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Experimental Stress Analysis

SIMULATION OF A BUCKET EXCAVATOR CAB REAL MOVEMENT

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Abstract: It is very suitable to test new designs of bucket excavator operator seat vibroisolation in the laboratory at first. Thus we have to simulate the real vibrations of the operator cab for these exams. The paper describes a procedure of data measurement and processing that we need for 3D-excitation simulating the real running conditions of a machine in a laboratory environment.

1. Introduction

During the innovation of an operator seat vibroisolation on the bucket excavator SCHRS 1320 we cannot test new solutions on a real machine because every outage of bucket excavator is very expensive. Therefore we decided to simulate real vibrations of the bucket excavator cab in the laboratory for these research tasks. This can save a lot of money because we can use a tested mechanism for the final real running evaluation. For the simulation of real vibrations we use six degrees of freedom platform. It is a unique device which was built in the Hydrodynamical laboratory of Technical university of Liberec [1]. The platform has to provide the same movement as floor of the operator cab during mining. The procedure of a real movement measurement and data processing is described in this paper. The resulting data are used as a driving signal for the six degrees of freedom platform.

2. Real movement measurement

The operator cab hangs on a bucket excavator frame and is exposed to mining vibrations transferred to the cab. The mining landform vibrations aren't only in a one axis, the cab goes to three-dimensional oscillations. It is a combination of 3-axial translations and rotations.

Figure 1: *The bucket excavator SCHRS 1320 operator cab.*

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That is why we have to measure 3-axis translations and 3-axis rotations for a record of a cab movement. Because the cab goes with a bucket excavator during the mining we have no fixed point and we cannot measure translations and rotation directly. We have only one possibility for a measurement of cab oscillations – measuring accelerations. We can use standard accelerometers and in this case we have to measure 3-axis acceleration at minimal tree points. We directly record translations and we can compute rotations from signal differences. Defined measuring points have to be located in the cab very exactly for a correct calculation of rotations. Instead of several standard accelerometers we can use only one special gyroscopic sensor for example a gyroscopic sensor MTi from Xsens Technologies. This sensor measures 3-axis acceleration and 3-axis rotations directly.

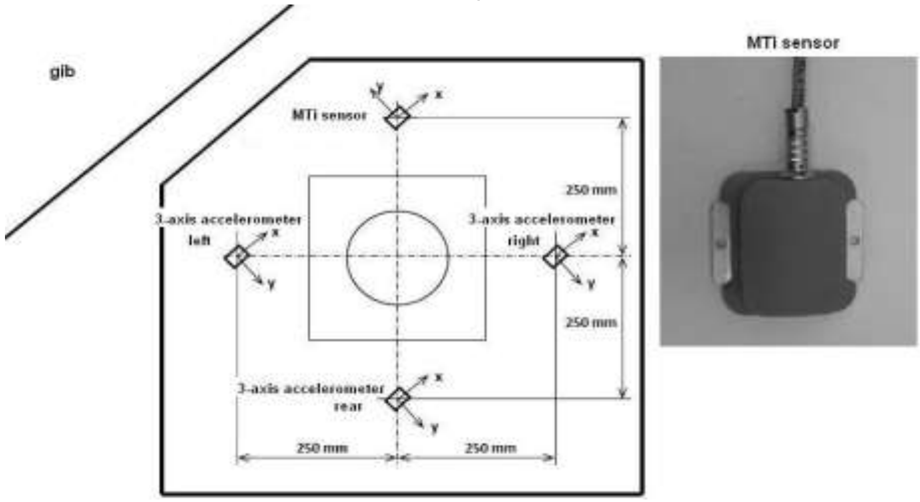

Figure 2: *The location of measuring points in the cab and photo of gyroscopic sensor.*

3. Data processing

The real movement of cab is recorded as 3-axis acceleration in tree designated points. For a control of six degrees of freedom platform we need six signals for its six engines. So we have to convert measured data to control signals. This operation is divided to two steps. First step is a conversion from accelerations to translations. It is standard mathematic operation – double integration. But one problem is hidden here. A mean value of a primary measured signal isn't zero and the integration causes a gradient of mean value of result. Such signal is unusable. We have to correct this gradient before its next use. It is very difficult because we have to balance a mean value and must not change a character of a signal. We made a special algorithm for this operation. One example is displayed on a figure 3. A primary measured signal is on the left graph and in the middle there is its first integration with a gradient of mean value. Last graph shows a balanced integral, it means the integration with a corrected mean value by our special algorithm. These data we can use for a next computation step. 3-axis translations of cab in the defined points are results of described operations.

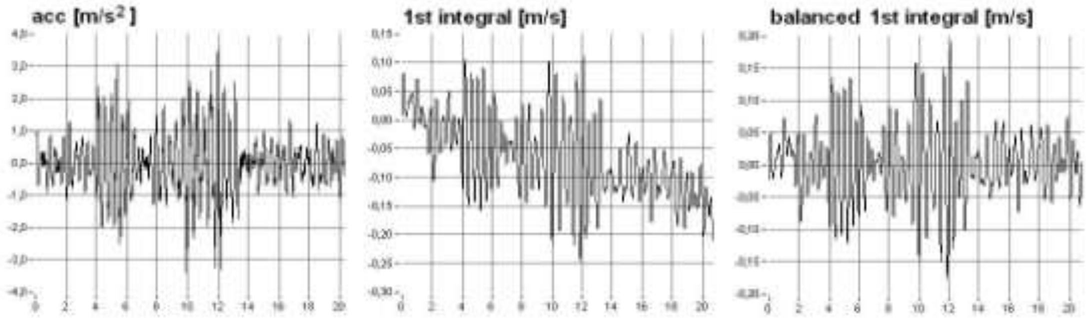

Figure 3: *Example of integration with mean value correction.*

In the second step we have to convert 3-axis translations in the defined points to control signals for six engines of the platform. For this purpose multibody model of the platform was created in MSC.ADAMS/View software. This model is shown on the figure 4.

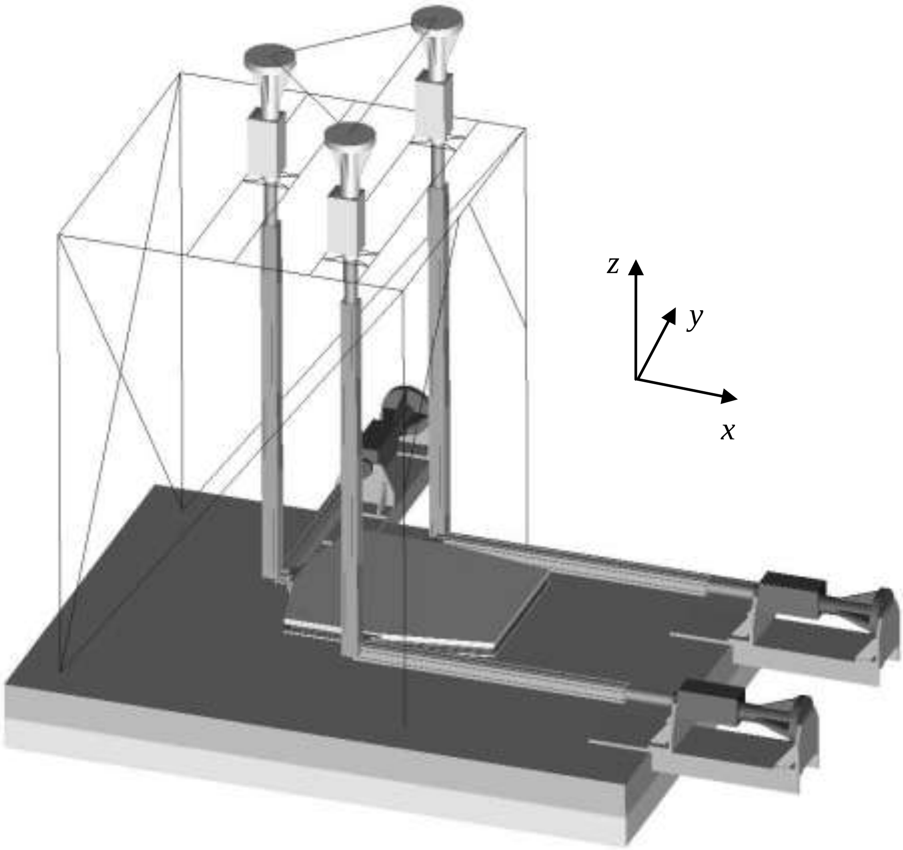

Figure 4: *Multibody model of platform in MSC.ADAMS/View software.*

Model is composed from rigid fundamental and flexible platform frame (wireframe in figure 4). Another parts of model are six linear motor (represented only by two parts - piston and part of motor geometry), six linear rods with spherical joints on their ends and one platform board. Movement of board is realized by six linear motions of motor pistons.

For signal translation we created three points on platform board in defined position from measurement of real cabin. In this points we applied required number of components of translational motion converted from measure data. It means three components (x, y, z) in the first point, two components (x, z) in the second point and one component (z) in the third point. Six components together to fix six degrees of freedom. The platform board movement is defined by this unambiguously. After simulation run we are able to get required movement of linear motors for measured board movement.

Another way we are using for converting points movements to linear engine motions is by special software. It is detail described in [2]. This software was developed for this purposes especially. Contrary of the simulation it is able to determine collision position of platform board. This position are results of limited angles of spherical joints.

On figure 5 is illustration of six linear engines motion for part of measured signal of 1 *s* length and figure 6 shows the same signal of 40 *s* length in separate graph for each engine.

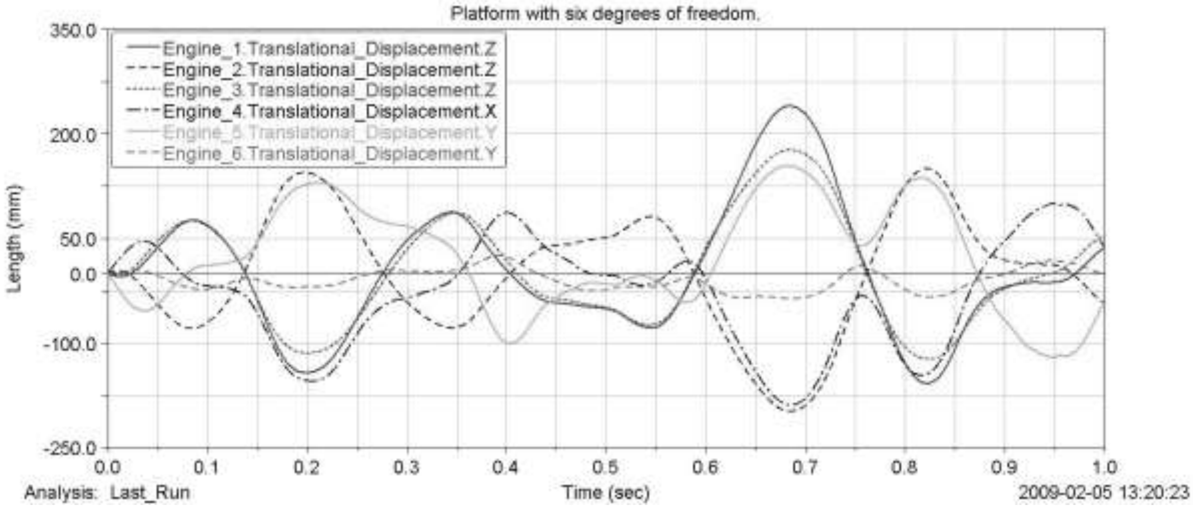

Figure 5: *The six linear engines signals of 1 s length.*

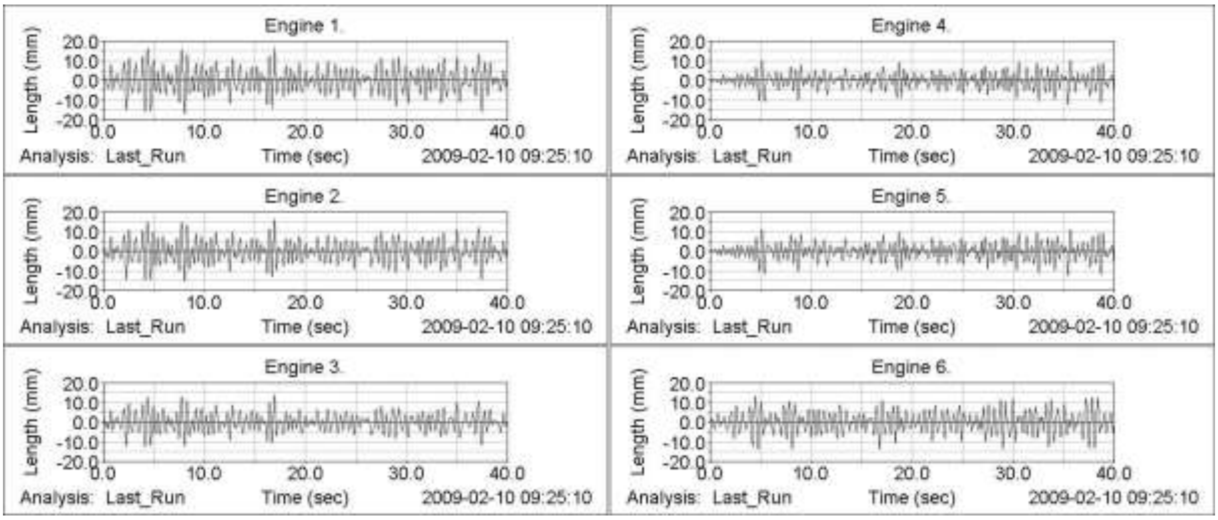

Figure 6: *The six linear engines signals of 40 s length.*

4. Verification of data processing

Now, we will compare movement of designed points we computed from simulation and we measured in real cab. For our purposes we will compare acceleration signal, because we want control both double integration of acceleration and simulation model in MSC.ADAMS/View software. Example of comparison simulated and measured acceleration in *x* direction of one of designed point is shown on figure 7.

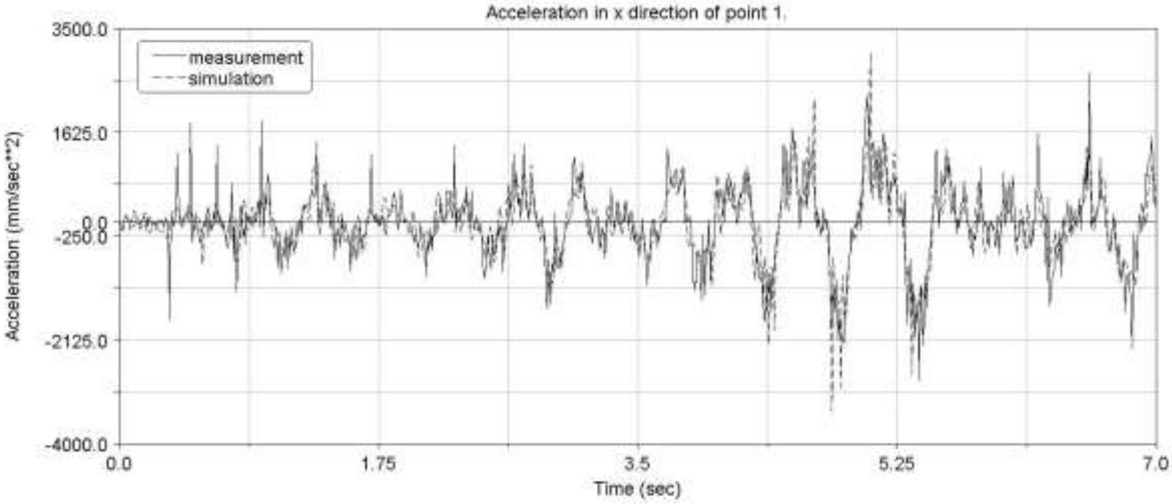

Figure 7: *The measured and simulated signal comparison.*

From previous figure in some intervals we can see larger peaks of measurement signal and in different intervals we can see larger peaks of simulation signal. The reason of peaks in simulation signal is because rigid kinematical joints were used in multibody model (spherical joints). In measurement peaks are done by signal noise. Despite this fact we can see a good accordance between both signals. This conclusion result also from comparison of acceleration from another point of board and also for another measured signal in different time of mining. From previous results we can assume that we can use described procedure of data conversion for any other measured signal of bucket excavator cab.

Acknowledgement

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