Influence of the fibre spring-damper model in a simple laboratory mechanical system on the coincidence with the experimental results

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Abstract

Experimental measurements focused on the investigation of a fibre behaviour are performed on an assembled weigh-fibre-pulley-drive mechanical system (see Figure 1). The carbon fibre (of the length 1.82 meters), which is driven by one drive, is led over a pulley. On its other end there is a prism-shaped steel weight (of the weight 3.096 kilograms; it is possible to add an extra mass to the weight of the weight of 5.035 kilograms), which moves in a prismatic linkage on an inclined plane (angle of inclination could be changed, but the measurements were performed at angle 30°). In presented case the position of the weight is symmetric with respect to the plane of a drive-pulley symmetry [1]. Drive excitation signals can be of different shapes with the possibility of variation of a signal rate (e.g. [1]). The influence of the fibre stiffness and fibre damping coefficient in the computational model on the coincidence of the simulation results and the experimental measurement results is evaluated. Time histories of the weight position and of the force acting in the fibre are the measured quantities.

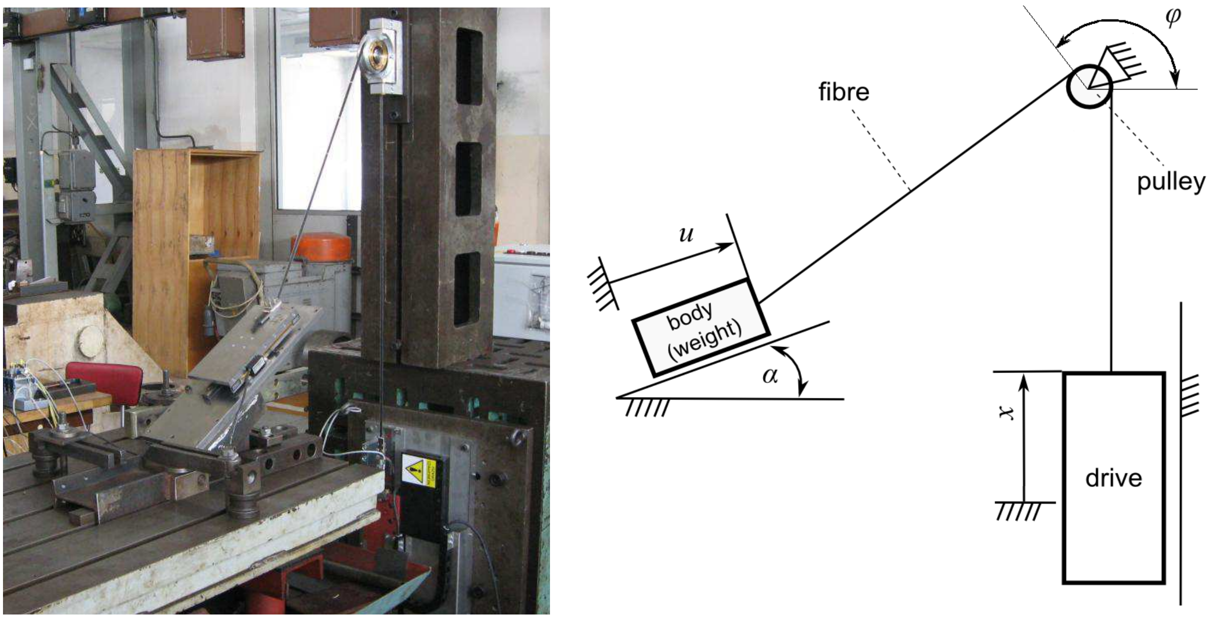

Figure 1: A real weight-fibre-pulley-drive mechanical system and its scheme.

A massless fibre model is used in the model of the investigated system. The weight, the pulley and the drive are considered to be rigid bodies. Motion of the drive is kinematically prescribed. Investigation of the fibre properties eliminating the influence of the drive and the pulley (weight-fibre mechanical system only) [2] was an intermediate stage before the measurement on the weigh-fibre-pulley-drive mechanical system. A phenomenological model (comprises e.g. influences of fibre transversal vibration, etc.) was the result of this investigation, but the general phenomenological model of the fibre was not determined. The fibre damping coefficient, the fibre stiffness and the friction force acting between the weight and the prismatic linkage were considered to be system parameters of the phenomenological model. The parameters determined at investigating the weight-fibre system [2] were applied in the fibre model of the weight-fibre-pulley-drive system.

At simulating the experimental measurements for “quicker” drive motion (e.g. [1]; see Figure 2) the local extremes of the monitored time histories of the weight displacement and of the force acting in the fibre are dependent on all the phenomenological model parameters. From the obtained results it is evident that parameters of the fibre phenomenological model must be, in addition, considered dependent on velocity of the weight motion. That is why the influence of considering the velocity-dependent stiffness and the velocity-dependent damping coefficient in the fibre model on dynamic response of the system is investigated.

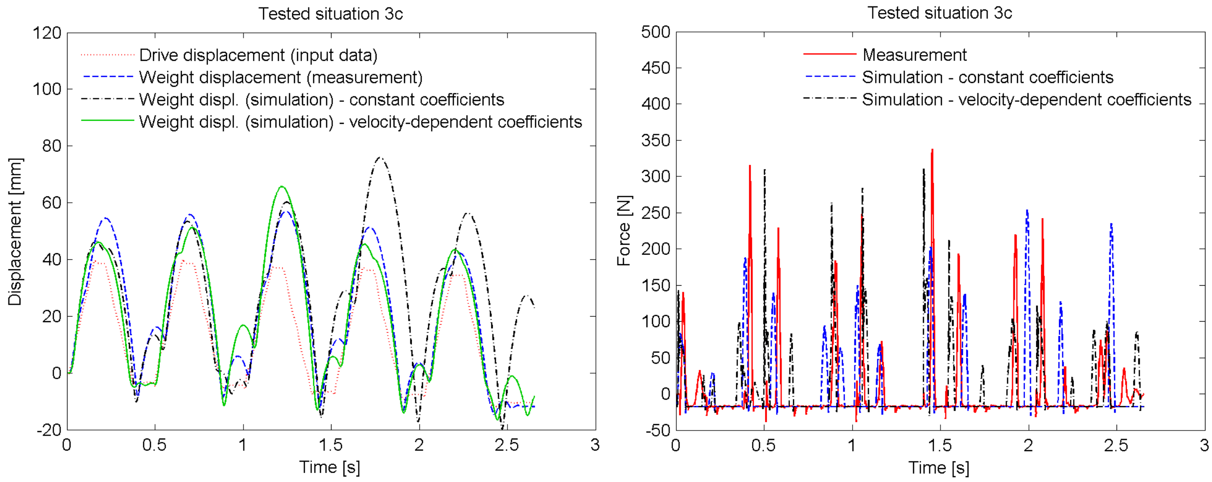

Figure 2: Time histories of the weight displacement (left) and force acting in the fibre (right).

The velocity-dependent stiffness c of the fibre is supposed in the form

$$c = \begin{cases} c_{\mathrm{c}} \,, & \text{if } v \le v_{\mathrm{tr}} \\ c_{\mathrm{c}} + (v - v_{\mathrm{tr}}) \cdot c_2 \,, & \text{if } v > v_{\mathrm{tr}} \,, \end{cases} \tag{1}$$

where c_{c} is constant fibre stiffness (taken from [1]), c_2 is constant, v is instantaneous velocity of the weight and v_{tr} is threshold value of the velocity of the weight [3]. The optimal (constant) values of constant c_2 and the threshold value of weight velocity v_{tr} were found.

Damping coefficient b of the fibre is considered in a similar way as the velocity-dependent stiffness

$$b = \begin{cases} b_{\mathrm{c}} \,, & \text{if } v \le v_{\mathrm{tr}} \\ b_{\mathrm{c}} + (v - v_{\mathrm{tr}}) \cdot b_2 \,, & \text{if } v > v_{\mathrm{tr}} \,, \end{cases} \tag{2}$$

where b_{c} is constant fibre damping coefficient (taken from [1]), b_2 is constant. The optimal (constant) value of constant b_2 was found.

Development of the fibre phenomenological model continues. It can be supposed that in a more sophisticated phenomenological model of the fibre more complicated dependencies of the fibre stiffness and of the fibre damping coefficient on the weight velocity will be considered.

References

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