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Solution of rotating masses of transport system using MATLAB/Simulink

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Summary

In the article we give attention to mechanical system and related subject of controlling dangerous vibrations of mechanical systems propulsion. In the center of attention there is namely the mechanical system of conveyor propulsion. In order to specify the intensity of vibrations, dynamic analysis is used and for its realization we have to reduce mechanical system. The article therefore presents also the kinetic differential equations that describe reduced mechanical system with damping. Besides mechanical system there is also a brief description of simulation program MATLAB/Simulink, which is closely related to the topic of controlling torsional vibrations, because this program manages to predict it, to a certain extent. Using this program we are able to solve different kinds of systems and vibrations, in our case it is the three-mass torsionally oscillating mechanical system and this solution is also encompassed in the article. It is important to note that this is only the plan of solution description.

1 Mechanical system

Basic illustration of torsionally oscillating mechanical systems, namely propulsion of conveyor belt is in Figure 1. Mechanical system is propelled by synchronous electric motor with speed-moment characteristic $M_M = f(\omega)$. In the output there is operational appliance of performance with constant torque load M_Z. The performance of electric motor is transferred by belt drive over transmission up to driving shaft of conveyor drum. Driving and driven element of mechanical system is connected to transmission by flexible shaft coupling. Coupling provides transferring of load torque.

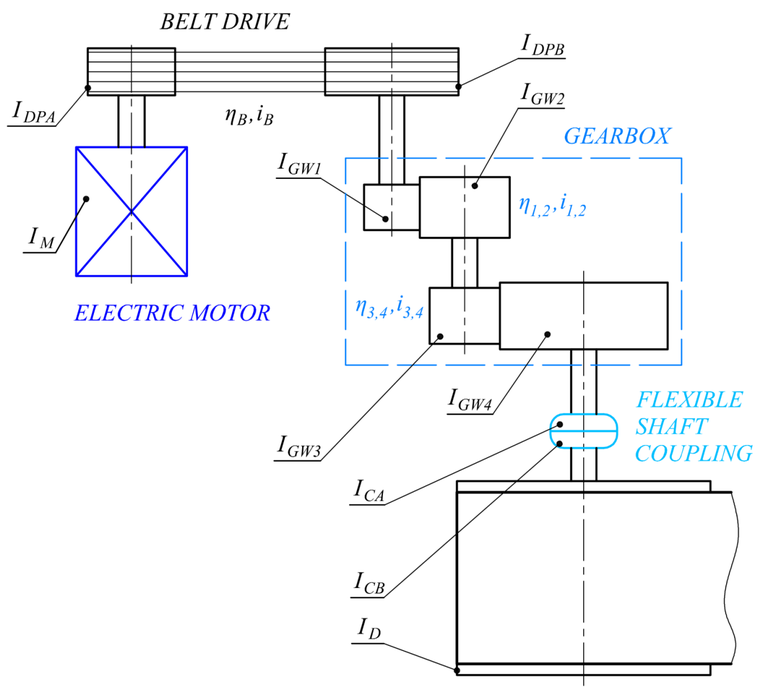

Figure 1. Mechanical system.

Every part of the engine has its dynamic properties characterized by moment of inertia, stiffness and damping. To consider the size of vibration in system, the dynamic analysis is used. While implementing dynamic analysis the system (Figure 1) is replaced by mathematical model (Figure 2) that consists in discs connected to stiffness k and viscose damper b by linear springs.

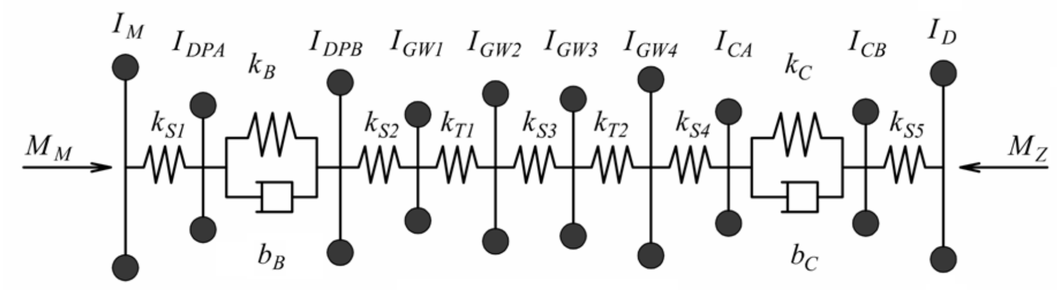

Figure 2. The dynamic model of mechanical system.

In Figure 3 there is former dynamic model reduced to three-mass system. This reduction was implemented in order to simplify calculation of torsional vibration size – system in Figure 2 contains a lot of connecting elements with moment of inertia and it complicates achieving a result.

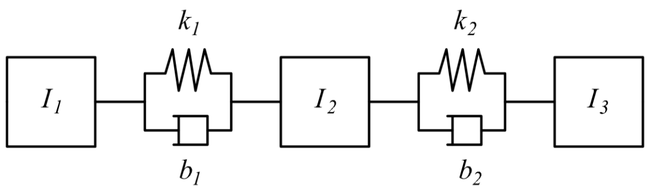

Figure 3. Reduction to three-mass system.

Kinetic equations of damped three-mass mechanical system (Figure 3) are composed by using of releasing method and look like:

$$I_1\ddot{\varphi}_1 + b_1(\dot{\varphi}_1 - \dot{\varphi}_2) + k_1(\varphi_1 - \varphi_2) = M_M, \quad (1)$$

$$I_2\ddot{\varphi}_2 - b_1(\dot{\varphi}_1 - \dot{\varphi}_2) + b_2(\dot{\varphi}_2 - \dot{\varphi}_3) - k_1(\varphi_1 - \varphi_2) + k_2(\varphi_2 - \varphi_3) = 0, \quad (2)$$

$$I_3\ddot{\varphi}_3 - b_2(\dot{\varphi}_2 - \dot{\varphi}_3) - k_2(\varphi_2 - \varphi_3) = -M_Z. \quad (3)$$

2 Solution in program MATLAB/Simulink

Simulation programs are nowadays frequently utilized means for establishing systems or products into area of using. They became trend because they help predict and consequently prevent from possible harmful influence. Modeling of mechanical system in MATLAB/Simulink based on the input data (Table 1, Figure 4,) helps us graphically represent the time progressions of kinetic and dynamic quantities (Figure 5).

Modifying derived kinetic equations (1), (2) and (3) for three-mass model:

$$\ddot{\varphi}_1 = \frac{1}{I_1}\left[-k_1\varphi_1 + k_1\varphi_2 - b_1\dot{\varphi}_1 + b_1\dot{\varphi}_2 + M_M\right],$$

$$\ddot{\varphi}_2 = \frac{1}{I_2}\left[k_1\varphi_1 - (k_1 + k_2)\varphi_2 + k_2\varphi_3 + b_1\dot{\varphi}_1 - (b_1 + b_2)\dot{\varphi}_2 + b_2\dot{\varphi}_3\right], \quad (4)$$

$$\ddot{\varphi}_3 = \frac{1}{I_3}\left[k_2\varphi_2 - k_2\varphi_3 + b_2\dot{\varphi}_2 - b_2\dot{\varphi}_3 - M_Z\right].$$

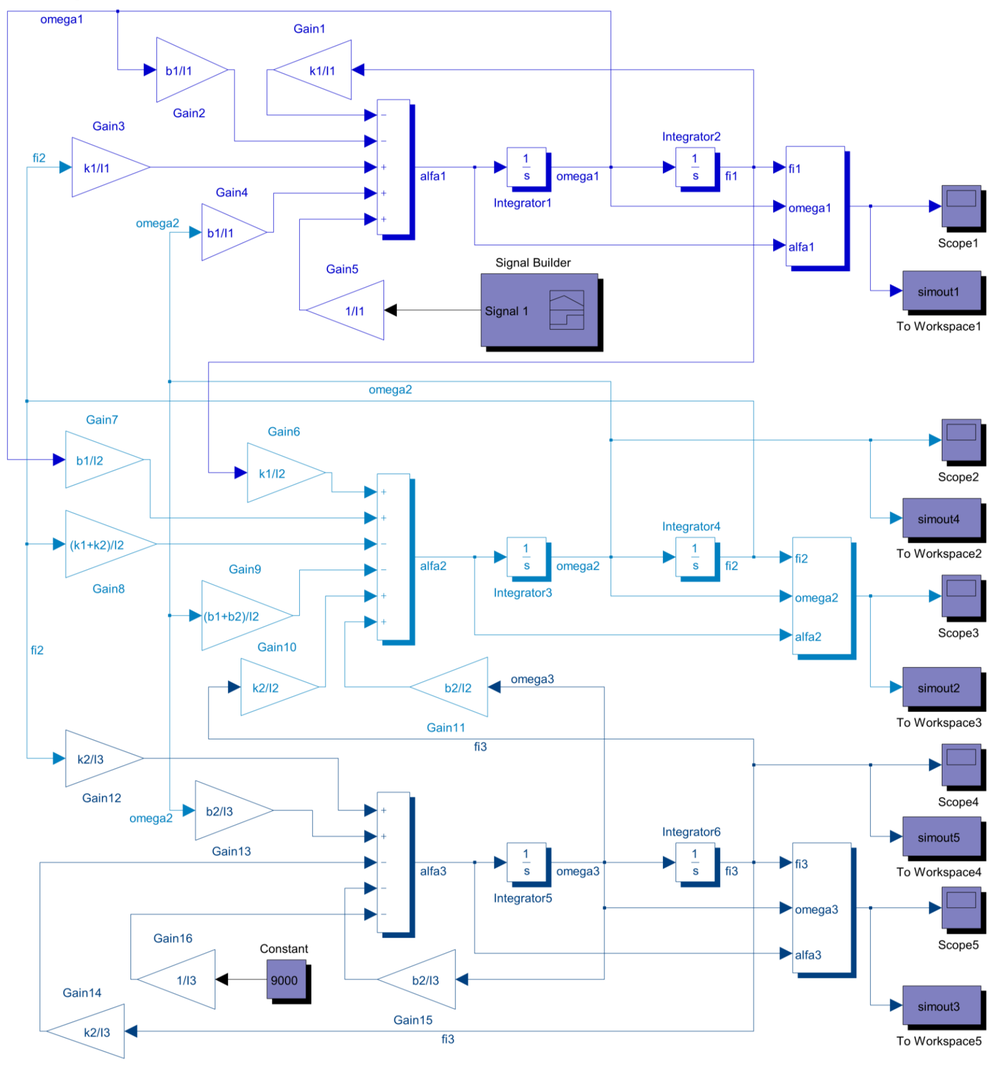

Figure 4. The block diagram of three-mass system in Simulink.

Table 1. The forms of input data recording in Simulink.

M-file

% input data
% I – [kg.m2]
% k – [(N.m)/rad]
% b – [(N.m.s)/rad]
I1=80; I2=300; I3=800;
k1=230000; k2=40000;
b1=1700; b2=4000;

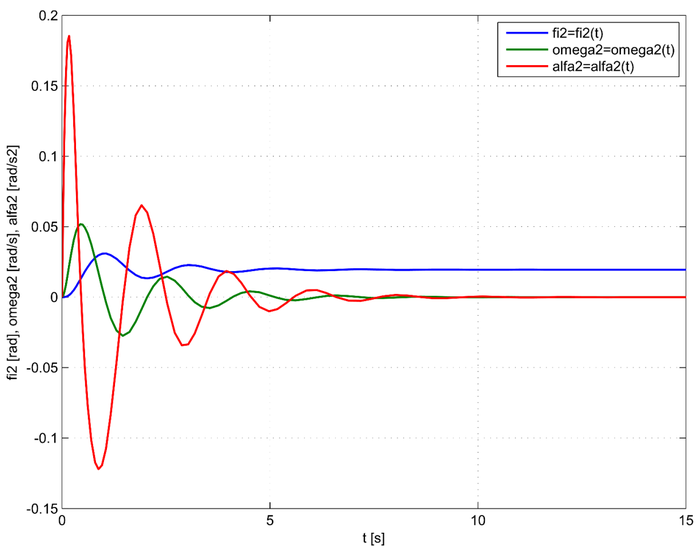

Figure 5. The simulation results in Simulink.

Acknowledgments

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