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# Modelling and synthesis of discrete – continuous subsystems of machines with damping

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**Abstract:** Nowadays discrete-continuous systems are more commonly used in designing models of mechanical systems. Therefore, there has been an increasing interest in such methods of synthesis which could be applied both for systems with converged and continuously distributed parameters. Such synthesis involves a search for a structure of a discrete-continuous system that complies with some specific requirements concerning certain phenomena of dynamics. The continued fraction method of the synthesis of the dynamic characteristics distribution makes it possible to obtain cascade structures of the discrete-continuous system. The investigation into the structures of cascade systems was conducted by means of the software method for distributing the dynamic characteristics to the continued fraction based on graphs and structural numbers.

**Keywords**: Dynamic flexibility; Hypergraph; Continued fraction based;

## 1. MODELLING OF MECHANICAL SYSTEMS WITH CONVERGED AND CONTINUOUSLY DISTRIBUTED PARAMETERS

The modelling of discrete-continuous vibrating mechanical systems vibrating longitudinally is considered on the basis of the system in Fig.1.

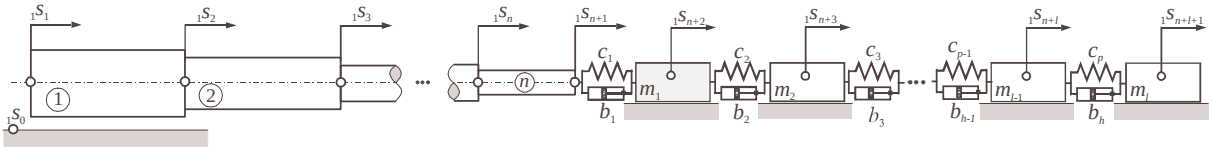


Figure 1. The discussed discrete-continuous model of a longitudinally vibrating system

The dynamical characteristics of the investigated system, determined by means of the graph and structural number method, constitute the starting point for the synthesis, which involves a search for such structure and such parameters that would fulfil the assumed requirements. The elements of the discussed class of mechanical systems are treated as two-terminal networks [1].

The mechanical system, made up of both converged and continuously distributed parameters, is modelled with the second category graphs, also called hypergraphs, where the subsystem with converged parameters is substituted by the second category block graph ${}^{2}_{1}X^{(n+1)}$ with defined internal structure – which is a configuration of couplings, also referred to as polar graph ${}_{00}X$ of this subsystem.

The hypergraph [Fig.2] of the dynamical system with discrete – continuous distribution of parameters is accomplished by representing the system model as a structure (the concept of a structure of a system is not unique and should be strictly defined each time). In this paper, the concept is understood in accordance with [1 - 10], where the physical system parameters are assigned to the graph elements.

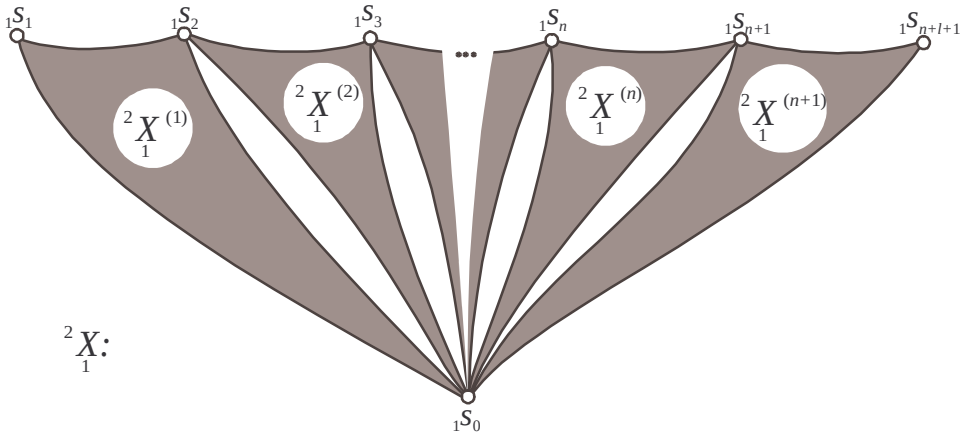


Figure 2. Hypergraph of the model of the discrete-continuous system

The discussed method of modelling discrete-continuous mechanical systems involves the unique transformation essential for the solutions of the syntheses and analyses of such systems. Accordingly, at least one inverse transition from the characteristics through parameters to the system is a unique transformation.

## 2. THE SYNTHESIS OF MECHANICAL SYSTEM WITH DAMPING OF PROPORTIONAL TO INERTIAL PARAMETERS

The synthesis of mechanical system with proportional damping to inertial parameters [8] is:

$$b = 2h \cdot \sum_{i=1}^{n} m_i \tag{1}$$

where: $b$ - value of center damping; $h$ - parameter answering for damping of system ($h = \text{idem}$), having dimension of frequency; $m_i$ - value of inertial elements determination in result of synthesis discrete systems.

Value of parametr *h* has to be determination of Eq.2:

$$0 < h < |f_{min}|, \tag{2}$$

where: $|f_{min}| \neq 0$ .

In Fig.3. damping system, where value of parameter *b* qualifies of medium in which this system moves, has been shown.

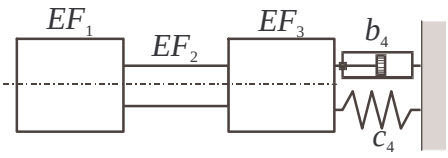


Figure 3. Geometric structural form of the synthesised discrete-continuous system with damping

## 3. ANALYSIS OF SYNTHESISED SYSTEM BY MEANS THE METHOD GRAPHS AND STRUCTURAL NUMBERS

The programme of analysis of mechanical systems has been created on the base of graphs method (see page 1) and them connections with structural numbers [1 ÷ 10]. Results of analysis are presented in Fig.4.

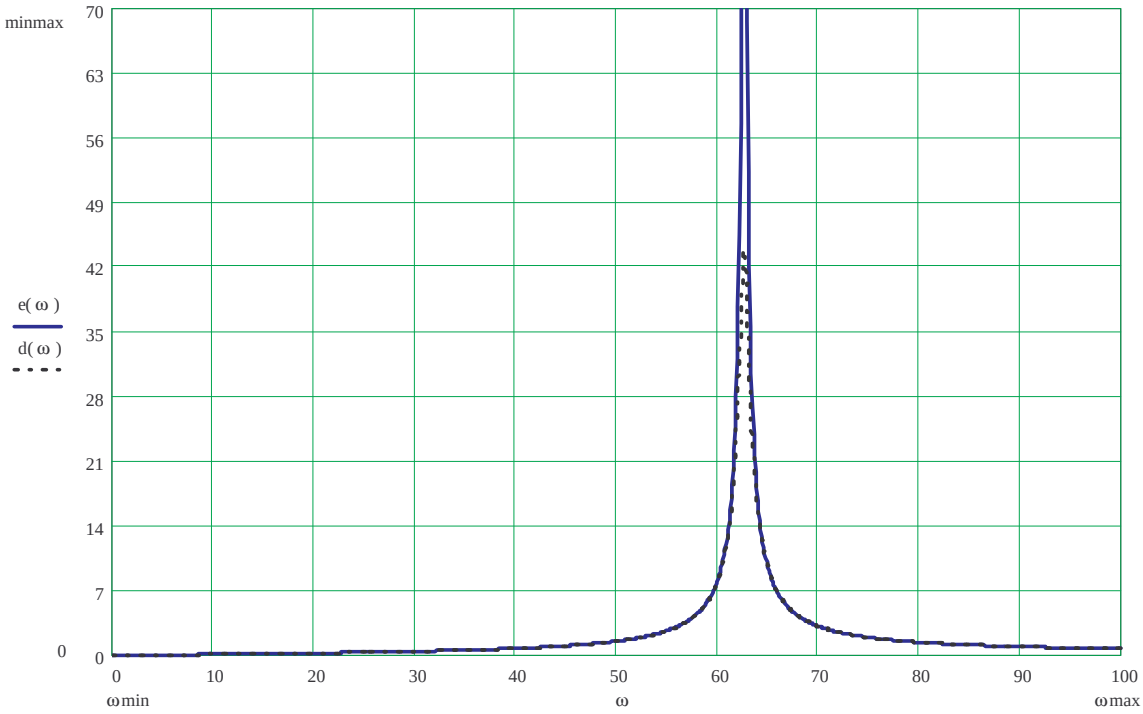


Figure 4. Diagram of dynamical flexibility of synthesised system
$d(\omega)$ - dynamic characteristics with damping

## 4. CONCLUSION

The greatest intensity of vibrations might be fund in conditions of resonance. They can be avoided due to a proper selection of frequency free vibrations. Exiting the resonance zone is a crucial condition of the machine's work but it does not eliminate entirely the problem of vibrations. The free vibrations frequency appear in more than one machine. In these cases damping has a decisive role as it lowers the vibration amplitude in a serious way. That is why the methods of modelling and synthesising, concerning the discrete-continuous systems presented in the work, may influence considerably the research and selection of parameters of the analyzed machine.

## ACKNOWLEDGEMENT

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