Equipment and Methods Used for Evaluation of Vehicle's Systems Vibrations on Rough Terrain

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Abstract. Whatever the purpose of research in the automotive area, a decisive role in obtaining relevant and compelling data on research is given by the test equipment, the data acquisition, and methods chosen for their achievement. Mechanical vibrations, especially those arising upon reading this of trails highly rough, in which amplitudes are of very high or are perceived for long periods of time, causes the serious damage to the human body: biological, mechanical and psychical. Obtaining accurate data concerning vibrations and shocks products in an area of rough terrain, as well as understanding thereof, it creates the possibility of establishing new technological approaches which to lead in reduce injuries caused by them on the human body.

Keywords: vibrations, data acquisition.

1 Introduction

Multiple researches on the influence of mechanical vibrations generated by the road surface and the suspended structures of vehicle that act on the human body, have demonstrated the importance of knowledge as accurate of their manifestations [1].

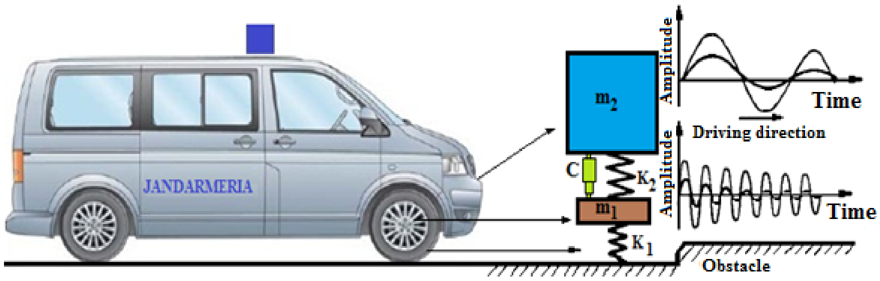

Fig. 1. The depreciation's influence over the suspended and unsuspended masses [2]

Research objectives are related to the selection and use of some equipment and programs according to the research activities proposed to be conducted. The intended purpose of the research is to obtain real and cogent data on the vibration values that affect the human body during high speed travel on rugged terrain.

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In Fig.1 is presented the theory of operation of a vibration damper on a vehicle. As a result of approach to some rough trails, the equipment must allow to obtain real values of existing vibration, for the sprung (suspended) and unsprung masses of the vehicle.

2 Equipment used for acquiring the data on rugged terrain

The equipment chosen for the research was carefully selected, in order to serve as much as possible to purposed scope [3, 4]. Also, its installation was carried out in accordance with the specific needs of research, so that it can record data about the conformation of the route followed, the accelerations induced by route and the vibration transmitted to the seat and driver. Fig. 2 illustrates the general layout of the seats and data acquisition equipment (orange markings), installed on the test vehicle - VW T4.

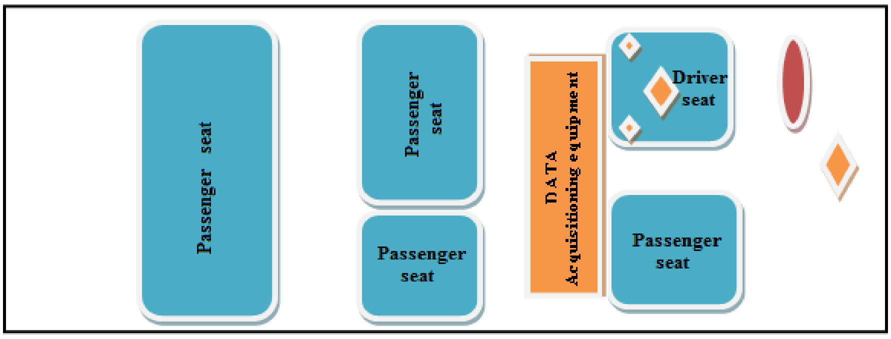

Fig. 2. Location of seats and equipment in the vehicle

Fig. 3. GPS antennas and their position on the vehicle's roof

The equipment used in experiment is described below:

- To identify the vehicle position and to register the track it was used a "SpeedBox" system produced by Race-Technology - the system consists in a GPS reception with two antennas, an inertial measurement unit and a data processing module. Fig. 3 shows the mounting position of the Speedbox unit on the vehicle roof. Speedbox is used also to determine the vehicle attitude, measuring the pitch, yaw and roll rates of the vehicle.

- Two GPS receiver are installed in front and rear of vehicle roof, as a backup solution for Speedbox (type DL-10 [5]) which provides a PVT solution (position, velocity, time).

Fig. 4. PicDAQ - Inertial Measurement Unit

- The accelerations on three axes are measured with PicDAQ systems mounted in front of vehicle and also on the floor, approximately in the vehicle's center. These units are supplemented with another complementary accelerations measurement unit, named Loka [5] (Fig. 4, Fig. 5).

Fig. 5. PicDAQ, DL-10 and Loka units mounted on vehicle's floor

- To obtain the values of vibrations transmitted to the seat structure and the driver of the vehicle, there were used sensors of type 4504 A mounted on the seat frame structure and a type 4447 sensor positioned on the surface of the chair seat (Fig. 6).

Fig. 6. Installation of vibration sensors type 4504 and 4447

In any travel regime and also on any type of road, the displacement of vehicle is accompanied by the appearance of vibration and shocks. The unevenness of the track creates shocks on the wheels, which are converted into oscillations at different frequencies by means of the tires and suspension. It is subsequently transmitted to the frame of the vehicle and from there to seats and passengers.

3 Methods for vibration evaluation

During off-road driving, the speed varies according to the slope, steering angle, existing weather conditions, so that multiple oscillations with different frequencies and amplitudes are perceived.

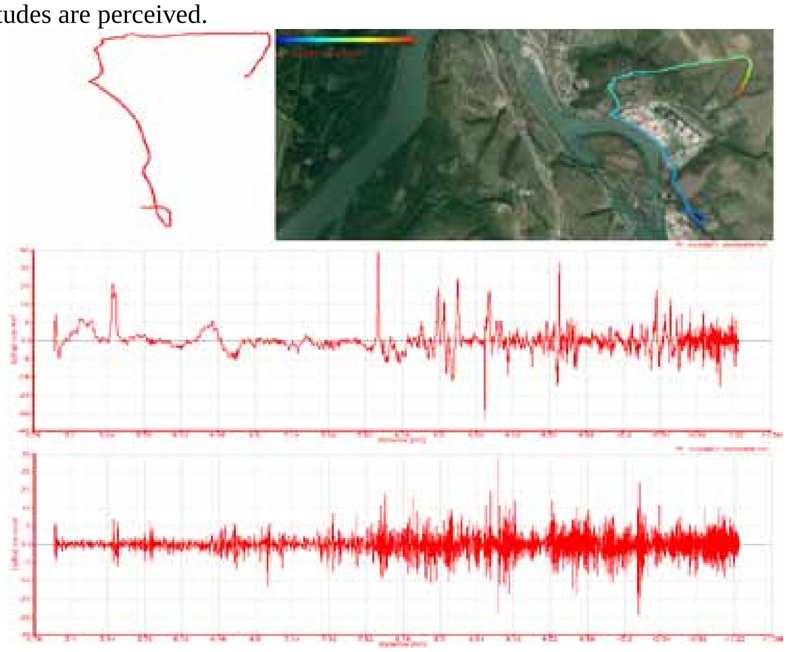

Fig. 7. The analyzed route and vertical profile of the track, measured with Speedbox

The route analyzed in the study followed a road with pronounced rough sectors (Fig. 7). Data received from the GPS antennas allow the correct identification of the route followed during driving and those received from the tri-axial accelerometers have identified the characteristics of the land. Fig. 7 shows the route taken and also data related to the variations of terrain characteristics (yaw, pitch) [6].

In Fig. 8 it can be observed the level variation of the terrain along the whole length of the route, recorded using the GPS system.

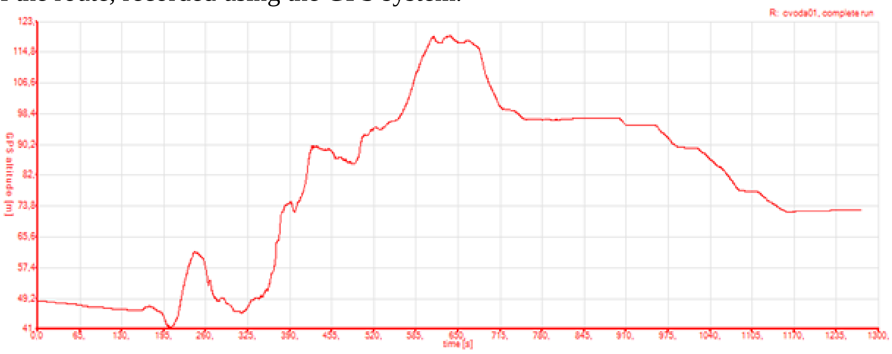

Fig. 8. The variations of elevation in terrain, recorded via GPS receivers

Fig. 9 shows the high values of vertical accelerations vs. the vehicle's speed, measured on the entire length of the route.

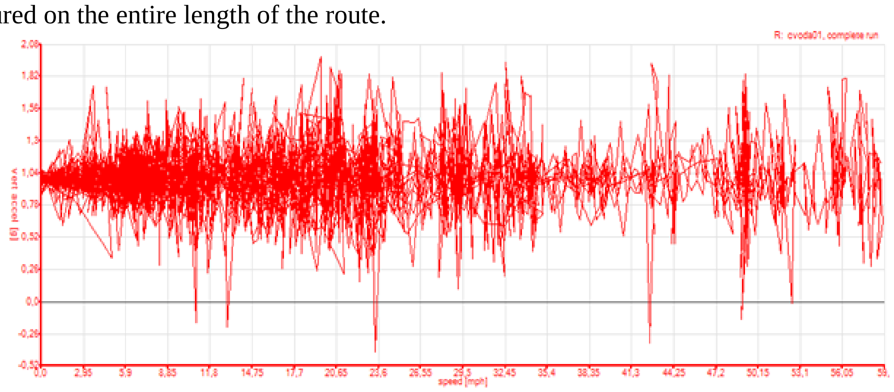

Fig. 9. The values of vertical accelerations, as a function of vehicle speed (Speedbox)

The information related to the position and speed of the vehicle is collected using the GPS based data acquisition system, DL-10, installed in front and rear of the vehicle roof. Data recorded consist in NMEA sequences, stored in in text files on a SD-card. The standard NMEA 0183 provides the requirements for the electrical signal and data transmission protocol, on a serial data bus, between the GPS receiver and another device.

The DL-10 system uses a single type of NMEA sequence: "GPRMC". This sequence contains a minimum data, PVT (position, velocity, time) recommended for determining the solution, based on the received GPS signal. A sample of the received sequences is given below:

```
$GPRMC,095145.100,A,4420.0085,N,02804.0713,E,0.00,327.15,
130516,,,D*60
```

Table 1. GPRMC fields

Field	Description
$GPRMC	The identifier
095145.100	Time (hour, minute, second, milliseconds)
A	Active signal
4420.0085,N	Latitude, North
02804.0713,E	Longitude, East
0.00	Speed in knots
327.15	Course (direction of travel) in degrees, relative to North
130516	Registration date
D*60	Checksum

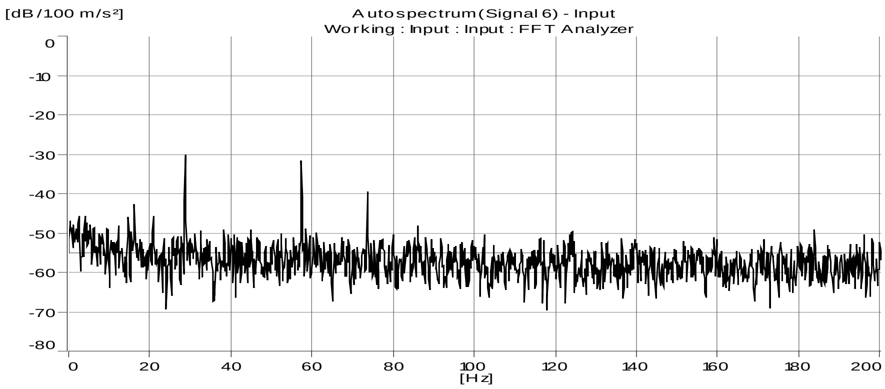

Fig. 10. Sample of the signal measured on *z* axis, on the driver's seat

In order to determine the existing vibrations on the driver's seat and also to find the values transmitted to the driver’s body, when driving in rugged terrain, there were used two piezoelectric tri-axial vibration sensors, type 4504-A, mounted on the metal structure of the seat, and a sensor for measurement the vibration transmitted to the human body, type 4447, installed on the seat, under the driver.

Both products are manufactured by Brüel & Kjær.

A sample of data recorded using the sensor 4447 is shown in Fig. 10. As a result of driving the vehicle in rugged terrain, using the carefully selected equipment, there were obtained relevant data for the research.

Thus, it was observed a concordance of data measured by the various equipment used and also the accuracy of the information recorded. Under imposed conditions of travel, it was identified a very wide frequency range of oscillations with different amplitudes, presenting dangerous levels for the human body.

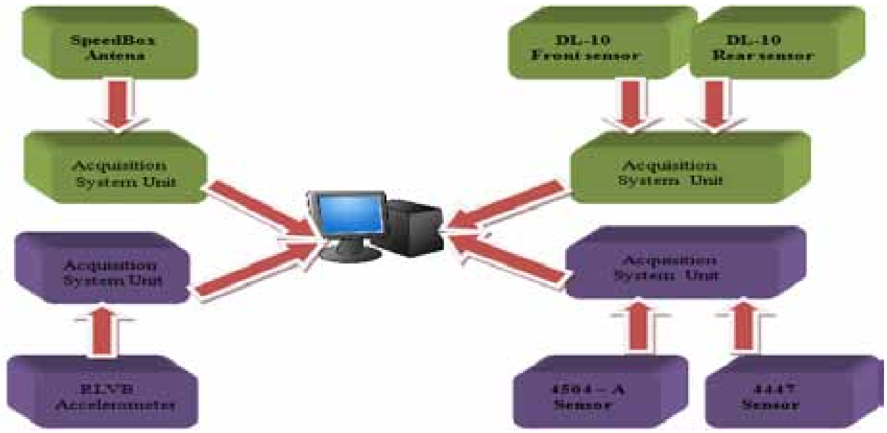

Fig. 11. The block diagram of data acquisition process

Fig. 11 shows the block diagram of the data acquisition process, following the authors' configuration.

4 Conclusion

The relevance of the research is given by a number of factors, with major importance for the method to approach the analysis of vibration measured on the vehicle structure and also on the passengers, when traveling in rough terrain.

As conclusions, it can be stated that:

- the use of appropriate equipment for the research purpose facilitates the achievement of accurate and real data from field;
- by using equipment based on GPS receivers, it can be obtained a significant correlations between the different devices used for data acquisition - a common time base;
- choice of the right method for installing the equipment that collect the signals at the structure level of the vehicle, makes it possible the achievement of necessary data;
- choice of well-developed programs offers the possibility to achieve the tests and subsequent processing of the received data;
- continuous development of electronic equipment, miniaturization and increase in performances, their opportunities for interoperability, creates great advantages to researchers in all areas of the automotive related fields;

- linking a large number of equipment makes it possible to obtain data as accurate as possible on the pursued phenomena.

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