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Physical and geometrical data acquiring system for vibration analysis software¹

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Abstract: In the article a numerical vibration analysis of the excavator model is presented. This model with a discrete distribution of the parameters, shown in three working positions, is attracted to kinematic and dynamic excitations. The analysis is made in GRAFSIM program, which was intended and prepared for projecting and analysing 2D and 3D mechanical systems with linear couplings. The program works on the basis that the algorithm transforms matrix hybrid graph model structures into block diagrams structures [1,2]. The time and frequency responses from the examined mechanical system are presented.

Keywords: Matrix hybrid graphs; Matrix block diagram; Software for vibration analysis;

1. INTRODUCTION

The basis of many essential technical problems is understanding the important section of mechanics that deals with mechanical systems vibrations. In many complex cases it is enough to create a simplified model of real one, described suitably with well-chosen collected masses as well as with elastic – dumping elements to explain action of a real object. The phenomenon description and estimation on the basis of a created model requires engineers with special knowledge of analytical methods as well as suitable theories useful in cases requiring investigations. There are many helpful engineering programs that are being developed quickly worldwide. This progress refers to the division dealing with kinematics and also the dynamics of mechanical systems. The GRAFSIM program allows the possibility to generate time responses on individual Dynamics and kinematics excitations, to show zeroes and poles of characteristic equations on the complex surface in a tabular form. It also generates state matrix equations of a discrete model of the mechanical system. By bringing in certain program working conditions, many types of numerical data that represented the examined system had to be determined at that time directly by user through a suitable interface system. The process of manually inputting data into the program was time-consuming and susceptible to key punch errors. The CATGEN program is considered as the next step in improving the process of mechanical systems analysis. The CATGEN program transmits data between the CATIA program, where the geometry of the model is created, and the GRAFSIM program, that uses the matrix hybrid graph and block diagram method for carrying on vibration analysis of the system [1,2,3]. This connection aids in avoiding many computational mistakes as well

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as significantly shortening the preparation time of the physical model analysis. CATGEN makes the preliminary recognition of a 3D model and automatically takes its' necessary geometrical and physical parameters such as: masses and inertial elements moments of inertia of an accepted model of the system, local co-ordinate systems of inertial elements, attachment co-ordinates of elastic-dumping elements in local co-ordinate systems of inertial elements with which they are incident and angles between co-ordinate systems of elastic-dumping elements and inertial elements, attachment co-ordinates of dynamic excitations in local co-ordinate systems of inertial elements, with which they are incident, angles between co-ordinate systems of dynamic excitations and inertial elements and angles among kinematics excitations co-ordinate systems and elastic-dumping elements. The linear and angular elasticity of the elastic elements and the linear and angular suppressions of the dumping elements must have been established independently.

2. EXAMPLE

Taking an example of a step-by step look at a 3-dimensional model of a Mitsubishi RV-M1 robot shows how to use the CATGEN program for computer aided vibration analysis of a 3-dimensional mechanical systems with linear couplings [4].

2.1. Step 1 – modelling in CATIA environment

To create the solid model of a robot in the CATIA program, drawings have been taken from the internet. On the way of idealization the real robot, the solid CATIA model includes 5 elements: the base, the rotator arm, the first arm, the second arm and the grasp. After modeling the process of particular elements the assembly was made. The kinematics knots, coincidental points and type of material for all elements were set. Fig. 1 shows the particular elements and the end result of the modeling process.

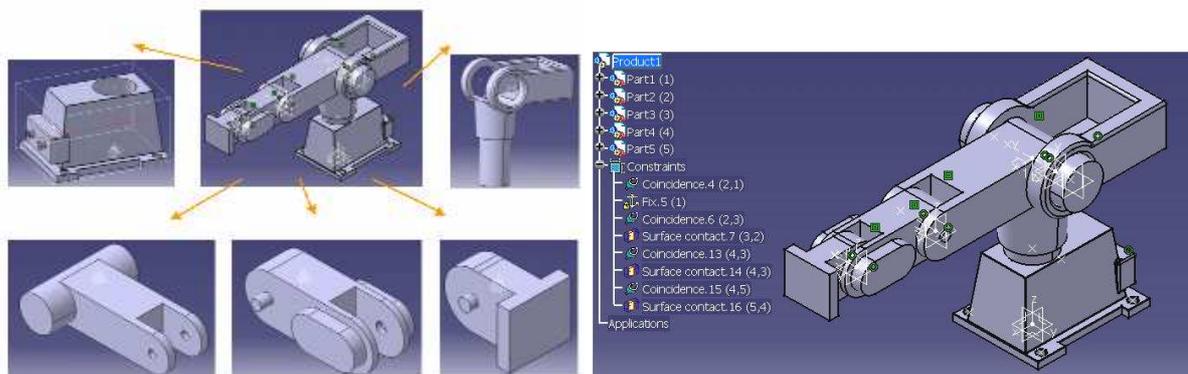


Figure 1. Particular elements of the robot Mitsubishi RV-M1

2.2. Step 2 – CATGEN environment

After activating the CATGEN program the created file needs to be opened in CATIA. The user friendly interface shows a view of the robot. The tabs which are responsible for geometrical and physical parameters of particular elements will automatically fill up with data as masses of elements, moments of inertia, densities, areas of surfaces, and matrices of inertia. The user is obligated to determine how many of the elastic-dumping elements are used and the number of kinematics and dynamics input excitation. After filling up the input parameter tab the user is able to click the “Generate tables for Inertia Elements (EI) and excitations” button which will generate and activate all CATGEN tabs responsible for input data.

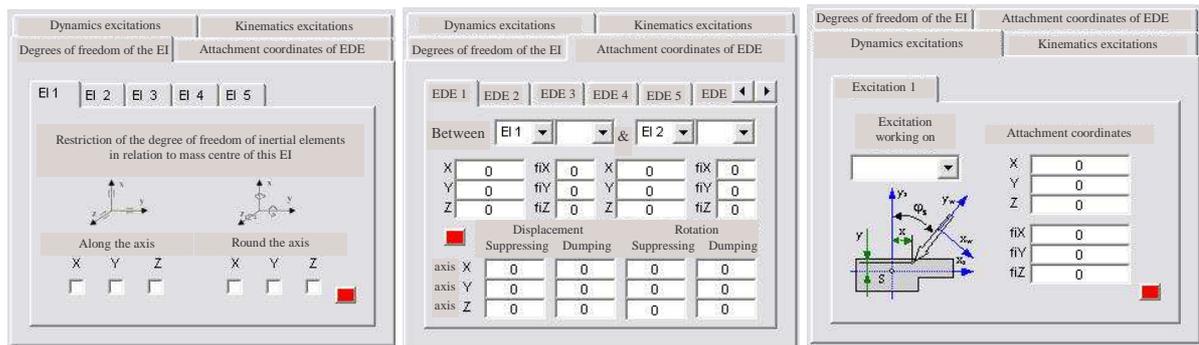


Figure 2. CATGEN tabs: a) “Degrees of freedom EI”, b) “Attachment co-ordinates of EDE”, c) “Determining of dynamics excitations”

First of the important tabs is “Degrees of freedom EI” (Fig. 2a). The user is able to restrict the degrees of freedom of all of the elements along and round the axis. The next tab is called “Attachment co-ordinates of Elastic-Dumping Elements” (Fig. 2b) the user is able to define elastic parameter and dump parameter of the EDE which connect particular masses. After choosing the specific EDE and characteristic end points on both side of EDE the CATGEN program will automatically generate coordinates of the indicated points. The CATGEN program gives the possibility of determining dynamics and kinematics input functions of the excitations. In the case of dynamics excitations the user has to choose the EI on which the excitation will interact and the Cartesian coordinates of this excitation (Fig. 2c). In the case of kinematics excitation, the user has to choose from the CATGEN combo box one of the existing excitations and make a declaration of its type: displacement, velocity or acceleration (Fig. 3a). In both cases, the process of choosing is simple and user friendly.

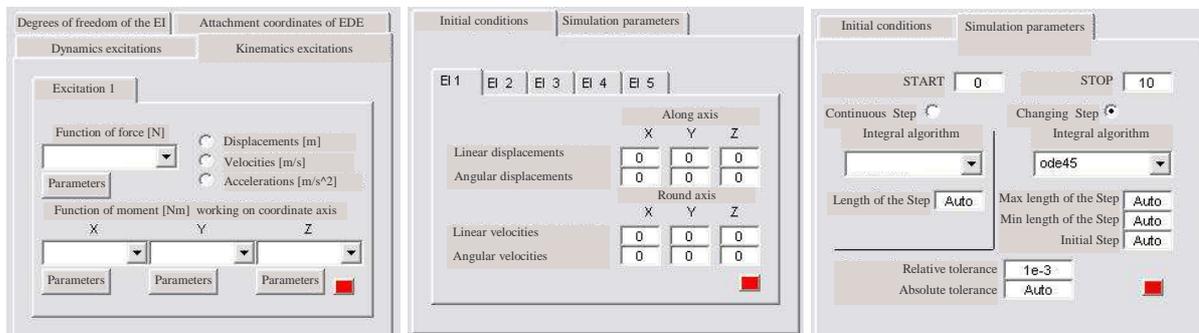


Figure 3. CATGEN tabs: a) “Determining of kinematics excitations”, b) “Initial conditions”, c) “Simulation parameters”

Every analysis requires the determining of simulation parameters and initial conditions. The tab which is responsible for that is called “Initial conditions”, as shown in Fig. 3b. The user has the possibility to determine the linear and angle displacements and velocities along and around the axis. The last step is the determination of the simulation parameters. In the tab shown in Fig. 3c the user has to define a time period of simulation and choose one of the existing integrate algorithm which will be used by the MatLAB environment to make calculations. In this tab tolerance and precision of the calculations is defined. After all the tabs are filled up the user is able to generate the input file for the GRAFSIM program. For this the “Generate m-file for MatLAB” button needs to be selected.

2.3. Step 3 – Make the vibrations analysis in the GRAFSIM environment

After activating the MATLAB environment the user has to start the GRAFSIM program and open the file just created in the CATGEN program. Since all the GRAFSIM windows exceed the borders of this article a detailed analysis is restricted. All characteristics, time diagrams of the inertia elements and elastic-dumping elements as an answer for dynamic and kinematic excitations are shown in [4].

3. CONCLUSION

Since the CATGEN program has a compact structure, it has a source code that gives the possibility for the next liable automations that can take place in the process of mechanical systems analysis. More work is being done in order to extend the possibilities of the programme, and to integrate into every environment (CATGEN, GRAFSIM, MATLAB – SIMULINK). Only fully integrated environments will limit to a minimum the necessary time for carrying on analysis of vibrating mechanical systems with many degrees of freedom. The presented programme environment gives the following possibilities:

- to calculate time responses of any model elements on a set of dynamic excitations or kinematics ones in the function of displacement, velocity and acceleration and initial conditions applied on displacements and velocities,
- to determine decibel amplitude-frequency-phase characteristics of inertial elements,
- to test stability of analysed models of mechanical systems (Nyquist characteristics),
- to generate state matrix equations of the discrete model of the mechanical system,
- to show zeroes and poles of characteristic equations on a complex surface and in a tabular form,
- to generate matrix shape of a block diagram in the case of defined excitations and responses of the system.

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