EXPERIMENTAL ANALYSIS OF SHOCK INFLUENCE PARAMETERS ON PENDULUM TESTING RIG

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Abstract: *In this paper the results of the investigation of the influence of mass drop height, elastic (stiffness) characteristics of cylindrical shock simulator (programator), and preloaded spring elements on the horizontal platform, on the shock pulse paramators are presented. In order to obtain a shock pulse with specific acceleration form, amplitude and duration, shock experimental investigation was conducted on a pendulum testing rig. For this purpose series of shock measurements were performed using piezoelectric and inductive accelerometers placed on the platform to measure the horizontal acceleration. The results of the investigation are presented in form of tables and diagrams of investigated shock pulse parameters.*

Keywords: SHOCK SIMULATOR; SHOCK PULSE; SHOCK MACHINE

1. Introduction

The shock and vibrostability testing are becoming more and more a necessary stage in the modern day design.

There are a large number of elements of different structures used in the various branches of the industry, for which performing of the shock tests in order to verify their functionality and durability is a necessity. These are, above all, different types of shock transducers, accelerometers, and a better part of the electronic equipment for various purposes, firearms equipment, and special pneumatic and hydraulic equipment, equipment for motor and railroad vehicles.

Generally, the procedures, norms or standards for testing became more complex and strict as the position of an element or an assembly has a higher degree of responsibility.

The norms and the standards as well as the testing procedures are prescribed with a number of both national and international documents.

This issue is treated and is regulated by numerous regulations and guidelines in the armies of all major countries, and national agencies for space flight and research. For example, NASA has published three standards and two manuals relating to test procedures for impact and vibration.

2. Description of the pendulum tesing rig

Shock testing machines (commonly called shock machines) are mechanical devices that provide mechanical shock on the equipment being tested. Shock machines have one common characteristic, which is to produce short lasting shocks and cause significantly large inertial forces to the products that are being tested. The shock test machine must be able to reproduce shock movements with high precision in order to ensure the comparative assessment of the equipment.

The answer to a simple system can be expressed as a function of the relative displacement, velocity and acceleration of the system. Usually the responses expressed through the velocities and acceleration are obtained as $2\pi f$ and $(2\pi f)^2$ times relative displacement, where f is frequency expressed in hertz. The corresponding curves of responses are called range of shock responses of displacement, velocity or acceleration

The figure of the small shock machine that the tests were conducted on is given below (Figure 1). It is a simplified version of a well-known shock machines, has a significantly smaller total mass and a pendulum (hammer) with a small mass. It serves the purpose is testing the functionality and reliability of the elements of the braking system of railroad vehicles.

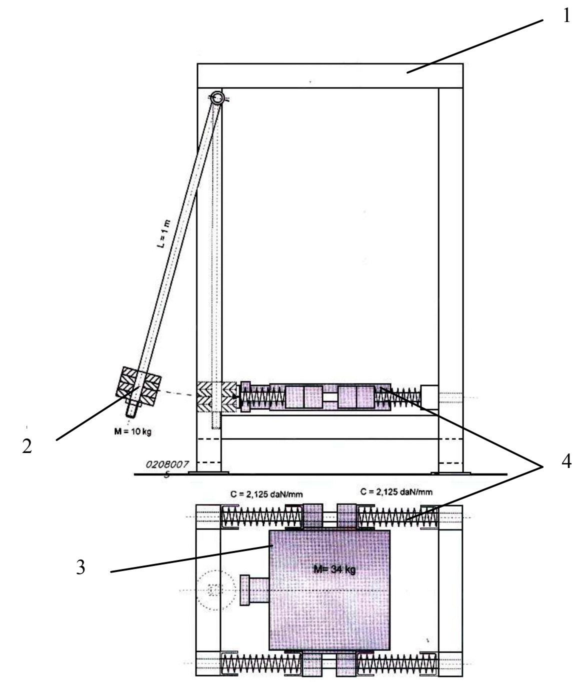

Fig. 1 *An existing solution of a shock testing machine*

The existing solution of the shock testing machine for railroad vehicles is consisted:

1. Support frame,
2. Pendulum (hammer) with mass m = 10 kg and a length of the length of the arm 1 m,
3. A testing platform for the element with a mass of M = 34 kg,
4. Four springs with stiffness c = 2,125 daN/mm.

3. Used measurement equipment

During the experimental research a wide range of measurement equipment was used in order to ensure the accuracy of the obtained results. A Hottinger B – 12 inductive transducer and three types of piezoelectric transducers were also used during the experimental research process. The measurement equipment used is listed below:

- A B&K 2515 vibration and impact process analyzer with a 4370 piezoelectric transducer.
- A Microlog CMVA60 (product of SKF) vibration and impact processes analyzer with a CMSS2200 S/N S2803 piezoelectric transducer.
- A SPIDER 8 (product of HBM) with parallel monitoring of the measured data from an inductive transducer and AC210-1A piezoelectric transducer, product of CTC.

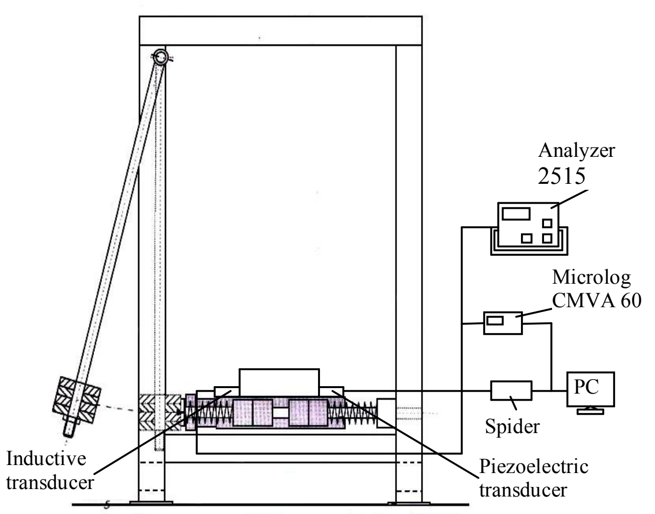

Fig. 2 Used measurement equipment

The final measurements were conducted with a Spider 8 (product of HBM) measurement instrument and the CATMAN 4.0 software.

4. Results of the conducted tests

The preliminary test had shown no significant difference of the shock parameters (A- intensity и τ- duration) depending on if the shock is metal-to-metal, metal-to-plastics, metal-to-wood) etc. This conclusion is supported with the fact that the most commonly used shock simulation machines use different types of elastic plates, but most commonly rubber elements with the common name – programmers [1] and [2].

In order to successfully conduct the experimental test, a series of programmers made of rubber-metal combination was manufactured. In the manufacturing process, two types of rubber with different diameters and thickness were used, providing the opportunity to change the stiffness and the damping.

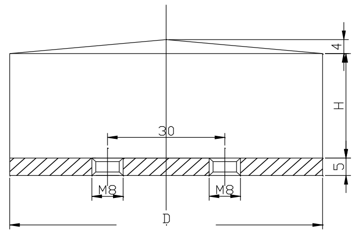

Fig. 3 Shock simulator – programator

In the course of the conducting of the experimental tests, four parameters that have a significant shock on the amplitude and the width of the shock, were changed:

X- Initial force in the spring of the platform (I - 17 daN; II - 34 daN; III - 68 daN),

Y- programator type (1 - H=14 mm, 2 - H=19 mm, 3 - H=24 mm, 4 - H=40 mm, A-soft rubber, B-hard rubber),

Z- Height (angle) of drop of the hammer (1 - 10^o; 2 - 20^o; 3 - 30^o),

W- mass of the hammer (1-basic mass).

Based on the results of the tests, an analysis on the influence of the different parameters of the system (programator type, height of drop, stiffness of the platform, mass of the hammer etc.) on the amplitude and the duration of the shock was performed. A part of the analysis is graphically displayed on the graphs (figure 4 to figure 9).

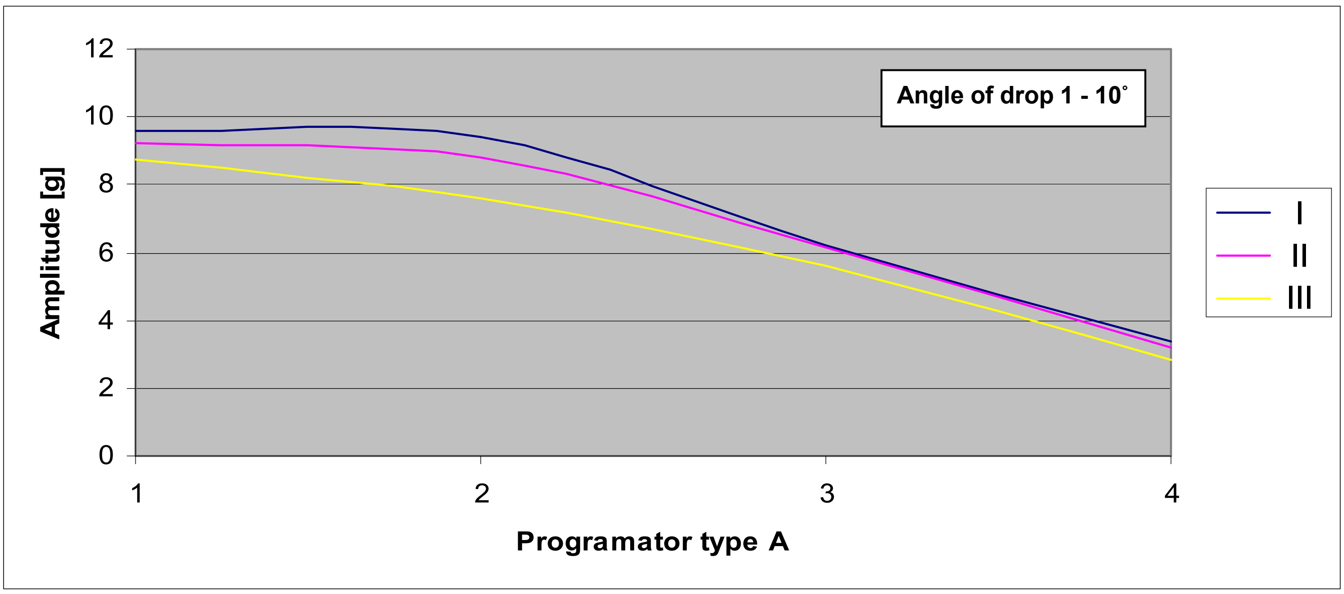

Fig.4 Influence of Initial force and angle of drop on amplitude

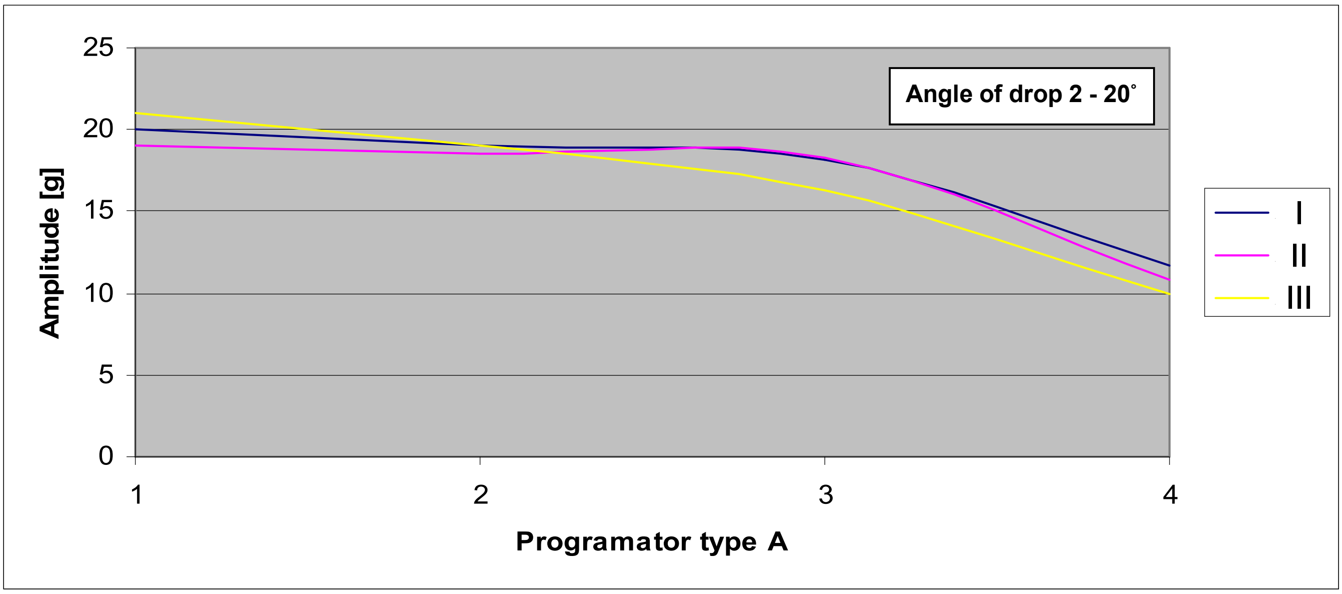

Fig. 5 Influence of Initial force and angle of drop on amplitude

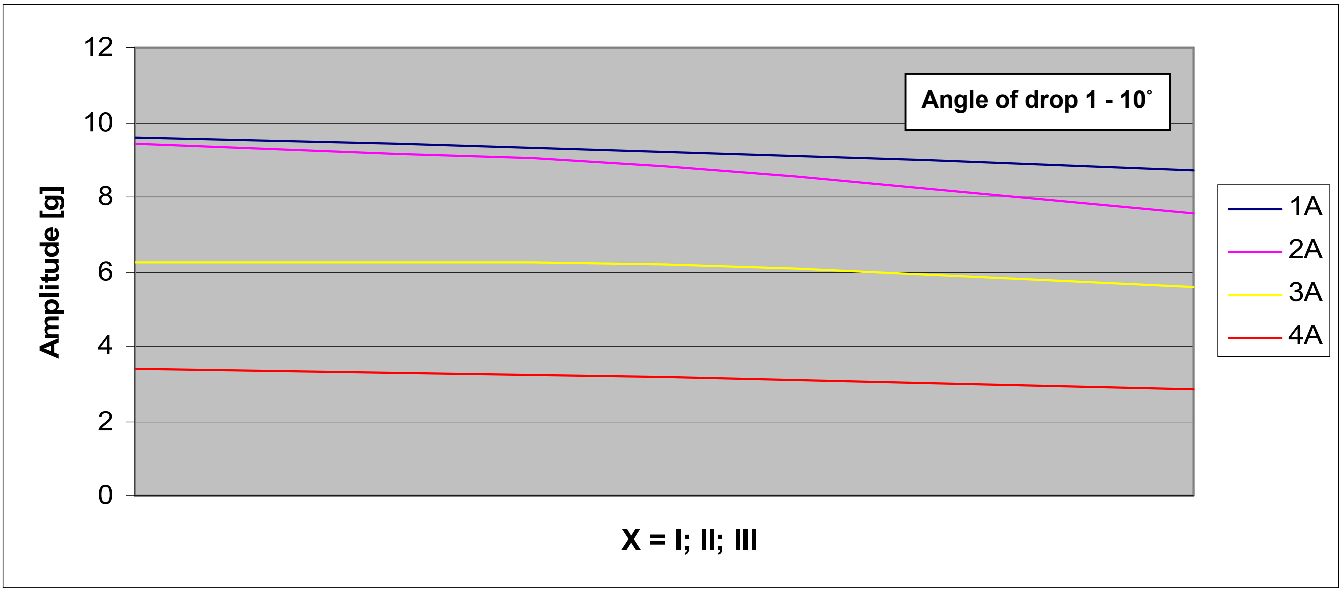

Fig. 6 Influence of programator, Initial force and angle of drop on amplitude

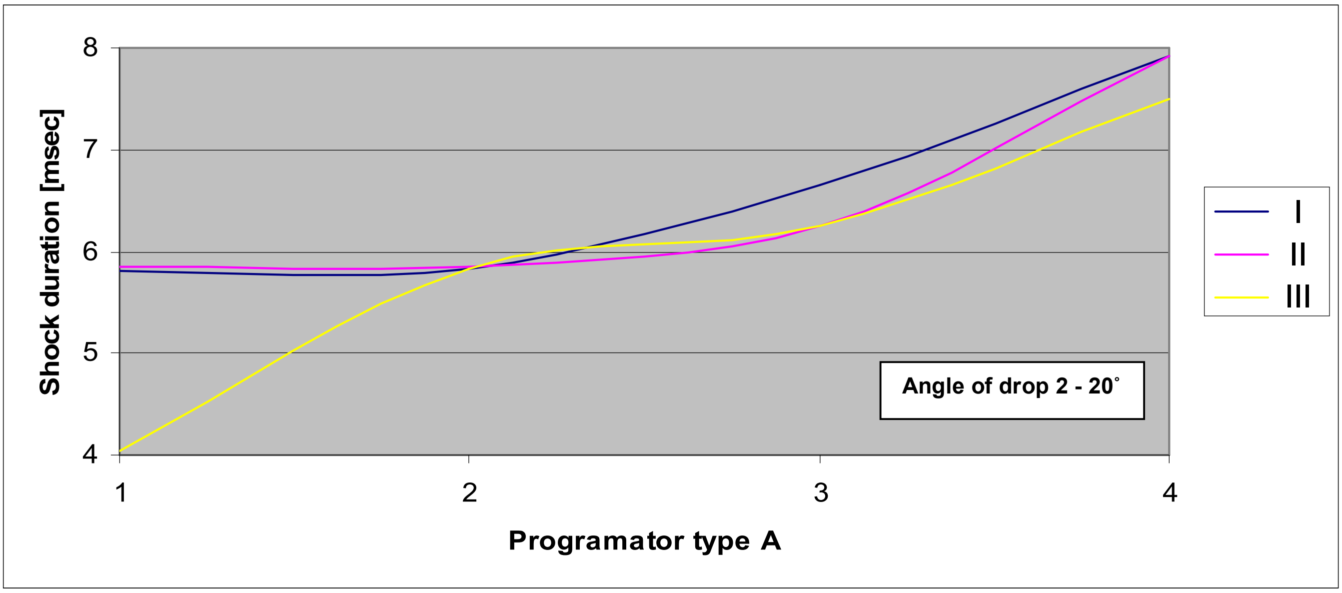

Fig. 7 Impulse duration changing for programator A, different initial force and angle of drop 1

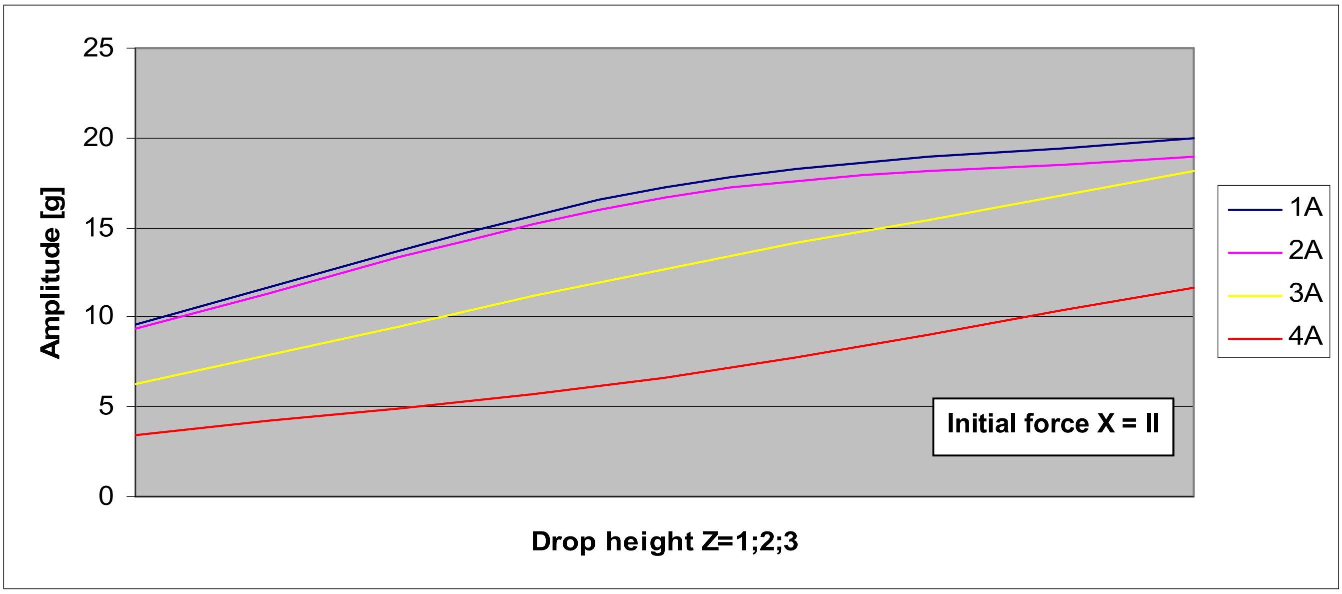

Fig. 8 Impulse amplitude changing for different programators, angle of drop and initial force II

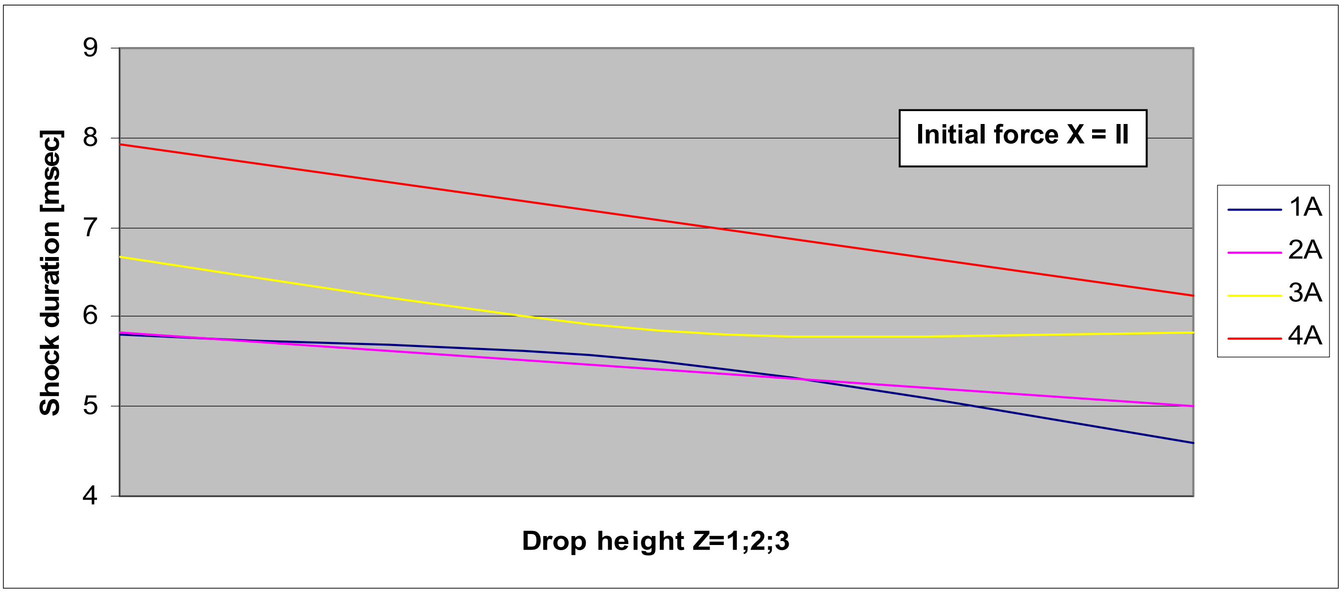

Fig. 9 Impulse duration changing for different programators, angle of drop and initial force II

The figures 4, 5, 6, 7, 8 and 9 shows that the increase in the drop height results in an increase in the acceleration, while it decreases with the decrease of the programator stiffness. It is also clearly shown that with the increase of the platform stiffness (tightening the screws 2, 4 or 8 circles) the amplitude value slightly decreases.

As for the duration of the impulse, it decreases with the increase of the drop height and with the increase of the stiffness of the programators.

5. Conclusion

On the basis of the conducted experimental tests, the following conclusions can be derived:

1. As expected, the drop height of the hammer and the stiffness of the programmers have a dominant influence on the shock parameters.

2. The shock machine presented is a very light shock machine which characterises with a small total mass, small mass of the fixing device for the testing element and small hammer mass.

3. Accelerations over 20g and impulse duration over 10 – 12 seconds are very hard to achieve which limits the use of the machine to quick, auxiliary tests.

4. The programators are very convenient constructive form of shock parameters regulation, because it provides a simple way to fulfil the prescribed testing norms and standards.

5. The pre-tensioning of the platform has a smaller influence, and so its function should be replaced with more practical design solution.

6. Literature

1. Harris C.M., Piersol A.G., "Harris' Shock and Vibration Handbook", McGRAW-HILL, 2002.
2. Clarence W. de Silva, "Vibration and Shock Handbook", Taylor&Francis, 2005.
3. Petreski Z., Ilievski A., "Shock Testing Rig Design", Technical Report, Faculty of Mechanical Engineering, 2010.