The designing of the measuring stand for research of mechanical properties of composites

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Abstract. The paper is focused on the designing of the measuring stand intended for determination of mechanical properties of composites as natural frequency, time of damping etc. The measuring stand is designed to be universal for various composite materials and different shapes and dimensions of the measured samples or parts. The one of advantage is that the measurement are repeatable with the same parameters of impact force thus the measuring errors are minimized.

Keywords: measuring stand, sample, impact force, table, position, impact ball

1 Introduction

To determine the mechanical properties of composite materials is not trivial task. In present, such properties are determined by analytical, numerical and experimental approach. The basic analytical approaches are mentioned in [1]. The numerical approaches are still developing regarding the suitable and reliable numerical method [2-6] overcoming the problems of numerical analysis (more in [7]). The mechanical properties as natural frequency, natural shapes, time of damping etc. can be determined also experimentally [8]. This paper is contribution to experimental determination of mechanical properties of composites by development of the measuring stand that will be the part of the measuring chain.

In generally, to analyse the modal properties of production machines, equipment, materials the bump test with modal hammer is used (more in [9]). Combination of the proposed measuring stand supplemented by vibrometer can partially substitute such equipment. Moreover, the accuracy and reliability of measuring and measuring stand was the main goals since the accuracy of measurement depends mainly on the quality of the measuring apparatus and the skill of the scientists taking the measurement and reliability is the degree to which an assessment tool produces stable and consistent results [10].

2 Individual parts of stand and their function

To develop model of the measuring stand (Fig. 1), the software Autodesk Inventor Professional 2016 was used. To determine the natural frequencies and shapes of samples, it is needful to apply the impact force. The modal hammer is usually used to apply impact force and determine mentioned properties. In this case, the impact ball with specific parameters is used. The ball rolls on the inclined groove. The ball impact the sample by specific velocity applying the specific impact force that can be calculated by analytical form.

The proposed design of the measuring stand defines a position-adjustable measuring stand. Priority has been proposed for the research (testing, measurement) of behaviour of composite materials – natural frequencies and shapes. However, it is designed to be usable for other types of materials to be subjected to such measurement. When designing the stand, consideration was given not only to the variety of materials but also to the shape and size of the samples to be measured. Except to classic flat rectangular sample shapes and rotating shapes up to a diameter of 125mm, it is possible to measure essentially any shape of the sample if it is possible to clamp it in the clamp of measuring stand. Stand is of rigid ...ility to adjust the various positions needed for measurement

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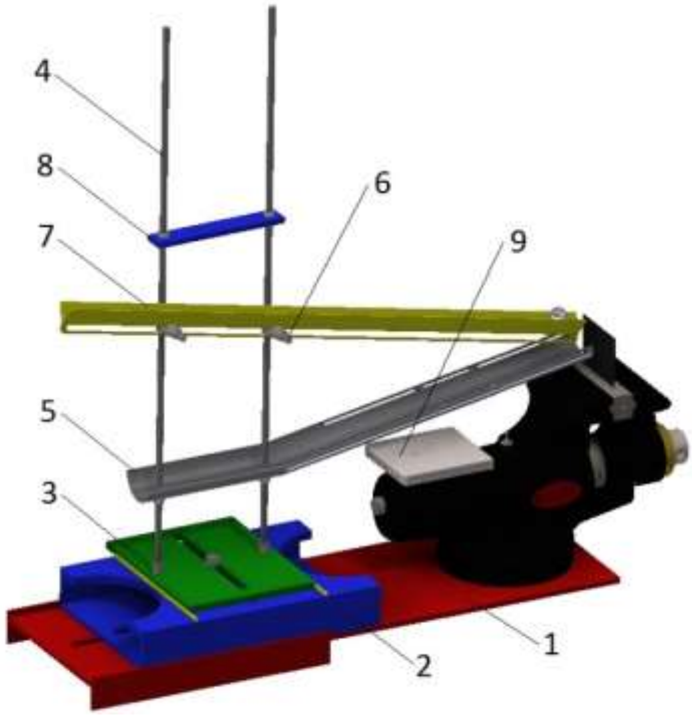

Fig. 1. 3D model of the measuring stand 1 – base plate, 2 – longitudinal table, 3 – cross table, 4 – threated bars, 5 – outlet of impact balls, 6 – adjusting screws, 7 – impact ball runner , 8 – fixator, 9 – clamp

The base plate 1 (Fig. 2) is from E295 of thickness 12mm. In the middle is the groove for adjusting screw. The groove is of 16 mm width and 400 mm length. It is sufficient for large range of table motion. The sides are welded to base plate on the lower part so as the welds do not interfere with moving the longitudinal plate. The sides are also the limiting slides for longitudinal table. At the opposite end of base plate, there are the holes for fixing the clamp.

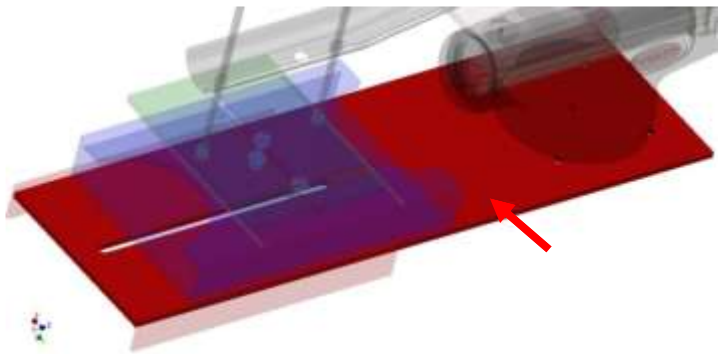

Fig. 2. 3D model of base plate

The longitudinal table 2 (Fig. 3) enables to change of distance in direction of measuring. It is welded structure consisting of plates of different thicknesses. This table has two grooves, one is on the lower side and the second one is on the upper side. They are perpendicular. The longitudinal table is by lower groove mounted to the base plate. The screw joint prevents mutual movement. The semi-circular cut outs allow easier manipulation with screw joints. Moreover, the sides are welded to longitudinal table to allow movement perpendicularly to direction of measuring. The groove is of 16 mm width and 260 mm length.

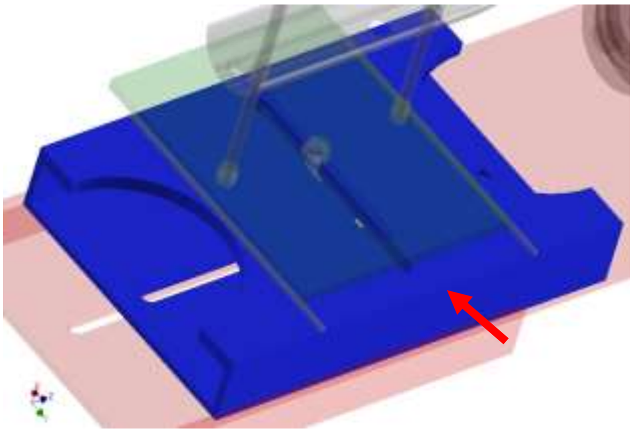

Fig. 3. 3D model of longitudinal table

The cross table 3 (Fig. 4) provides the motion perpendicular to measuring direction. The screw is in groove and it allow to fix the table in set position. The special nuts are welded to this cross table to be able to fix the guide threated bars. These bars are locked by contra-nut to avoid the spontaneous unlocking.

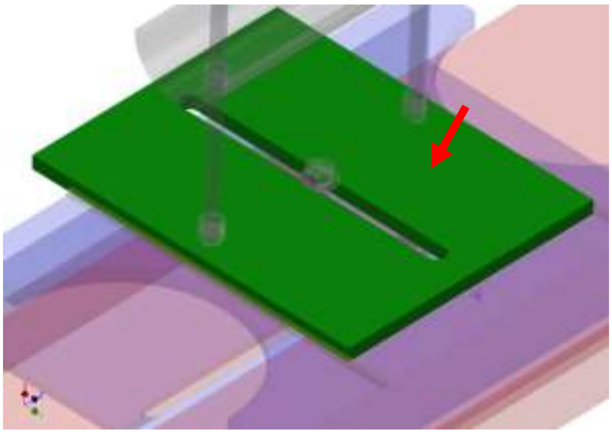

Fig. 4. 3D model of cross table

The guide threated bars 4 are used for the precise adjust of inclined impact ball runner by use of other special holders which are moving along these bars.

The outlet of impact balls 5 (Fig. 5) is the part of structure to avoid secondary excitation by repeated impact into structure (measuring stand). The shape and dimensions of outlet are designed regardless the shape and dimensions of impact body. Of course, its position must be adjusted so that it does not touch the sample or any other part where the sample is placed.

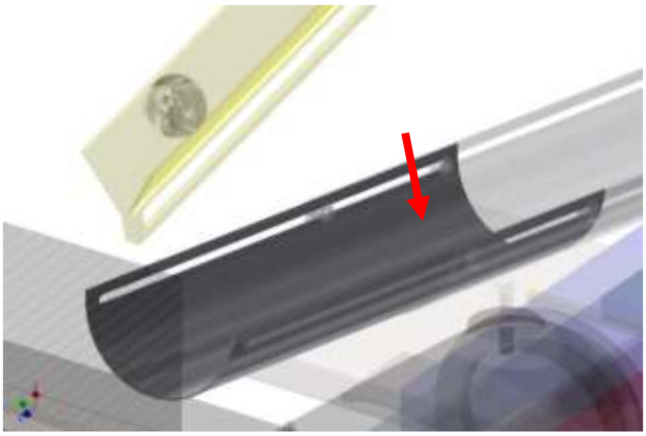

Fig. 5. 3D model of outlet of impact balls and ball runner

The adjusting screws 6 (Fig. 6) are special holders that can be moved along threated bars. Their position is locked by nuts on the both sides to avoid unwanted vibrations and spontaneous displacement as a result of impact ball movement.

The impact ball runner 7 (Fig. 5, 6) is mounted on the special holders using the pair of nuts on each side. The runner has shape of regular L-profile so that the contact of impact ball and runner is minimal. The shape of the runner also allows to use various types and dimensions of impact bodies. The runner is 1m long which can provide a wide range of impact force. The runner also has a ruler for adjusting the distance of the impact body from the sample, which is another factor influencing the magnitude of the impact force and thus the excitation.

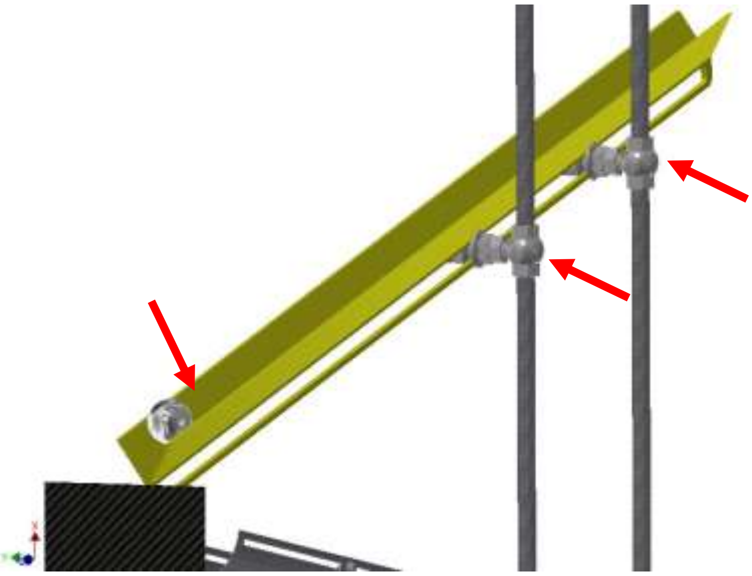

Fig. 6. 3D model of adjustable screws and ball runner

Fixator 8 (Fig. 7) serves to insure the mutual position of the threaded rods but regarding their length of 1 m, the additional insurance was necessary because they tended to change their mutual position or oscillate. This fixator is also moving along the rods and fixed by a pair of nuts on each of them.

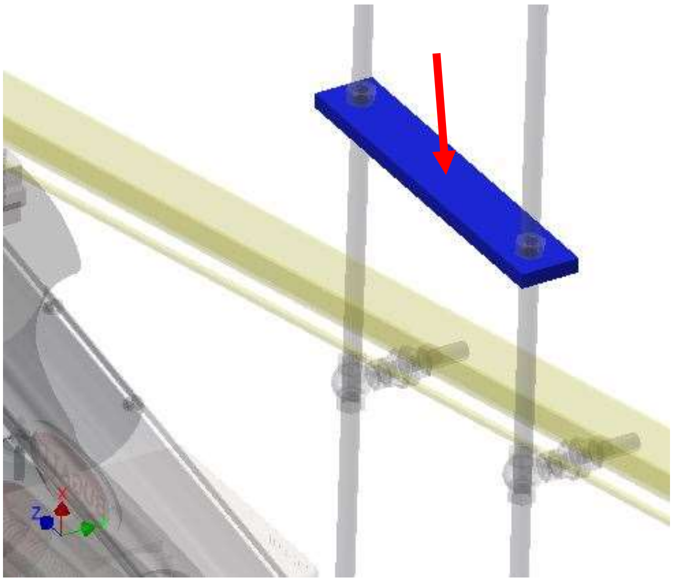

Fig. 7. 3D model of fixator of threaded bars

The clamp 9 is multifunctional in order to be able to hold the square flat samples. It is equipped with flat jaws and for the rotation samples the possibility of snapping into the prism, or a combination of these attachments. The clamp has a 125 mm the clamping range and it can also rotate about 360° about an axis perpendicular to the base plate.

The impact body can be balls of different diameters, weights and material. The ideal choice is sphere (ball) impact body because of the lowest possible friction, as the ball touches the regular L-profile at two points. The tested samples can be of various shapes (flat, rotational) up to 125 mm of clamp maximum jaw expansion.

3 Natural frequency and damping time

Some of results of measuring are provided in Figs. 8 and 9. Fig. 8 involve also samples of 3-layered laminates consist of the glass (IG) (Fig. 8, up) and the carbon (C) (Fig. 8, down) fiber twill fabric, respectively. The sample layers are oriented same way. The boundary conditions of experiment for both samples were same.

The results correspond with material properties of glass and carbon. Graph in Fig. 8 confirms the better damping properties of carbon. Moreover, the first natural frequency (Fig. 9) of carbon fibre laminate is higher (comparing to glass fibre laminate) due to its higher specific modulus of elasticity (Young modulus/density).

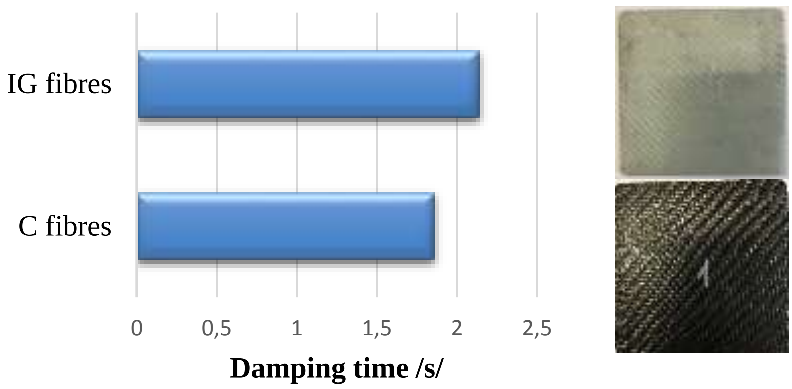

Fig. 8. Damping time and samples

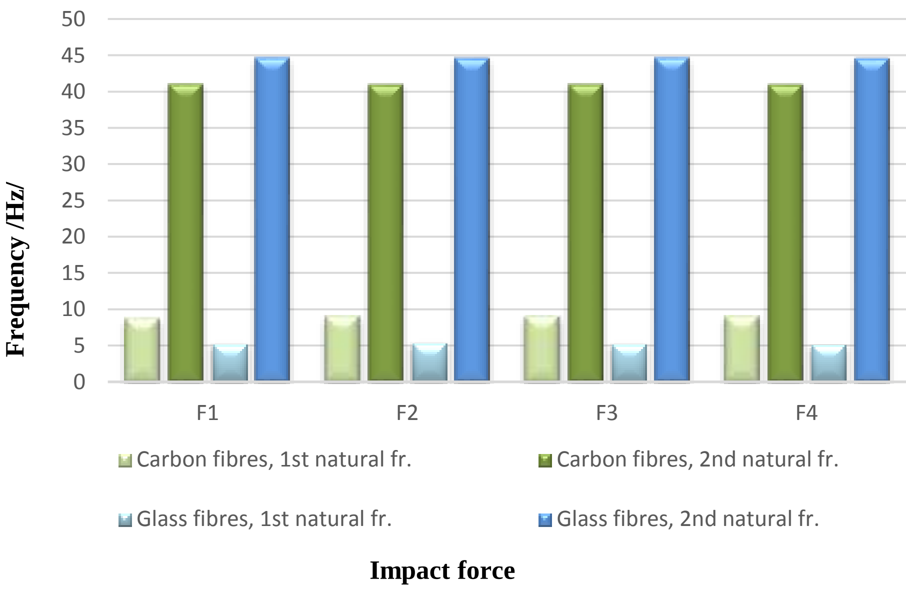

Fig. 9. Natural frequency

4 Conclusions

The proposed measuring stand is a part of the measurement chain to evaluate the mechanical properties of the composites - samples or specific components. It contributes to experimental approach that can be linked to the analytic as a comparison or as a combination with analytical and/or numerical approaches.

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References

[1] Agarwal, B. D., Broutman, L. J., Chandrashekhara, K.: Analysis and Performance of Fiber Composites. Wiley, 3rd ed., 562 p. (2006)

[2] Frydrýšek, K., Adámková, L. *Mechanics of Materials 1 - Extended Edition.* Ostrava: VŠB-TU (2008)

[3] Kompiš, V., Murčinková, Z. Thermal properties of short fibre composites modeled by meshless method. Advances in Material Science and Engineering. p. 1-8 (2014)

[4] Kompiš, V., Murčinková, Z., Žmindák, M. Toughening mechanisms for the fibre of middle-large-aspect-ratio-reinforced composites. Toughening mechanisms in composite materials. Cambridge: Elsevier; Woodhead Publishing (2015)

[5] Murčinková, Z., Murčinko, J. Application of Fibre Composite Materials for Increasing the Productivity of Production Machines. Archives of Current Research International. Vol. 2, No. 1. p. 35-45 (2015)

[6] Kompiš, V., Murčinková, Z., Žmindák, M. Physical micro-fields in large aspect ratio fibrous composites by meshless method, ECCM16: 16th European Conference on Composite Materials: Seville, 22nd – 26th June 2014. - Seville: ECCM, p. 1-8 (2014)

[7] Murčinková, Z. et al. Design of Fibrous Composite Materials for Saving Energy. Handbook of Composites from Renewable Materials, Design and Manufacturing, Vol. 2, pp. 49 - 93 (2017)

[8] Pavlenko, S., Šmeringaiová, A. Experimentálna analýza vibrácií závitovkových reduktorov (Experimental analysis of vibration of worm gear boxes). In: Výrobné inžinierstvo (Manufacturing Engineering). Vol. 8, No. 1 pp. 53-56. (2009)

[9] Demeč, P., Svetlík, J. Production machines. Technical university of Košice, p. 167 (2016)

[10] Piteľ, J., Tóthová, M., Židek, K. Technické meranie a diagnostika (Technical measurement and diagnostics), Technical university of Košice, p. 167 (2015)