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NUMERICAL VERIFICATION OF MODEL MULTIBODY SYSTEMS

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Abstract. The article deals with the influence of manufacturing and geometric asymmetry of the vertical oscillation of symmetric and asymmetric system consisting of rigid bodies linked flexibly with different kinematic excitation. The solution was performed using experimental and numerical analysis (with application of oscillation of vehicles and flexibly coupled machines). Numerical solutions were carried out by finite element method (FEM) on a simple model and experimental solutions on laboratory model of a mechanical system. The aim of the work was to create a numerical model and its solution using the finite element method. The experimental solution was used to verify the numerical model.

Introduction

Although the literature on the oscillation is very extensive, the effect of asymmetry is designed for simple cases of planar models.

Asymmetry is most often examined on half models or the quarter models. In other cases, such as when solving spatial model is considered general symmetry (usually planar symmetry, mostly longitudinal). The effects of structural asymmetry, asymmetry cargo storage, unbalanced excitation imbalance spring stiffness and damping are not in these cases not considered [1-5].

Vibration is a phenomenon that can be conveniently used in many technical applications, but often is unpleasant complications, leading for example to equipment failures. For exploiting positive effects of vibration and suppression of negative is needed with the whole issue of oscillation well acquainted. Explanation of the unexpected behavior of oscillating systems often requires quite difficult mathematical calculations. Some of them can be handled analytically, others require numerical approach.

When analyzing the effect of asymmetry of the vertical oscillation of mechanical systems need to distinguish three basic asymmetry given the geometric symmetry axes. These are two mutually perpendicular axes of symmetry intersecting at the geometrical center of the mechanical systém

- asymmetry of vehicle mass distribution regarding to the geometric symmetry axes, mass center position, directions of the main central inertial axes
- asymmetry of distribution geometry of elastic and bond dissipative elements, of the individual bodies of the system and their mechanical properties, spring stiffness, viscous dumping intensity (assuming linear bonds of particular quantities and small displacements and rotations of the system parts)
- asymmetry of kinematic excitation, i.e. for example roughness of the road surface or rail track in road and track vehicles which defines kinematic excitation of the system in the contact point of the wheel – road or wheel track.

These types of asymmetry may exist separately or together. For real objects (such as road or track vehicles) the third case usually (almost always) occurs [6].

Model of a mechanical system

For the analysis of the dependence of geometric asymmetry, and production and unbalanced excitation on vibration elements was created a simple model (see Figure 1). The model can be solved experimentally and numerically.

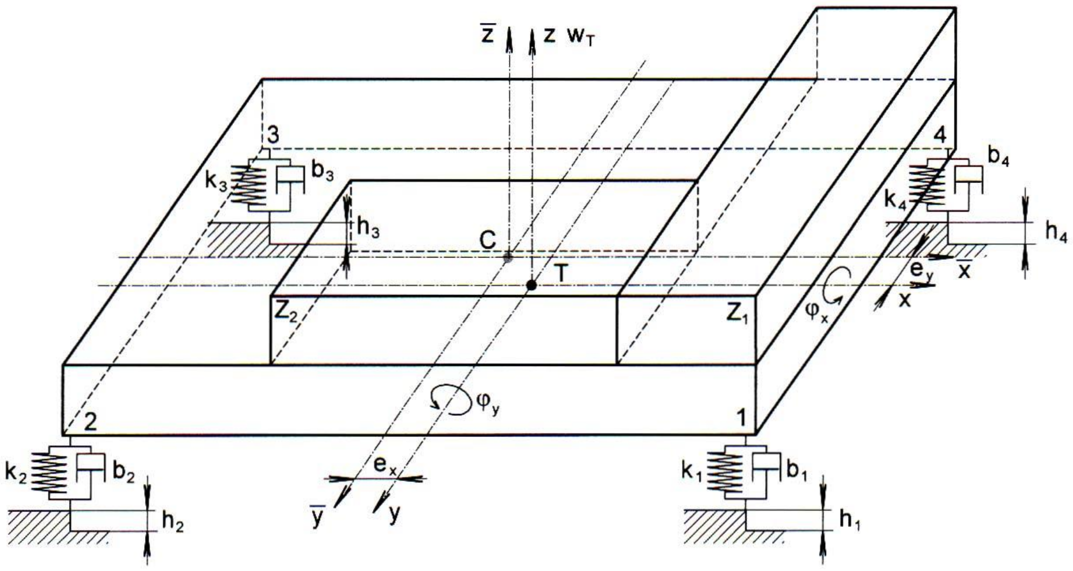


Fig. 1 The basic 3D model for experimental and numerical

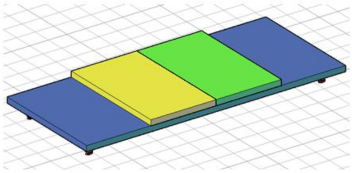
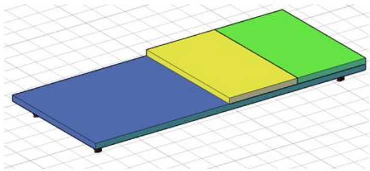
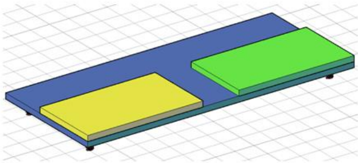
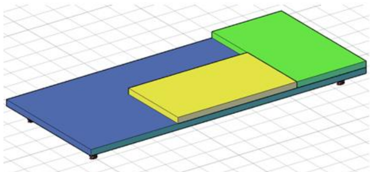
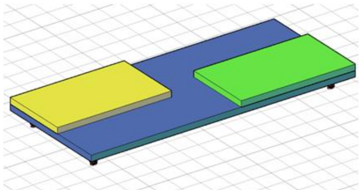
The model system consists of steel plates, which are stored on four coil springs. To simulate the geometric asymmetry serves two weights (weight of the two weights is equal to half the weight plates). These weights are placed on the plate in different combinations. For our research was chosen one variant symmetrical arrangement and five variants asymmetrical arrangement.

For experimental and numerical solution of vertical oscillation of a mechanical system was selected one case of symmetric excitation (jump all four springs at the same moment) and four variants of unbalanced excitation, which jumped one, two or three springs in different combinations. Again, but at the same time.

In the mid-position of springs were placed displacement sensor which scanned course of changes in position the measured points.

In Table 1 you can see all the solved cases of symmetrical and asymmetrical arrangement of the different variants excitation of mechanical systems.

Table 1 Variants of storage and excitation of mechanical system

variant of storage		variant of exication	
marking	scheme	marking	falling springs
I		A	3
		B	2, 4
		C	3, 4
		D	2, 3
		E	2, 3, 4
		F	1, 2, 3, 4
II		A	3
		B	2, 4
		C	3, 4
		D	2, 3
		E	2, 3, 4
		F	1, 2, 3, 4
III		A	3
		B	2, 4
		C	3, 4
		D	2, 3
		E	2, 3, 4
		F	1, 2, 3, 4
IV		A	3
		B	2, 4
		C	3, 4
		D	2, 3
		E	2, 3, 4
		F	1, 2, 3, 4
V		A	3
		B	2, 4
		C	3, 4
		D	2, 3
		E	2, 3, 4
		F	1, 2, 3, 4

Experimental solution

Solution was carried out on a laboratory model - see Figure 2 Movement of plates in the vertical direction was scanned in three points by inductive position sensor type Hottinger VA-50-T. The sensors have a range of 0-50 mm. The signal was led into bridge amplifier and evaluated in program LabVIEW. Graphs are from MS Excel, where the results were converted.

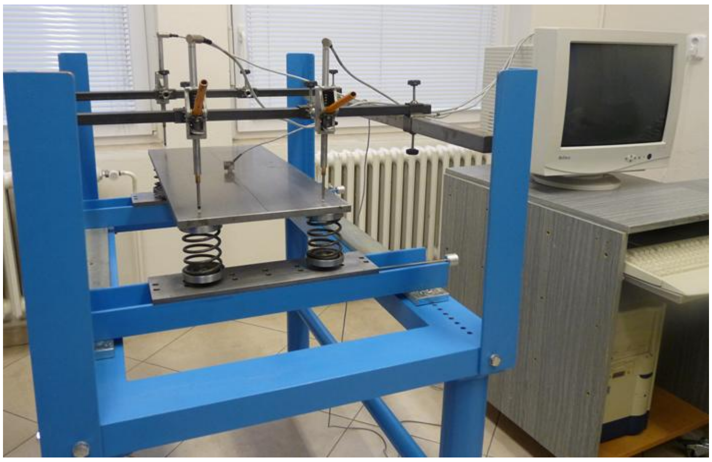


Fig. 2 Laboratory model of a mechanical system (without weights)

Numerical solution and discusion

For solving the vertical vibrations of the mechanical system, the simulation program ADAMS was used. For systematic analysis of different cases and the possibility of comparing the results of each solution method, a simple (but sufficiently general) 3D model was primarily defined. This model met the required prerequisites. The model was designed to depict the laboratory model system as much as possible.

The numerical model for investigating vertical vibrations was created in accordance with the model for experimental investigation the base consists of a rigid plate flexibly stored on four springs, which was supplemented by two identical off-load.

In Fig. 3 we can see the designed model for solving of vertical vibrations of the mechanical system in the ADAMS.

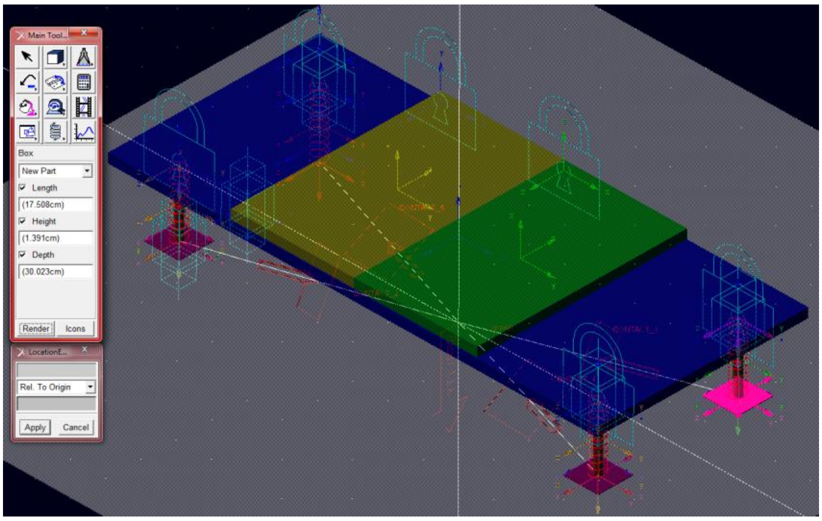


Fig. 3 Model systém in the ADAMS

The following figures shows selected results of experimental and numerical solutions. To compare numerical and experimental solutions are the results of both methods for each case inserted into one figure. Each graph corresponds to the same asymmetry and the same kinematic excitation. Shown are always all 3 position sensors.

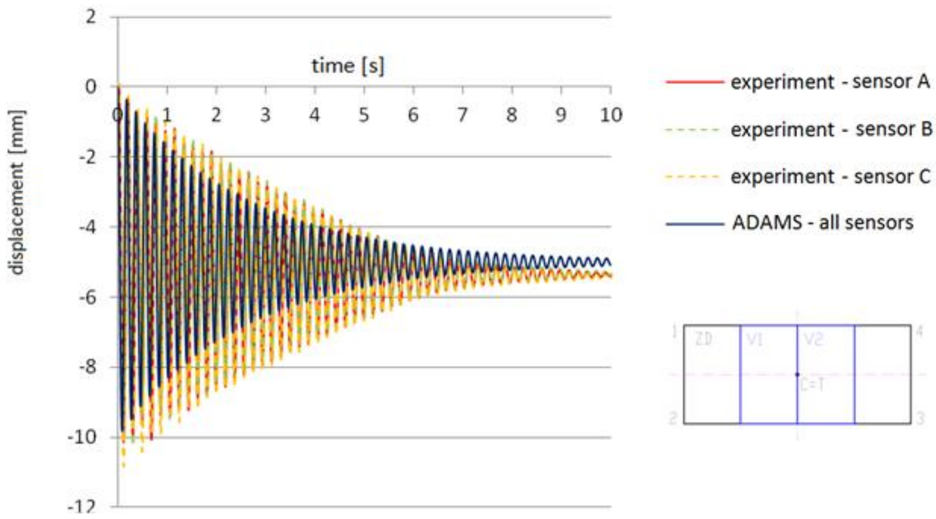


Fig. 4 *Variant of loadings I – falling springs 1, 2, 3, 4*

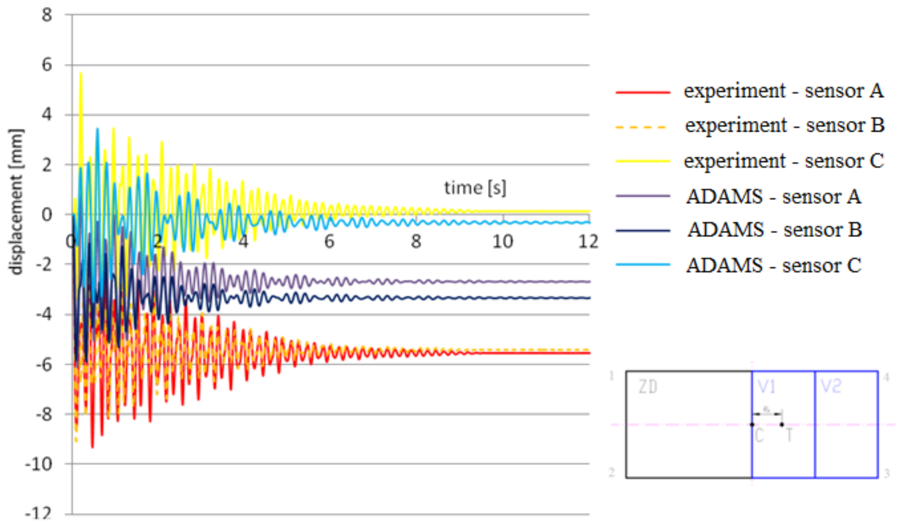


Fig. 5 *Variant of loadings II – falling springs 2, 3*

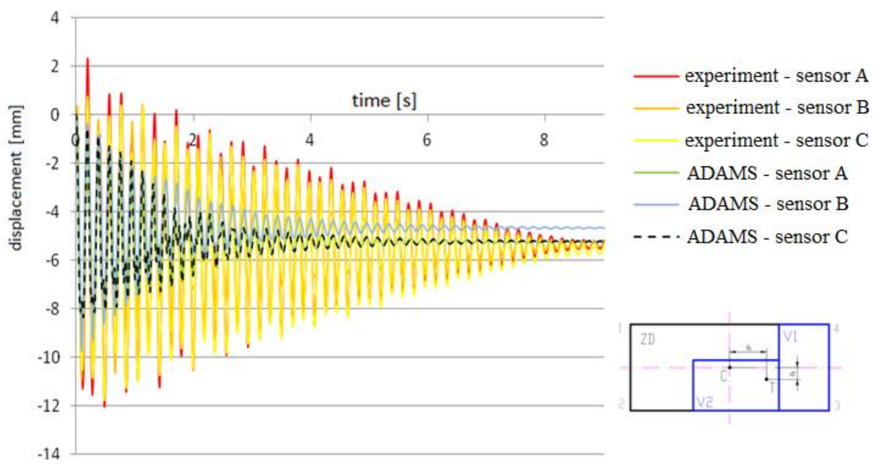


Fig. 6 *Variant of loadings IV – falling springs 1, 2, 3, 4*

From the above results show good agreement between numerical results and experimental solution. Slight differences are caused by the different material damping and spring stiffness. The numerical model has spring stiffness and damping entirely congruent. Error ranged for each measurement to 10%. It turns out that the use of ADAMS program is suitable (for a given case) and the results are in good agreement with experiment.

Summary

By comparing the obtained results were found to be good agreement of experimental results with the numerical model. The mathematical model can be used to describe and predict the behavior of the system for the general case of loading and kinematic excitation. Mathematical models must always be adapted to the specific type of mechanical system (due to the fact that design has on search parameters very significant impact).

The results obtained allow to determine the direction of further focus of research (eg, expand research on problems of unbalance, the transverse motion of a mechanical system, establish criteria for assessing the impact of geometric and mass unbalance of oscillation system.

Accommodation

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