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EXPERIMENTAL RESEARCH OF VIBRATIONAL PROPERTIES OF A SINGLE-AXLE TRAILER WHEN CROSSING AN INDIVIDUAL ROAD OBSTACLE

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Abstract: Investigation of road vehicles in term of their dynamics is very important task. There are assessed two main points of view, i.e. the driving safety and ride comfort for passenger. This article is aimed at analysis of dynamics of a single-axle trailer by means of real tests. Several driving manoeuvres have been performed and evaluated, at which, when a trailer has been towed by a passenger car. As the main output parameters, acceleration signals have been measured and recorded. The vehicle-trailer combination has been moved at several driving speeds.

KEYWORDS: A single-axle trailer, Road obstacle, Experiments, Vibrations.

1 Introduction

Trailers are currently an integral part of the daily life of humans. There are a large number of models to choose from with different configurations of individual components. By means of combining them, a suitable technical solution is created, satisfying the need for transporting loads with various dimensions and masses [1-4].

In particular, a chassis has a major influence on achieving required driving characteristics of a trailer. A chassis of a trailer ensures that the wheels are in a contact with a road and copies a road surface [5-9]. Moreover, a chassis through its individual components reacts to road surface irregularities and balances them in favour of safe driving [10-14]. A chassis is made up of several parts that work together in order to provide correct operation and favourable driving characteristics [15-18].

2 Road irregularities measurement

Irregularitirs and diverse road surfaces are major factors in stressing, wearing, and damaging a vehicle's chassis. For this reason, the overall effect of surfaces on the chassis and its parts is investigated. When measuring road irregularities, various parameters are determined, such as longitudinal profile of the road, rutting depth, cross slope of the road and others.

A comprehensive road surface quality assessment comprises several consecutive steps. After an initial visual inspection of the road surface condition, a suitably selected measuring device is subsequently employed in respect of the measuring parameters. Examples of available measuring equipment:

- CORRSYS DATRON DAS-3,
- Videocar,
- Profilograph GE,

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- Skiddometer BV11.

The DATRON DAS-3 sensors can be non-contact, such as a sensor for measuring speed and distance, or contact, such as the sensor for the force exerted on a brake pedal.

The Videocar system consists of a measuring vehicle, a camera, a length meter (odometer), an operation unit and software for controlling the device and evaluating the measured data.

The Profilograph GE measuring device is used to investigate and evaluate road irregularities. The principle of detecting and assessing road irregularities using this equipment is to scan longitudinal and transverse road surface profiles with laser sensors and to evaluate them with an operation unit. The equipment provides precise information on the condition of the road, its surface, and the unevenness in the course of measuring.

Measurement via the Skiddometer BV11 can be used to determine the coefficient of longitudinal skidding resistance (friction coefficient) on a given section, either local or average.

3 Measurement of accelerations on a single-axle trailer

The aim of the experimental part of this research has been to evaluate the accelerations acting on the axle of the trailer in all three axes, when the trailer crosses a road obstacle. The measurements were carried out in the campus of the University of Žilina, specifically on a parking place. The measurement introduced in this work was performed by means of the CORRSYS DATRON DAS-3 measuring chain. The dynamic changes of the vehicle along with the trailer in the course of passing over the obstacle were scrutinised. The road obstacle has been simulated by means of a wooden plate with the width of 25 mm.

The measurements have been performed on a vehicle-trailer combination, while the trailer was the main object under examination.

3.1 A vehicle-trailer combination

The experimental vehicle-trailer combination has been composed of a Suzuki Vitara passenger car and a Pongratz LPA trailer (Fig. 1). This figure also depicts basic dimensional parameters of the experimental vehicle-trailer combination.

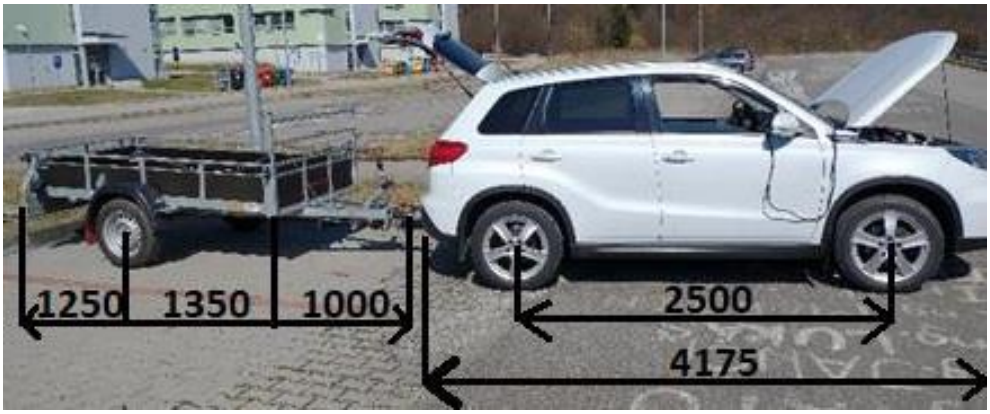


Fig. 1 Maxwell model. Figure (Times New Roman 12)

A Microstar Non-Contact 1-Axis Microwave Sensor and A CORRSYS-DATRON Pedal Force Sensor have been connected to the vehicle. The vehicle was equipped with a pedal force measurement unit, a central measuring unit and a display unit. The TAA-3206M4 sensor was mounted on the trailer through a bracket.

3.2 A vehicle-trailer combination

The DATRON DAS-3 system allows to measure and record quantities such as speed, distance, acceleration, measurement time, pressure, force and various other quantities. The system is made up of sensors, a control and display unit, a power supply, cables, a central measuring unit and a storage medium.

A sampling rate in the measurements carried out for the purpose of this work was 200 Hz. The sensors of the system can be digital, analogue, CAN (input from diagnostic port in vehicle). The DATRON DAS-3 measuring chain is depicted in Fig. 2.

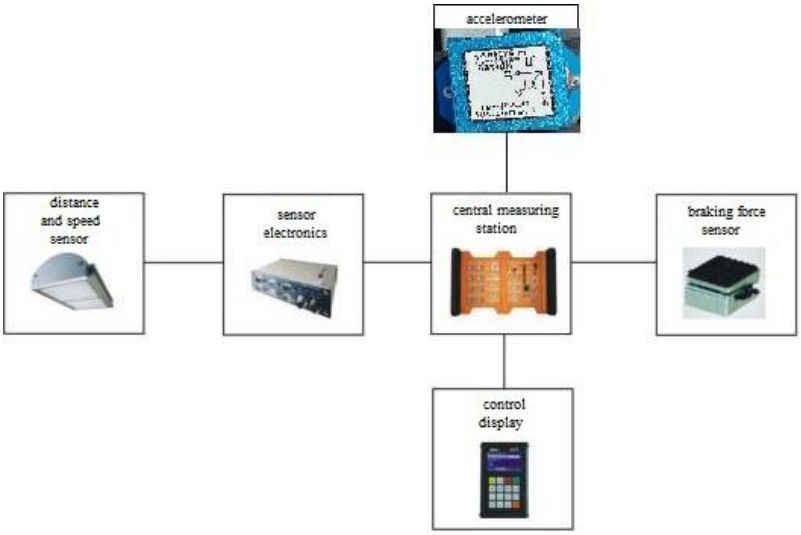


Fig. 2 DATRON DAS-3 measuring chain

In terms of measuring, it is essential to set adequate start and stop conditions of the measurement. Inasmuch as this system is capable of measuring and recording multiple quantities and parameters, different start and stop measurement conditions can also be a factor affecting the accuracy of the measurement.

4 Findings and results of experiments

A series of measurements were performed in order to scrutinise how the trailer behaves when passing through an individual road obstacle. The change in accelerations in the direction of the x, y, z axes and the forces acting on the wheel at the moment of its impact to the obstacle were observed. The trailer was partially sprung. In addition, the tyres acted as an additional damping element. Inasmuch as all measurements were carried out with the trailer unloaded, it was discovered that the trailer behaved as considerably stiff due to its load carrying capacity and its tare mass.

Measurements were performed at speeds of 10 km/h, 20 km/h, 30 km/h and 40 km/h. The following part of the paper involves the specification and interpretation of the measurement results from various ways of passing the vehicle-trailer combination over the obstacle at the speed of 10 km/h (passing by the right side and both sides of the system at the same time, respectively).

4.1 Measurement of a passage of the right side of the vehicle-trailer combination over an obstacle, 10 km/h)

Figures 3-5 show the acceleration curves depending on the distance at a speed of 10 km/h.

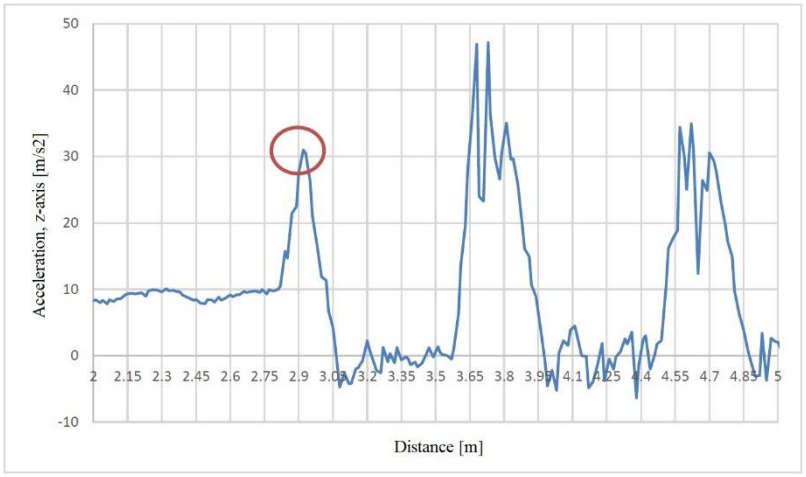


Fig. 3 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the right side, z-axis

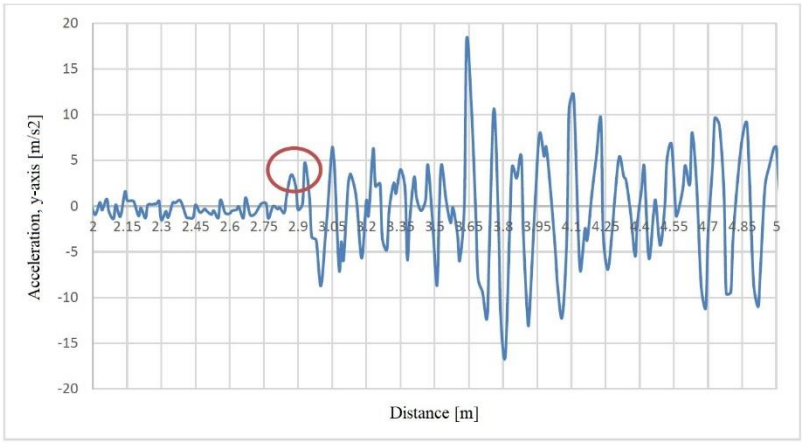


Fig. 4 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the right side, y-axis

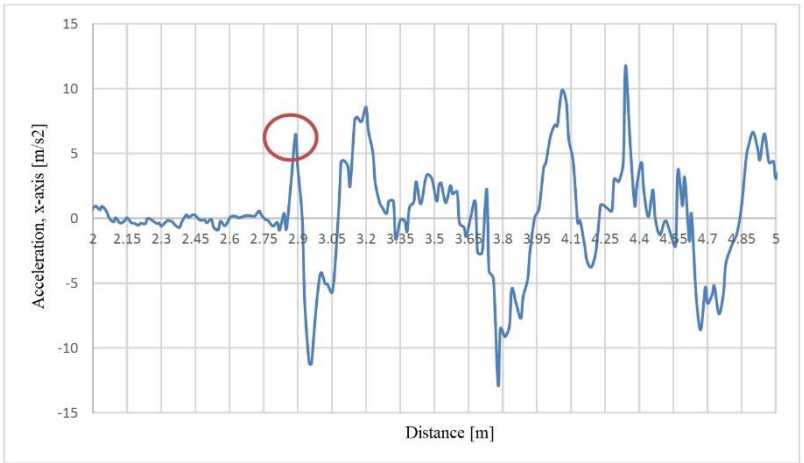


Fig. 5 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the right side, x-axis

Because of the three-axial acceleration sensor was placed only on the right side of the trailer, i.e. on the side of the passing over the obstacle, the recorded values from this measurement can be considered as best reflecting the condition at the point above the trailer axle. In terms of the graphs, the red circle indicates the acceleration value caused by the wheel striking the obstacle.

The peak shows the passage over the obstacle, thus as the vehicle towing the trailer. Further, the first negative curve demonstrates the process of the trolley trying to push into the vehicle. This course is repeated for another few metres until the trailer is balanced.

4.2 Measurement of a passage of the entire trailer over an obstacle, 10 km/h

The individual courses of accelerations as a function of the distance during the passage of the entire trailer can be seen in Figs. 6-8.

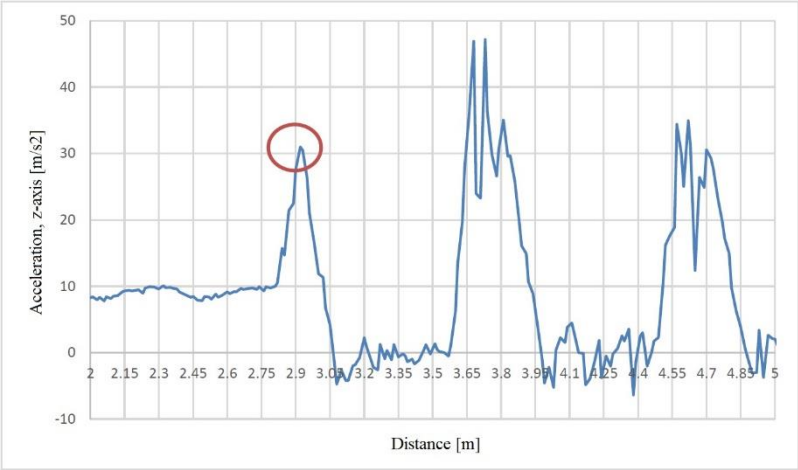


Fig. 6 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the entire trailer, z-axis

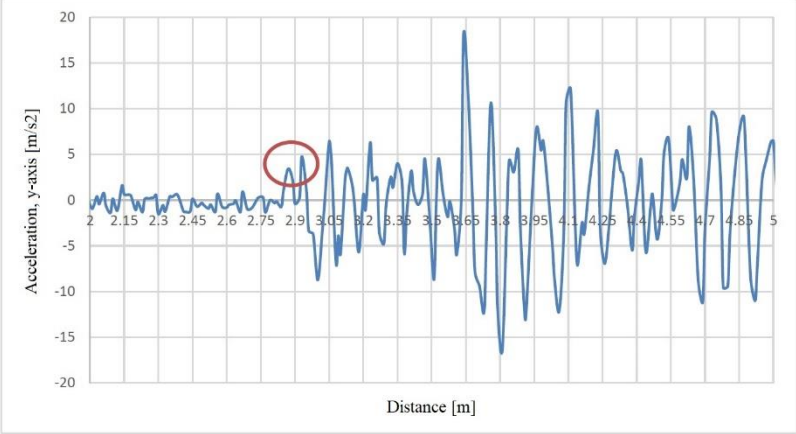


Fig. 7 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the entire trailer, y-axis

It clearly emerges from the graphical representation of the passage of both sides of the vehicle-trailer system that the hit to the obstacle occurs at a distance of 2.8 metres. Likewise to the passage of the right side of the vehicle-trailer combination, the trailer flies after the impact. After a distance of 0.5 metres, the trailer falls and then bounces, which is reflected in the largest amplitude on the graph with a value of 47.15 m/s^2. It can be assumed that both wheels hit the obstacle at the same time.

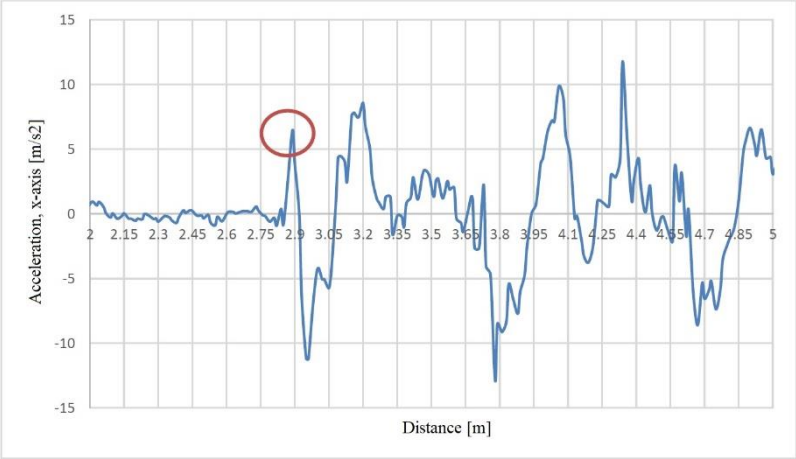


Fig. 8 A waveform of acceleration when the vehicle-trailer combination passes the road obstacle by the entire trailer, x-axis



Fig. 9 A trailer flying after hitting an obstacle

CONCLUSION

The paper set out to scrutinise the behaviour of the chassis of the trailer when passing over simulated obstacle, comparison of measured values and their graphical representation. During the measurements, the dynamic effects on the trailer induced by different ways of passing the vehicle-trailer combination over the unevenness were monitored. From the measured data and their graphical representations, it can be seen how the distance travelled changes after hitting the obstacle in addition to the accelerations and the applied forces. The most important changes were observed in the direction of the z and y axes.

The results of the individual measurements demonstrate that in none of the measurements did the system reach the highest acceleration values at the moment of the wheel impact on the obstacle, however only at the subsequent bounce of the trailer from the road. For the sake of elasticity, the system oscillates during flight. After rebound, the bounce occurs, which results in a higher acceleration. Ultimately, the vehicle begins to stabilise.

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