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Dynamic Operational Testing of Agricultural Trailer

MOSSÓCZY Pavel[1,a], UHLÍŘ Roman[1,b] and MALÝ Pavel[1,c]

[1]Czech Technical University in Prague, Faculty of Mechanical Engineering, Department of Designing and Machine Components, Technická 4, 166 07 Praha 6, Czech Republic

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

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Abstract. This paper introduces a description of partial section of complex development of agricultural trailer. Paper is focused on performed experimental measurements. This part of measurement is named as dynamic operational testing. For this purpose, testing polygon was designed. Experimental measurements on this polygon have brought data about load spectra of selected components of developed trailer. Used methodology of testing may be used on similar cases with welded steel constructions.

Introduction

Due to insufficient number of special trailer on the Czech market in the field of agriculture and pomology, the cooperation with industry on the development of special agricultural trailer began. For the product acceptance of the trailer by the market, the using of unique system of loading was planned and designed. Manufacture of the real trailer prototype began after the completion of the virtual prototype model. After its completion the experimental testing of real prototype (see Fig. 1) and FEM analysis of virtual model were started.

Fig. 1. First manufactured prototype of developed trailer.

Then creation and manufacture of the second and third prototype models followed. Special series of agricultural trailer were developed and manufactured by this process. Creation and utilization of the methodology for comparison between FEM analysis and experimental measurements was the main key for the successful completion of this process.

Methodology of Testing

Analysis and summarization of real operating conditions of trailer was the first step in the applied methodology. These conditions were described in details and extreme conditions were found too. Operating conditions were compiled as combination of driving style, load size and type of used track terrain. On the base of the desired complete set of real operation conditions, the parts of the experiment have been planned. Two main groups of measurement that depended on the method of the operating load of the trailer were designed. Therefore static and dynamic tests were prepared. The described real operation conditions of the dynamic experimental testing were simulated on a prepared test polygon. Real values of operating load were expected.

Description of Test Polygon

Polygon for dynamic tests with his length of 369 m was divided into individual parts which were precisely identified and marked. Each section simulated unique conditions and operating load of trailer. It contained routes like flat straight road, left and right turns, steep ascent, steep descent and their combinations. Moreover two different barriers were arranged on this polygon (see Fig. 2). Turns with small and large radius were designed here.

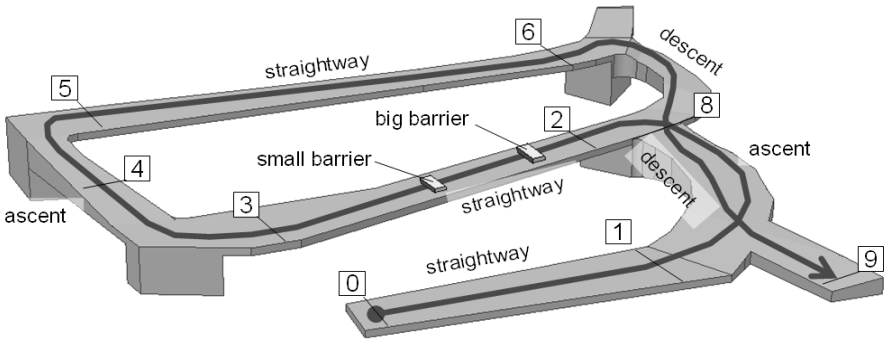

Fig. 2. Model of terrain characteristics of designed test polygon.

Testing on this polygon was intensive, but it respected the maximal construction speed of developed trailer. Maximal speed during experiment was determined on v = 5,56 m.s-1. Due to this limitation, nearly all parts of polygon were with no significant response. Crossing barriers had another effect. A small barrier with its height of 120 mm had a minimal effect to chassis behavior. But the second, 240 mm height big barrier caused extreme situation. Not all 4 wheels, but only 3 wheels were in contact with terrain (see Fig. 3 and Fig. 4). It caused extreme loading of chassis and frame of tested trailer, especially when fully loaded.

Fig. 3. Side view of big barrier crossing.

Fig. 4. Rear view of big barrier crossing.

Similar extreme situation appeared during crossing dividing line marked with point number 8 (see Fig. 2). Front wheel was extremely loaded, and in the same time, rear wheel was nearly fully unloaded.

Experimental Measurements

Modified software from the previous static measurements was used for collecting, archiving and data processing of measured signals. Measuring equipment was identical. Before the dynamic testing, reference values of mounted sensors were determined. These values have been used for adjusting offsets on the installed sensors. Strain gauges were mounted on the frame of trailer and on selected parts of chassis (leaf spring and semi-axle). But first, areas with the maximal and minimal tension were found with use of preliminary FEM analysis.

The dynamic tests experiment lasted for three days. Many test cycles with the same boundary conditions were done. Some cycles had to be repeated.

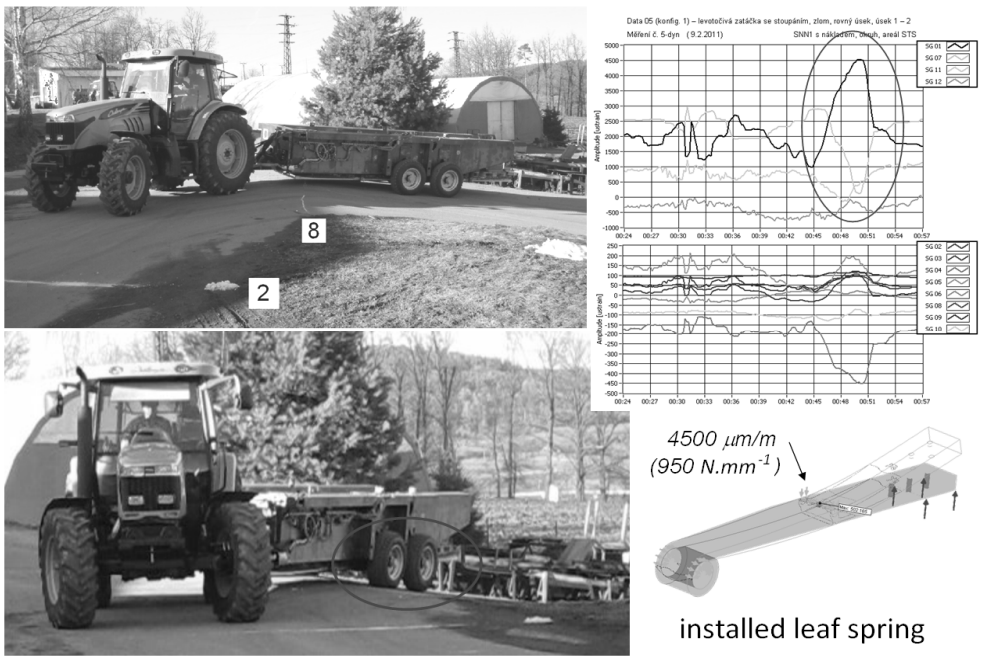

Fig. 5. Extreme situation - crossing of dividing line.

Processing and evaluating of measured data was performed in LabVIEW application with Real Time module. Used applications, which were unique, were programmed specially for described experiments.

Evaluation of Data and Comparison with FEM Analysis

Results from the dynamic experimental tests were compared with results of FEM analysis for corresponding operational conditions and loading. This FEM analysis and experimental measurement of selected parts of construction brought nearly similar results with deviation about 20%. Compliance of results of experimental tests and FEM analyses depends on the accuracy of experimental measurement, occurrence of random errors, accuracy of boundary condition definition, on the methodology of the experiment and many other factors.

Conclusions

All measured data were processed and spectra of loads for each measured part of trailer were drawn. Complex FEM analyses of selected components with the same marginal conditions as in the experiment were carried out. Both results were compared to each other and new improvements of construction of trailer were proposed. Therefore the used methodology with using test polygon was the right way to reach excellent results in development of special set of agricultural trailer. Many types of trailers and their operation conditions are similar like the developed and tested trailer, and reached results may be applied in the process of design of new components for such trailers.

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