MODELLING TORSIONAL VIBRATIONS IN SIMMECHANICS

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Abstract: This paper deals with modeling of torsional vibrations of mechanical system in Matlab/Simmechanics. Model of mechanical system was created in Matlab/Simulink Simmechanics toolbox. Results of simulation and test results on the real object were compared and presented in this article.

1. INTRODUCTION

In among groups of mechanical systems and mechanisms can be separated group of systems which behavior can be modeled using 2 or 3 mass/inertial system connect by spring and damper elements. Devices like rolling mills, robotic arms, transmission systems, flexible shafts in still rising demands for higher motion speed, provide to possibility of excitation of resonance frequencies. In addition, the increasing demands for better dynamics generate a constant need for new solutions. To model and simulate mechanical systems can be used a large group of software. Simmechanics with Simscape language and Matlab/Simulink environment is often chosen for modeling, simulating and development of various mechanical systems. Simmechanics software provides diagram block modeling and can be a reliable tool for modeling mechanical systems using rigid finite elements or even FEM [2]. Simmechanics block library contains groups of basic elements, parameters or functions like bodies, sensors, actuators, joints, springs and dampers. By connecting blocks and setting parameters of some of the blocks can be modeled almost each mechanical system.

2. MODEL OF MECHANICAL SYSTEM

Laboratory stand (Fig. 1) consists of AC motor drive and shaft of mechanical device with connected flexible shaft. On shaft were mounted two disks which position can be changed by moving them along shaft. This mechanical system was modeled in simulink environment as three inertial system connect with elastic rotational spring elements. Each inertia element was modeled as body with two parameter, matrix of inertia and dimension. Inertia of shafts and clutches was neglected. To model rotational spring it was used the Joint Sensor and the Joint Actuator block and Gain block from simulink (Fig 3), gain value was calculated using shear modulus of elasticity. Fig. 2 shows model created in simulink environment with Simmechanics block diagrams. Visualization of modeled system can be displayed in time of simulation and each body can be represented by ellipsoid of inertia (Fig 4)
Between AC motor shaft and flexible shaft with disks is located the torque sensor for measure torque generated by motor and transmitted to mechanical system. Measurements from torque sensor can be visualized on the screen of oscilloscope or saved on the computer hard disk drive via analog digital converter with usb interface. Measurements are saved as values with specified sample rate, on saved values can be performed FFT transformation. At simulations performed on laboratory stand sample rate of measurements were five times greater than second torsional vibration frequency of system.

Stiffness coefficient value of each elastic element was obtained from its geometry and material modulus of elasticity in shear. Geometry and moment of inertia of each element of mechanical system were combined and modeled in simmechanics, AC motor was considered
only from mechanical point of view, electric parameters were neglected and only rotor’s inertia was included in model.

Figure 3. Diagram of blocks modelling shaft stiffness

Figure 4. View of Simmechanics visualization window with model in time of simulation

3. SIMULATION RESULTS

Model was analyzed in two cases, first one when disks were close together (50 mm) and second one when disks were far from each other (300 mm). Resonance frequency of torsional vibrations of mechanical system was obtained from signal of torque sensor measurements using FFT algorithm (Fig. 5, 6) and from angular position of each body in simulation (Fig. 7, 8). Results have been compared in Table 1.

<table>
<thead>
<tr>
<th>Distance between disks</th>
<th>Frequencies calculated from eigenvalues of stiffness matrix</th>
<th>Frequencies measured from frequency response of signal from torque sensor</th>
<th>Frequencies measured from frequency domain in Simmechanics model</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 mm</td>
<td>124,66 Hz, 211,45 Hz</td>
<td>129,87 Hz, 210,28 Hz</td>
<td>123,3 Hz, 210 Hz</td>
</tr>
<tr>
<td>50 mm</td>
<td>123 Hz, 516,8 Hz</td>
<td>127,18 Hz</td>
<td>124,8 Hz</td>
</tr>
</tbody>
</table>

Table 1. Vibration frequencies obtained from simulations and measurements

Figure 5. Angular position of disk in frequency domain response measured on laboratory stand (300 mm between disks)

Figure 6. Angular position of disk in frequency domain response measured on laboratory stand (50 mm between disks)
3. CONCLUSIONS

Measurements from tests and simulations were similar in both cases and values of torsional frequencies were comparable. Even for that simplification and neglects in model creation, Simmechanics is a suitable tool for modeling mechanical systems. Strong point of modeling in Simmechanics is possibility to use Matlab m-files and Simulink models. With connection and use of the other toolboxes in environment of Matlab/Simulink it is easy to model physical systems which cover multiple domains like electrical, mechanical, pneumatic etc.

REFERENCES


MODELOWANIE DRGAŃ SKRĘTNYCH W SIMMECHANICS

Streszczenie: W artykule przedstawiono sposób modelowania drgań skrętnych w środowisku Matlab/Simulink w programie Simmechanics. Dla układu elektromechanicznego składającego się z silnika prądu przemiennego z dołączonym do niego podatnym wałkiem z dwiema tarczami został utworzony model drgań skrętnych w programie Simmechanics. Utworzony model miał na celu określenie częstotliwości drgań skrętnych powstających w układzie jak i wpływ położenia tarcz na powstające częstotliwości. Wyniki symulacji oraz wyniki badań na obiekcie rzeczywistym zostały porównane i przedstawione w artykule.