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Kinematic Values of Impacted Object

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Abstract: Acceleration sensors are used by destructive car tests for the determination of a time courses of kinematic variables. The main task is to determine the velocity of measured points of selected objects. The fundamental problem in the solution of this problem is the fact that the acceleration sensor simultaneously record two mechanical movements. One of them is the movement of the object as a rigid body and the other is damped vibration of the object itself as a flexible body which is characterized by its dynamic parameters.

Keywords: Crash Testing; Shock; Vibration; Measurement of Kinematic Values.

1 Introduction

Measured accelerations during destructive tests of vehicles are associated with two movements of the object. While the first one has relatively small amplitudes of low frequency components, the second is characterized by high frequencies and thus extreme acceleration amplitudes. The first movement of an object can be, in terms of its mechanical nature, understood as macro-movement and the other as micro-movement. One is superimposed on the other. The macro-movement of an object may be considered as a movement of a rigid body. The micro-movement of an object can be taken as the movement of a continuum. Fundamental differences in the both movements and their shock character bring problems in their further mathematical processing to obtain velocity.

2 Measurement on the Impact Test Equipment

The mechanical impact of two objects was realized on the test equipment to eliminate random effects and achieve a high degree of measuring results repeatability. For measurement of acceleration at impact were subsequently selected three variants. The first one was a classical connection of the sensor with the followed object with help of the paste. The second one consisted in a high-frequency mechanical isolation of the acceleration sensor and the impacted object. In the third case, the movement was scant by speed camera. The results obtained are described below and confront each other. Finally the measurement results by classical sensor connection were under get to Wavelet analysis.

The main goal was to separate searched kinematic variables of macro-movement from kinematic variables of micro-movement whose participation in the measured acceleration signal in this sense is parasitic. Using the test equipment for detecting kinematic variables of the impacted object under mechanical shock were considered three methods of measurement and subsequent evaluation to obtaining time response of speed just after impact.

2.1 Product Crash Test

In order to ensure repeatability of the measurement was used a jig (Fig. 1) for detecting kinematic variables of the impacted object during mechanical shock. They were evaluated three methods of measurement and followed by evaluation with a view to obtaining the time course speed just after the impact.

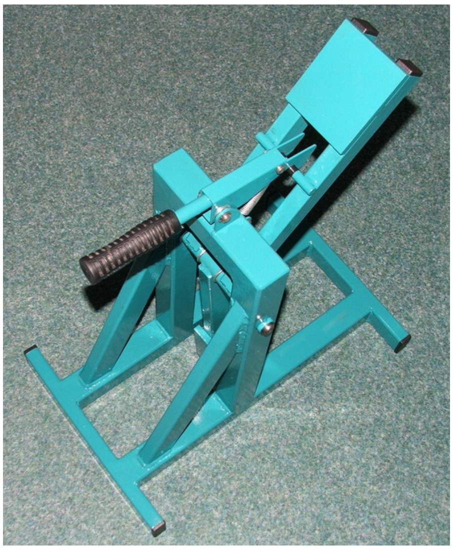

Fig. 1: Jig for the implementation of mechanical shock.

2.2 Measurement Results and Their Integration

Measurement results of acceleration, their integrations and velocities, are shown in the following Fig. 1. In the first column there are acceleration and velocity of the measured object in the case when the sensor is connected to it with paste. Here it is to see that the acceleration has very high amplitudes with high frequencies. This behavior belongs in the first place to the micro-movement. The integration is in this case difficult and incorrect because the velocity is continuing to increase (Fig. 2).

In the second column the connection of the sensor to the object is flexible and created with help of elastic material conformable to a foam rubber. Here the amplitudes of the acceleration are smaller and have lower frequencies. This behavior belongs in the first place to the macro-movement. The integration is not so difficult and the velocity corresponds to reality (Fig. 3).

In the third column there is shown the data record from the speed camera with the scanning frequency 5 Hz. The results are real and can be used for verification of measured and calculated values of the object velocity after the impact (Fig. 4).

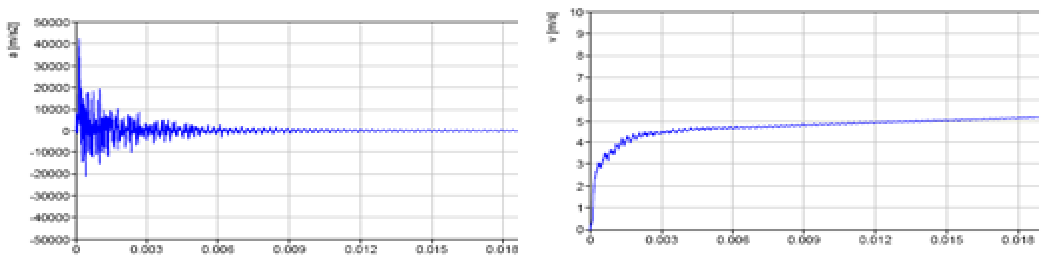

Fig. 2: Time function of acceleration and velocity of the object after the impact - classical connection of the sensor.

2.3 Measured Data Evaluation

With help of the sensor measured data of acceleration and following their integration there is possible to gain the following knowledge and context:

Measurement of the acceleration carried out with relatively rigid connection of the sensor to the object can contain errors that lead to wrong results after integration when we search for the velocity value. The influence of the micro-movement is very strong.

When we use a flexible connection between the sensor and the impacted object, the influence of the micro-movement is eliminated, the amplitudes and frequencies of the acceleration decrease and the parasitic signal disappears.

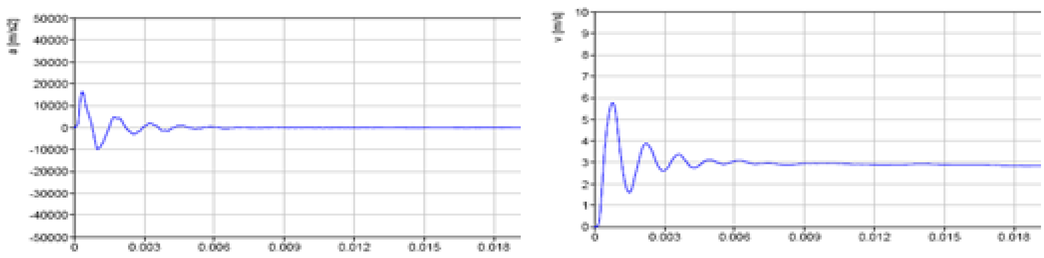

Fig. 3: Time function of acceleration and velocity of the object after the impact - connection of the sensor with high frequency isolation.

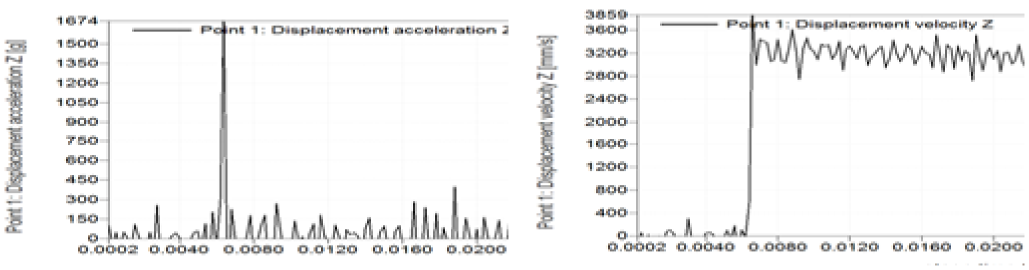

Fig. 4: Time function of acceleration and velocity of the object after the impact - data record from the speed camera.

The values of the velocity are very close to the values measured by the speed camera when the flexibility of the connection between the sensor and the impacted object is high enough.

Wavelet analysis of the measured signal with the positive direction oriented downwards axis acceleration was conducted at the measurement of kinematic quantities after impact with differing degrees of flexibility binding acceleration sensor and the measurement object. This method demonstrates the legitimacy of its use and on its basis can come to the following conclusions:

If the measured signal sensor with rigid bond to the measured object eliminates wavelet transform dramatically acceleration the relevant micro-motion and leaves the first component very close its character signals obtained from the sensors with sufficiently pliable bond sensors to the test object.

If the measured signal sensor with elastic bond to the measured object is the first component of a series of wavelet functions very similar its character to the measured signal.

Results of application of the wavelet transform to the signal of measurement in a certain degree of flexibility binding of the sensor and the object are shown in Fig. 5. It turns out that the measured signal which contains minimal parasitic component is transformed to a signal almost identical and the other components have zero integrals.

3 Conclusion

The sensors have to be mounted to the impacted object by a flexible connection. In this case the micro-movement of the object surface will be not transported on the sensor and the results of the acceleration measurement are correct.

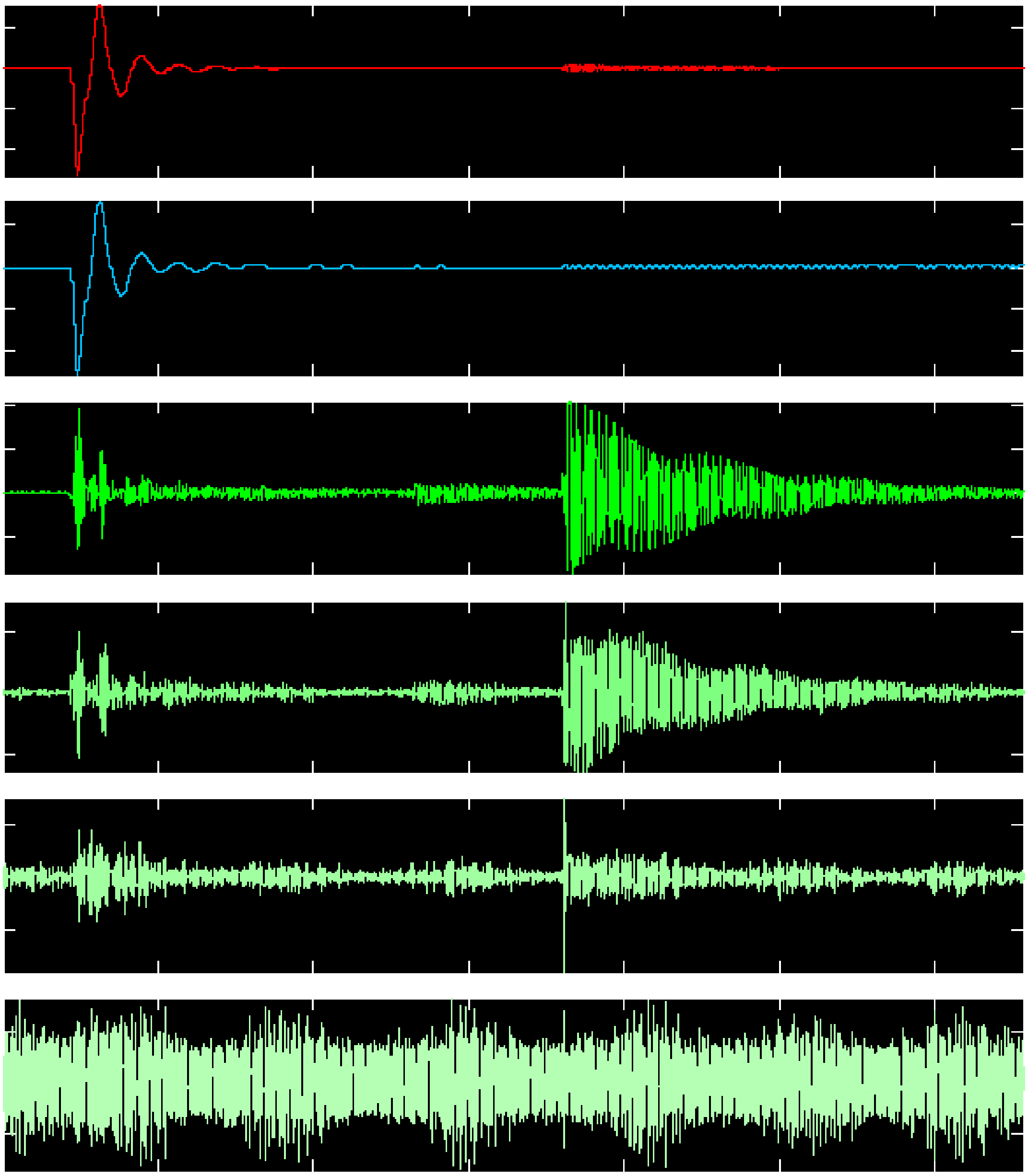

Fig. 5: Wavelet analysis for measuring sensor signals with a flexible bond to the measured object.

References

[1] SAE J211/1 (1995), Surface Vehicle Recommended Practice, (R) Instrumentation for Impact Test – Part 1 – Electronic Instrumentation, Revision March.

[2] SAE J211/1 (2003), Surface Vehicle Recommended Practice, (R) Instrumentation for Impact Test – Part 1 – Electronic Instrumentation, Revision December.

[3] Vehicle Safety Workgroup, (2006), Crash Analysis Criteria Version 2, Arbeitskreis Messdatenverabeitung Fahrzeugsicherheit, October 2006.