MOBILE STAND FOR TESTING VEHICLE DYNAMICS

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Summary

The research on vehicle dynamics contributes significantly to the development of the automotive industry. It has been conducted for many years by various research centres which use their own or commercial research stands. Purchasing a commercial mobile stand offered on the market is a serious financial problem. Additionally, it does not always give possibilities to measure all relevant parameters. Therefore, there was developed an own solution of such a device which is the subject of this publication. The paper presents a structure solution of only one of the modules constituting a mobile stand for testing the dynamics of a vehicle movement. The described module is a head used for measuring the steering angle and angular velocity of a wheel. It is an original, non-applied solution which allows to measure the actual steering angle of a vehicle. The advantage of the presented solution is that a simple design allows for a quick assembly and disassembly of the device in any vehicle by only one person. The stand was made at the Department of Vehicles and Fundamentals of Machine Design at the Technical University of Lodz. The attempts of assembly of the stand and tests on various passenger cars proved its practicality and possibilities of achieving the assumed research on the dynamics of vehicle movement.

Keywords: vehicle, vehicle dynamics research, measuring devices

1. Introduction

The research on the dynamics of vehicles is a crucial issue connected with a general understanding of the automotive development. Examinations of this kind have been carried out for years in research and development centers, either independent ones or those which are one of departments of automotive companies. The research equipment used in such tests is either an own device of a given laboratory or a commercial product manufactured by companies specialized in providing research software and hardware

The equipment used most often in testing the dynamics of vehicles are products of the following companies: Kistler (previously – Corrsys-Datron), Adma, Motec, Optimumg and Cybid. The equipment used to monitor, for example, the performance of an engine was not mentioned here.

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The products of the above-mentioned manufacturers, in particular sets of equipment for measuring the dynamics of vehicle movement, are not usually able to meet all expectations raised by a researcher of particular phenomena. Whereas, introducing individual applications upon client's request is either impossible or increases the costs considerably. Thus, using a many years' experience of the Institute of Vehicles, and later the Department of Vehicles and Fundamentals of Machine Design, in conducting research on measuring various dynamic parameters of vehicle movement, there was made a decision to build an own mobile device for measuring the dynamics of vehicle movement.

2. General concept of the solution

Taking into consideration chosen aspects of vehicle movement and depending on the acquired research experience, there were defined fundamental assumptions for building the measuring device. It was assumed that the device will be:

- mobile – which means it will be possible to transport the whole set to the selected place of research without any problem,
- adjusted to be mounted on any passenger car without any interference in a car's structure,
- constructed in a way that allows to measure the following physical quantities: linear velocity of a vehicle, longitudinal/transverse/vertical acceleration, angles of rotation around the longitudinal/transverse/vertical axle of a vehicle, angular velocity of all road wheels, turning angles of all road wheels, turning angle of a steering wheel, pressure force for the brake pedal, rotational speed of a combustion engine and the position of the accelerator pedal.

The general assumptions, which were made for building the device, allowed for elaborating on a detailed construction solution. The object of this article is one of the modules constituting the device. The module will be used for measuring the angular velocity and turning angle of a road wheel.

The testing research that has been carried out so far in a considerable distance from the seat of the research center led us to make the assumption that the module should be the same for each road wheel, even though the majority of potential vehicles (on which the research can be conducted) do not have turning wheels of the rear axle. In this case, just one additional replacement module is sufficient. It could be used for any wheel when the module mounted on a vehicle is damaged.

3. Structure of the module

The made assumption regarding a possibility to use the measuring equipment for any passenger car required to use appropriate software in the design phase - the software which

allows to develop the structure together with the kinetics of the device's performance. The software offered by Dassault Systemes CATIA V5 R20 was chosen for this purpose. Using the above software for works helped to accelerate the process of developing the design and building a prototype. The results of this part of works is shown in the following figures. They illustrate the appearance and different working positions of the device mounted on a vehicle.

In the Figure 1, there are presented three views of the front left vehicle wheel fitted with the device - in the case when a road wheel is in the straight position. This position was taken as a design position, i.e. an initial position. The net of white curves in the figure shows the contour of the external skin of a vehicle.

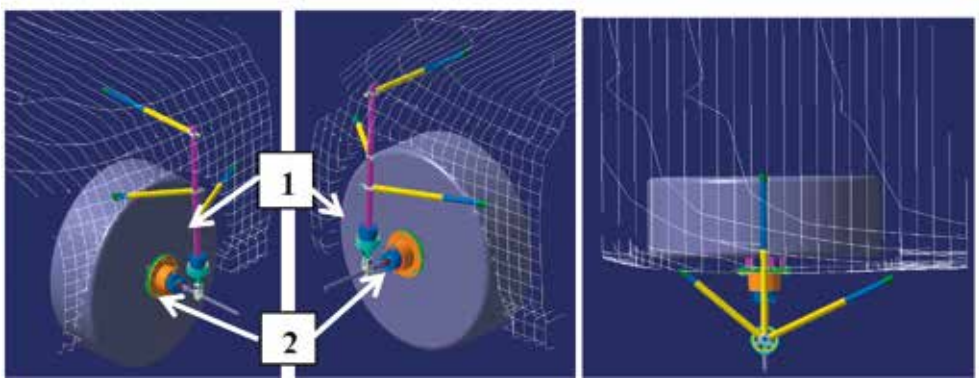

Fig. 1. The front left wheel fitted with a device, in the straight position

The presented module consists of two components marked as 1 and 2 in the Figure 1. The first component (1) is connected with a bodywork of a vehicle by means of suction cups through arms with a regulated length. Additionally, it has a built-in steering angle sensor (Fig. 2a) which allows for the measurement of the steering angle of a road wheel. The second component (2) is connected with a road wheel. There were used clamp connectors to join the components. The connectors are mounted on heads of the bolts securing a wheel. This solution allows for quick installment of this component in a car. Additionally, a specially designed shield will enable positioning of the above-mentioned connectors at each wheelbase and a number of bolts. In the module, there is built-in an angular velocity sensor (Fig. 2b). That is why the component allows for measuring the angular velocity of a road wheel.

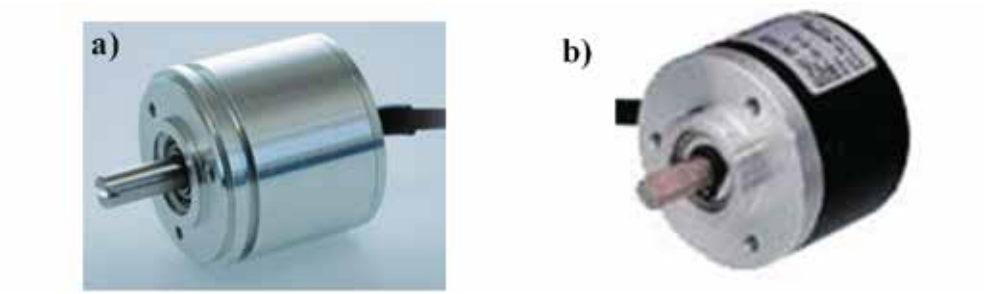

Fig. 2. Sensors used in the device
a) the steering angle sensor – Winkel series MAB36A, b) angular velocity sensor – Wobit series MOK40

In the Figure 3, there are presented three views of the front left vehicle wheel fitted with the device – in the left position.

While in the Figure 4, there is presented the view of the front left vehicle wheel fitted with the device – in the case of loaded suspension.

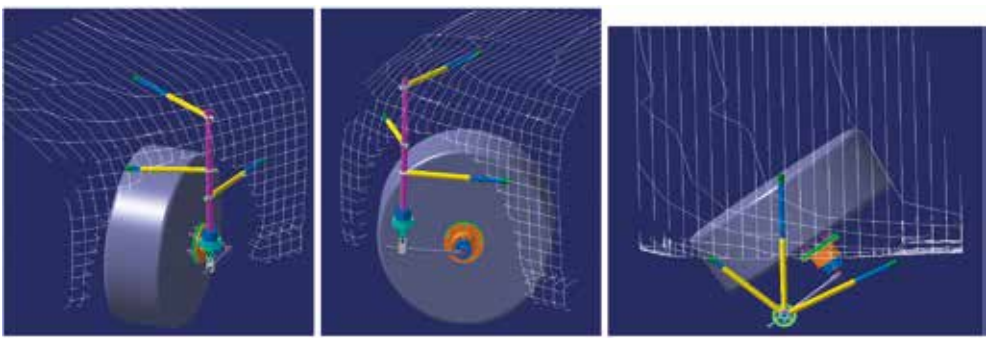

Fig. 3. The front left wheel fitted with a device, in the left position

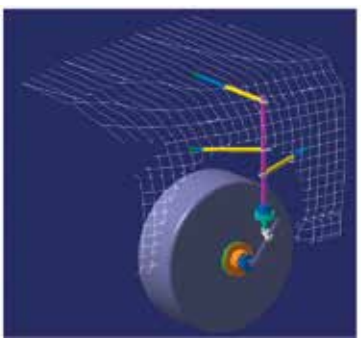

Fig. 4. The front left wheel fitted with a device, in the case of loaded suspension

The vertical roughness of the road appearing in actual conditions cause the displacement of the suspended mass in relation to the masses which are not suspended. It was taken into consideration in the developed device that the displacement in both directions can reach 130 mm. The above values were defined on the basis of the measurements of a group of real passenger cars. Despite the above, we expect that the research tests will be carried out on such surfaces and in such conditions that so high values of suspension deflections will not be reached.

A characteristic feature of the designed and build device is lack of linear dependence between the actual turning angle of a wheel and the measured turn of the component 1 fitted with a steering angle sensor. Moreover, this dependence will be different for particular vehicles, which results from various solutions of their suspensions and possibilities of mounting a device on a vehicle. Thus, every time before starting the tests, it will be necessary to determine the characteristics of nonlinearities and maintain the same conditions of installing the device on a vehicle during the tests. In order to facilitate these actions, there were manufactured two identical turntables with steering angle sensors. The appearance of one of them is shown in the Fig. 5.

Fig. 5. The device used to determine the characteristics of the nonlinearities

Exemplary characteristics of the dependence of the head's turning angle on the steering angle of a wheel (achieved when modeling the stand) can be seen in the Fig. 6.

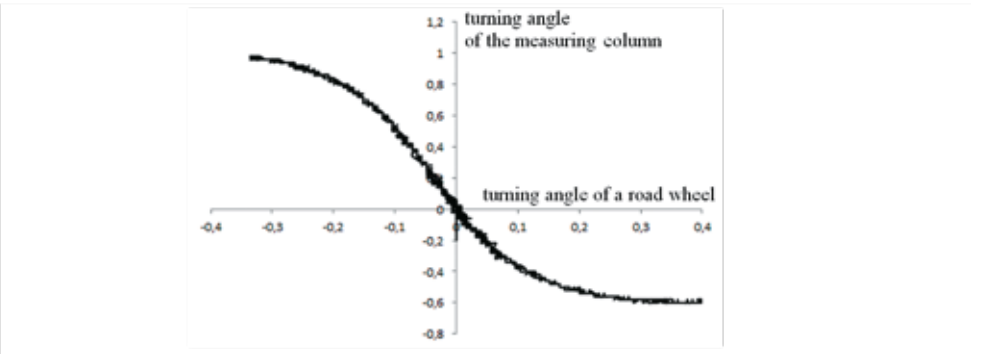

Fig. 6. Characteristic of wheel steering angle in function of the measured angle. Graph axes scaled in units of voltage

Based on the prepared documentation, there was built a prototype. Later on there was built a target solution of the measuring module when the mass reduction had been done. The following photographs present the way of installing the final device on a vehicle in different positions of a road wheel.

Fig. 7. View of the device mounted on a real car

4. Conclusions

The presented solution for the device measuring the angular velocity of a road wheel and its steering angle is a basic module of the mobile stand for testing vehicle dynamics. It must be stressed that a numerous installation of this device on various cars showed that the installation can be done by a single person in a short period of time. Thus, it should be assumed that the device may be an advantageous alternative to expensive commercial solutions. First measurement tests that were carried out, using all described modules of the device, showed correctness and practicality of the proposed solution. It is a very good sign of making use of the developed device in various commissioned tests, students' laboratory tests and scientific research.

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