INNOVATION IN EDUCATION OF COMPOSITE TECHNOLOGY

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1. Objectives

At present the theoretical and practical instruction composite technology oriented primarily on static behavior of composite materials. Students are introduced with the problems of the design, testing and non-destructive testing of composite materials. The issue of the influence dynamic load on the composite resistance and energy absorption of composite materials in the education included only marginal. These areas are classified main for the use of composites in various sectors industry sectors and future mechanical engineers should be at least basic knowledge and practical experience in the field.

The aim was to extend the subject of the study program of laboratory experiments demonstrating the response of thin composite structures to dynamic loads and allow students to acquire basic theoretical information and practical experience in dynamic testing of composite materials.

2. The procedure and method

Solution of the project was divided into the following phases:

1) Construction design of test device
2) Design of measuring chains and processing of measuring and valuating software
3) Manufacture of the impactor
4) Preparation of materials for learning

2.1. Construction design of test device

This stage was performed detailed of experimental device demonstrating the influence low-energy impacts – Impactor (Fig. 2.1, Fig. 2.2), including preparation of drawings. The Design was completely performed in NX4 CAD system from Siemens PLM Software

Construction was designed in accordance with ASTM standards (American Society for Testing and Materials), specifically with the standard ASTM D7136/D7136M-07. This test method deals with investigations of composite materials resistance to impact damage. The test specimen is a rectangular panel 100x150 mm with thickness 6mm (Fig. 2.5). Specimen is subjected to impact. Impactor has a smooth hemispherical striker tip with a diameter of 16 mm and a hardness of 60 to 62 HRC.

The construction was taken into account the maximum realization of mass-produced components in order to reduce production costs.

The construction is designed so that the basic cube is bolted from the construction duralumin profiles. At the top of construction is by end blocks mounted cylindrical guide rail. Bottom end is attached directly to the upper plate of basic cube. On guide rail is mounted crosshead by ball bushings. The bushings ensured the minimum possible resistance when moving.

Crosshead is designed as a hollow with minimum weight. Into the crosshead can be delivered to the mass of weights 22 kg. On guide rail is to mounted beam with latch mechanism which gives the height of impact and thus the velocity impact. The combination of height and weight to set the impact energy.

At the bottom of the cube are pneumatic pistons, which prevent their eject re-impact of striker in the specimen.

Effective length of the guide rail was designed for 870 mm. With a lift 870 mm and weight 22 kg is possible achieve a theoretical maximum impact energies 188 J.

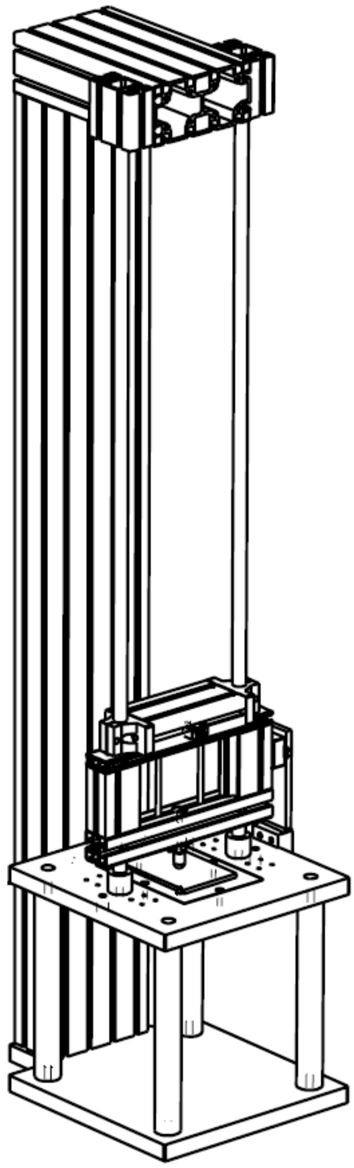

Fig. 2.1 – Testing device
by ASTM D7136/D7136M-07

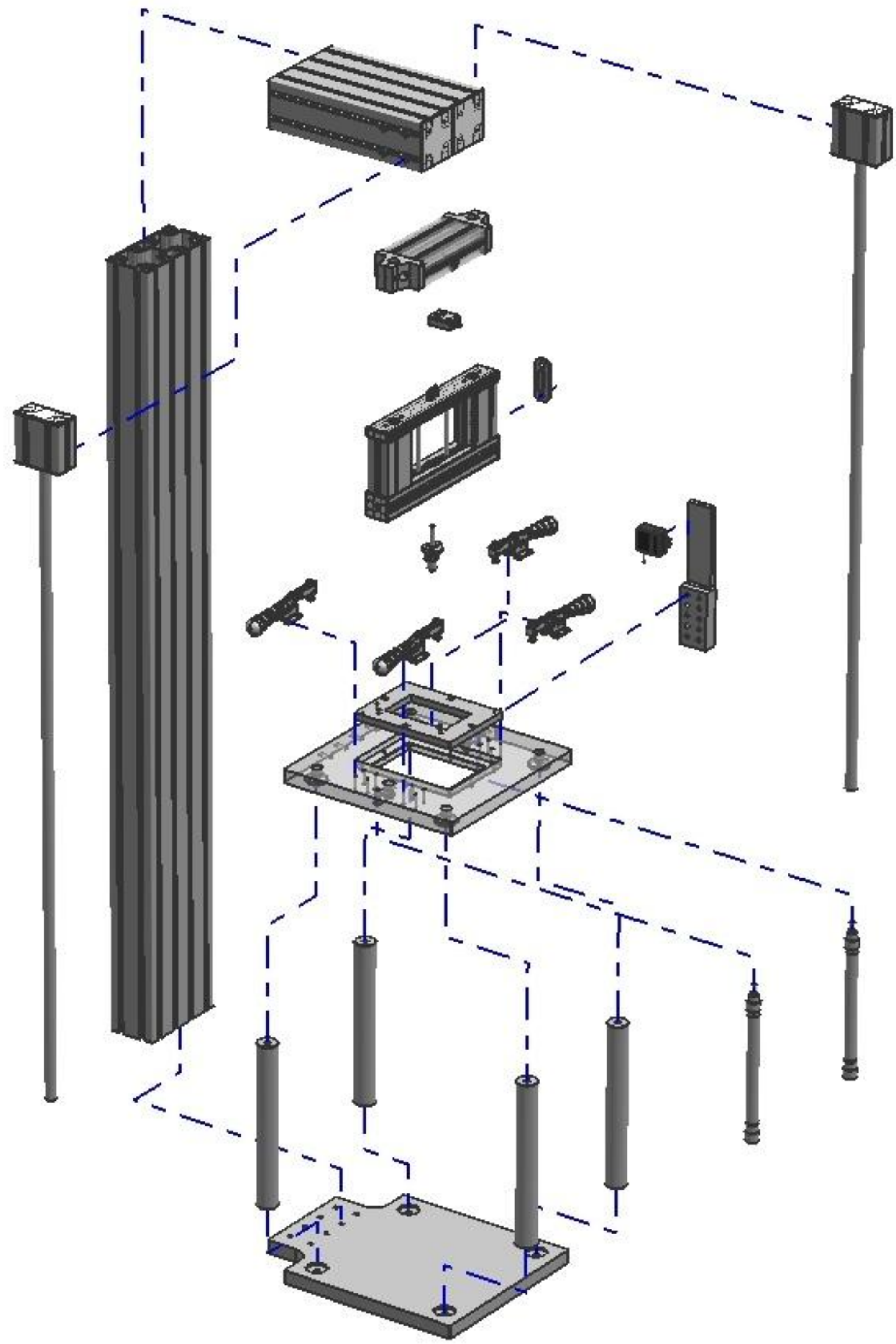

Fig. 2.2 - Scheme of test device

2.2. Design of measuring chains and processing of measuring and valuating software

Measuring chains

The stage was designed measuring chain (Fig. 2.3) for measuring, recording load and response of the test specimen with a sampling frequency of 20 KS/s (20 kHz).

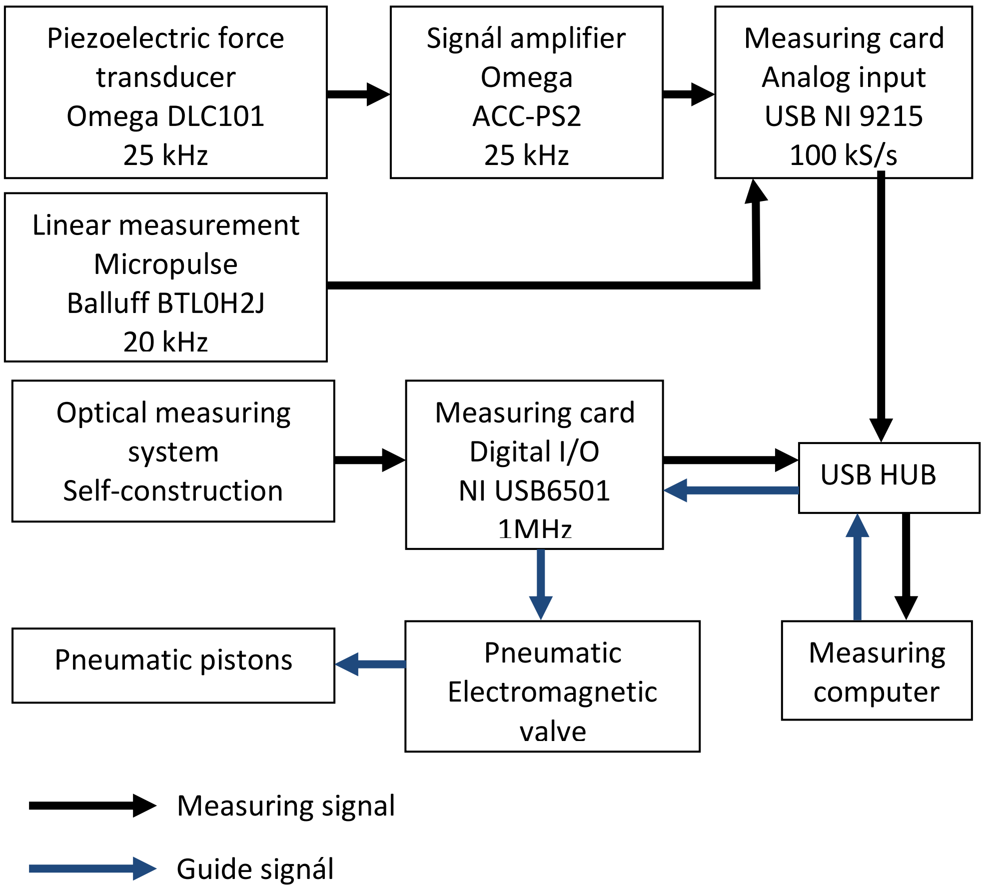

Fig. 2.3 Measuring and control chain

Used measuring chain is divided into two parts. The first part is for data acquisition and a second control of pneumatic pistons. Measuring part consists of measuring the force that is realized with a piezoelectric load cell DLC101 from Omega. The load cell signal is amplified by signal amplifier ACC-PS2 from the same company, from which it is currently operated. The analog signal in format 0-10V is scanned measuring card NI 9215 from National Instruments. The card sends a signal through the USB interface to the measuring computer, where the signal is recorded and then processed.

Another measured dimensional is the velocity, which is read two methods. The first method is the measured velocity throughout the fall. This velocity is measured by linear encoder Micropulse BTL0H2J from Balluff. The sensor has an analog output 0-10V and needs no further amplification and, therefore, is directly connected to card NI USB 9215. Because it is trajectory sensor, not velocity, it is necessary to signal to the computer by using software differentiating under measuring time, thus obtaining velocity.

The second method of measurement was added for improving impact velocity. This system is based on optical gate, which measures the time for which the gate crosses a defined screen. The system measures the velocity close (0.5 mm) before the impact. The signal of this system is digital and is captured by measuring card NI USB 6501, which sends a signal by using the USB to the measuring computer.

Control of pneumatic piston is realized by using electromagnetic valve VUVB-L-M42-AD-Q8-1C1 by Festo. The valve is controlled by card NI USB 6501 which has digital inputs and outputs.

Software

The recording software built in LabVIEW 2010. The program records the impact force and location of crosshead, from which based on the time calculate the velocity. Also measures the velocity impact from optical sensors and controls the pneumatic pistons. All measurement data are saved in a file format *.lvm.

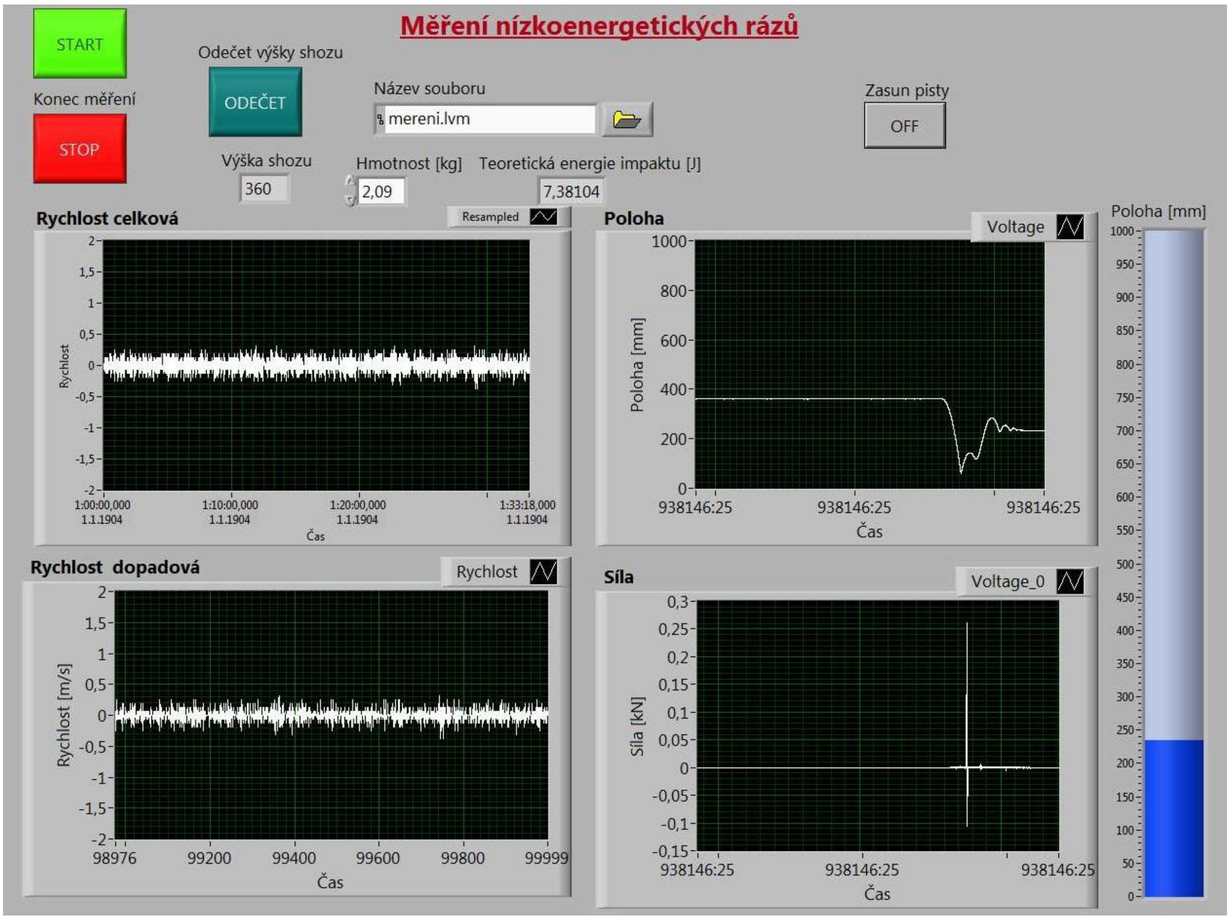

Fig. 2.4 Interface measured software

Processing of measured data

Processing of measured data is solved by NI DIAdem 11.1 software from National Instruments.

2.3. Manufacture of the impactor

Manufacture of the impactor and its recovery proceeded in the laboratory, Department of Aerospace Engineering. During phase was at a delivered basic cube fitted a frame of aluminum profiles (Fig. 2.7). During installation identified the need for production of some parts and modification bought parts. The frame was fitted to guide rail with crossbar, which is thrown from the crosshead with impact striker (Fig. 2.9). Was assembled and equipped with measuring and control electronics (Fig. 2.8). Pneumatic components were installed. Were subsequently revived measuring chain and optimized software for data acquisition.

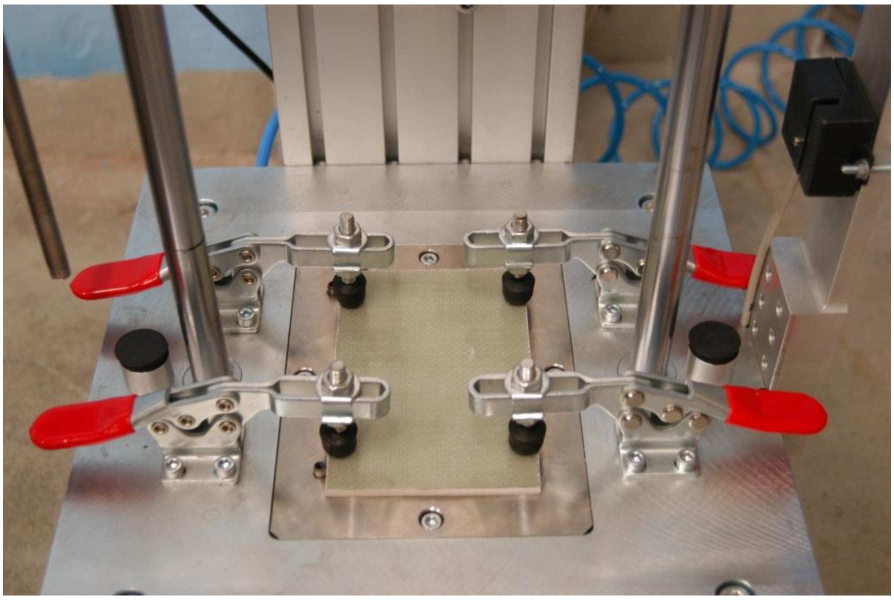

Fig. 2.5 - Mounting specimen to the basic cube

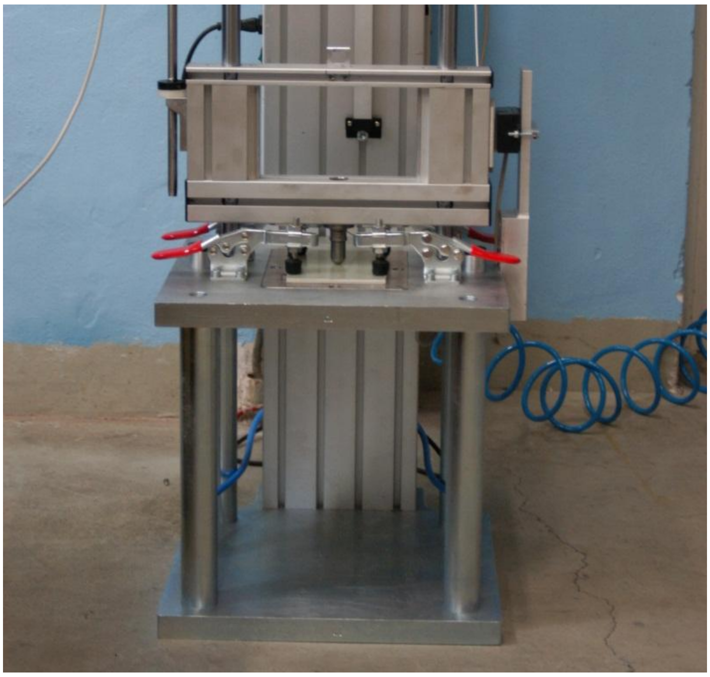

Fig. 2.6 – Basic cube

Fig. 2.7 – Impactor design

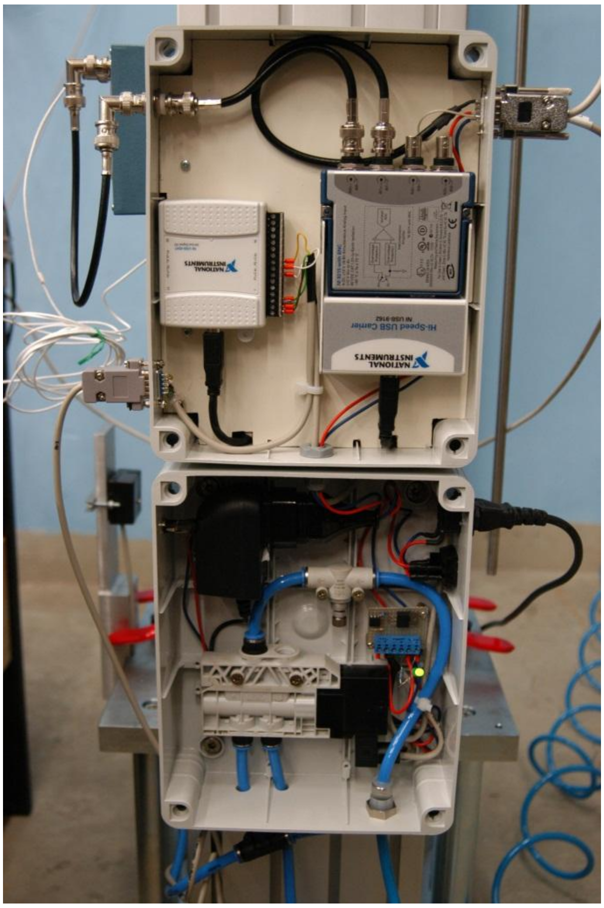

Fig. 2.8 - Measuring and control electronics

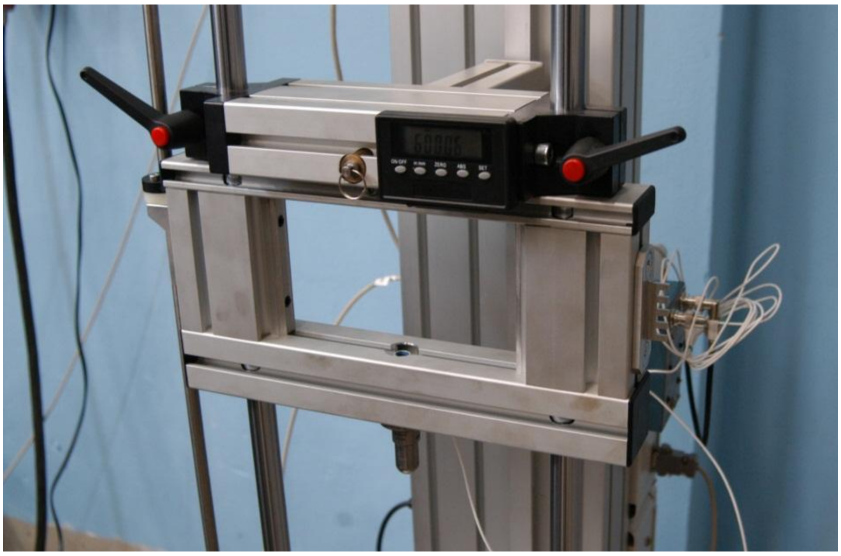

Fig. 2.9 Crossbar and crosshead with impact striker

2.4. Preparation materials for education

Was created laboratory role “Determining the size of the dissipated energy in the impact specimen and a comparison with the static load non-impact specimen”.

Job submission:

Determine the height of impact to meet the requirements of ASTM D7136/D7136M-07 the relative size of the impact energy to the specimen thickness of 6.7 J / mm thickness. Make the impact of two specimens from different materials (glass and carbon composite). From impact velocity and reflection velocity determine the size dissipated (absorbed) energy.
Energy of both specimens compare and the result reasons.
Make a static load test in accordance with ASTM 7137/7137M-07 for impact patterns. Tests repeat on the same non-impact specimens and load capacity compare.

3. Results and outputs

The outputs are:

1) Educational assist - Impactor demonstrating the influence of low-energy impacts on composite materials
2) Equipment for acquisition and processing data at dynamic loads
3) Educational materials for theoretical preparation, implementation and evaluation of laboratory role

4. Conclusion

Testing device designed in this project allow the extension of education composite technology from a laboratory role demonstrating the response of thin composite structures to dynamic loads. Laboratory role being carried on this device allows students to acquire basic theoretical knowledge and practical experience in dynamic testing of composite materials.

Another benefit of the project for the Faculty of Mechanical Engineering is also actively involved of doctoral students in the development education and improvement of composite technology.

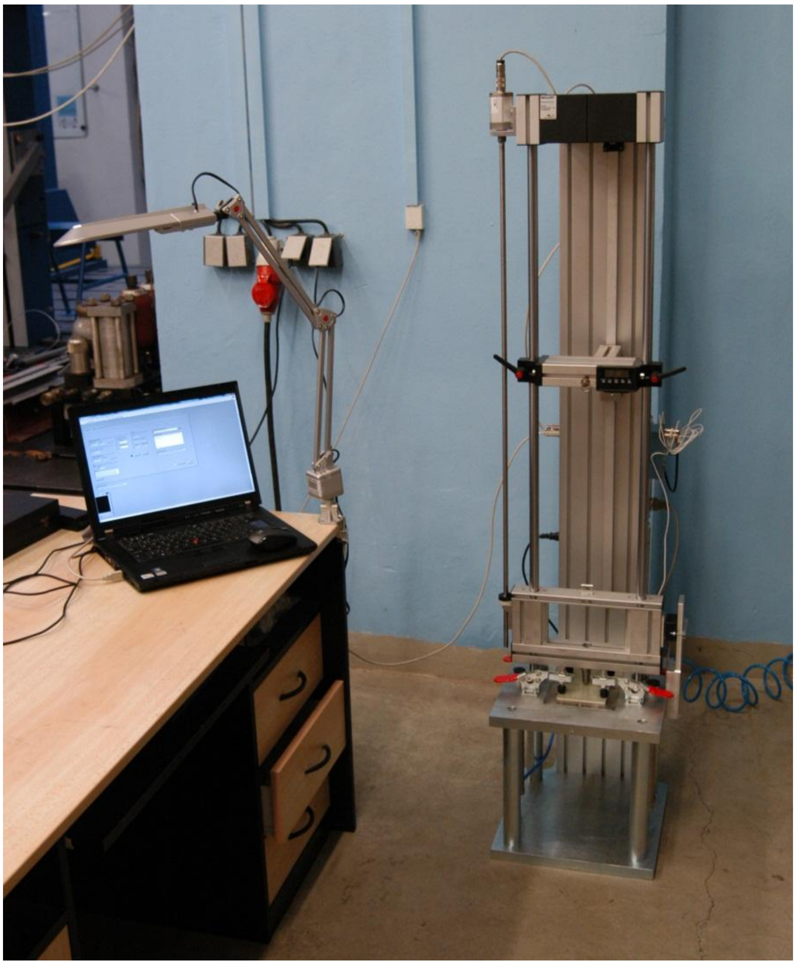

Fig. 4.1 - Created laboratory workplace