected during experiment. To achieve relevant results of calculation the precision and quality of mesh has been thoroughly adjusted (Fig. 4).

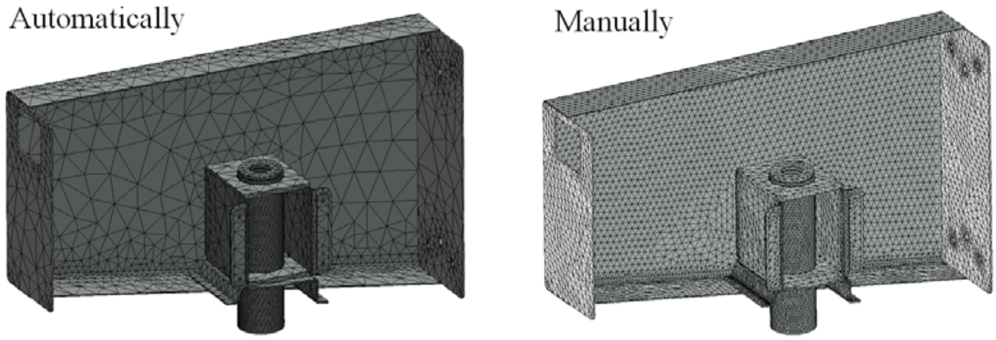


Fig. 4 – Automatically and manually generated mesh

Automatically generated mesh model consists of 33,804 elements and maximal dimension of elements is set up to 80 mm. Manually generated model structure consists of 94,597 elements with maximal element dimension of 15 mm.

## The Experiment

Operational tests were planned as static and dynamic. Static tests serve mainly for estimation of first group of operation conditions and for trailer mechanisms behavior. Static tests were performed repeatedly, before and after the completion the dynamic tests. Dynamic tests which simulated specified operational conditions were executed on two different test polygons. The first test polygon contained routes like flat straight road, left and right turns, steep ascent, steep descent and their combination. Testing on the second polygon was characterized by more intensive load and by higher speed of trailer with smaller turn radius of polygon. The results of experiment were load characteristic for various types of operational conditions. Areas with maximal and minimal tension were found. The most unfavourable operation condition was identified.

For overall design of tests and determination of boundary conditions on front hitch the special force sensor has been designed (Fig. 5). Sensor is able to measure in two axes and mounting of sensor is performed between towing attachment and its attachment flange.

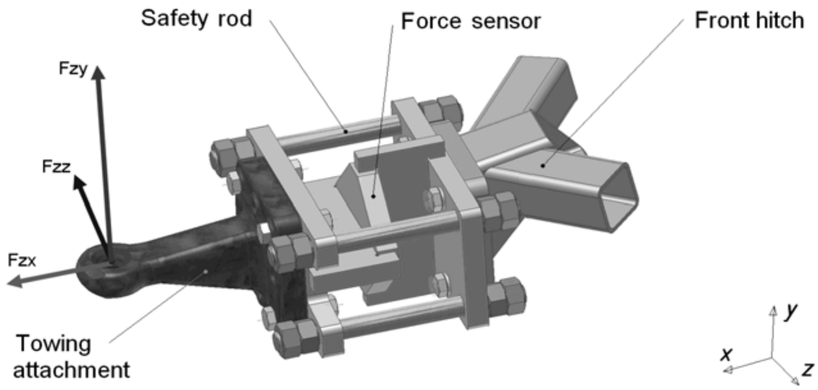


Fig. 5 – Force sensor

Both types of operational tests were performed at the areal of company, which manufactured the trailer prototype.

## Final Comparison of FEM Analysis and Experimental Measurement

FEM analysis and experimental measurement of selected parts of construction have brought nearly similar results with deviation about 20%. Comparison between two evaluation software is shown in Fig. 6 and results are shown in Table 1.

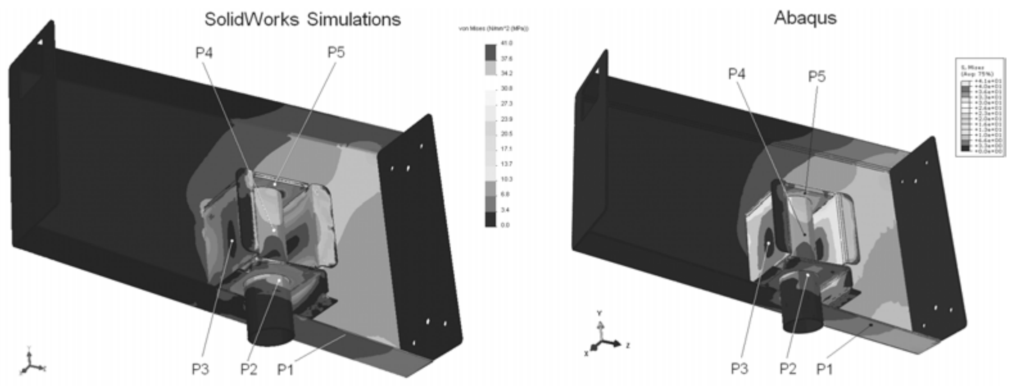


Fig. 6 – FEM analysis results

Table 1

| | | Range of tension at defined point [N.mm$^{-2}$] | | | | |
|---|---|---|---|---|---|---|
| **Software** | **Mesh quality** | **P1** | **P2** | **P3** | **P4** | **P5** |
| SW Simulations | standard | 5 ÷ 10 | 5 ÷ 10 | 0 ÷ 5 | 5 ÷ 10 | 15 ÷ 20 |
| SW Simulations | smooth | 6,8 ÷ 10,3 | 6,8 ÷ 10,3 | 0 ÷ 3,4 | 6,8 ÷ 10,3 | 17,1 ÷ 20,5 |
| Abaqus | smooth | 6,7 ÷ 10,0 | 3,3 ÷ 6,7 | 0 ÷ 3,3 | 6,7 ÷ 10,0 | 10,0 ÷ 13,3 |

## Summary

Experimental measurement and FEM analysis have brought large amount of data. Data are described like operation load spectra for different forms of load, working speeds, terrain characteristics, etc. Many types of agricultural trailers and their operation conditions and their loadings are similar like developed type of trailer, and reached results may be applied here. The next goal is to designate the method of service life prediction of those similarly designed trailers.

## Acknowledgement

This work has been supported by project MPO: FR-TI1/119.

## References

[1] Dynybyl, V., Češpíro, Z., Kanaval, J., Mossóczy, P., Výkonová metrologie - Experimentální podpora vývoje a inovací mechanismů ve strojírenství. (ČVUT, Praha, 2009). ISBN 978-80-01-04325-7.

[2] Uhlíř, R., Mossóczy, P., Petr, K., Malý, P., “Force sensor for front hitch of agricultural trailer”, International Mechanical Engineering Forum, 2011 (Prague), pp. 173-178. ISBN 978-80-213-2156-4.

[3] Uhlíř, R., Mossóczy, P., Petr, K., Malý, P., “Provozní zkoušky silového snímače”, Zborník 52. K KČaMS, 2011 (Ostrava), ISBN 978-80-248-2450-5.