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ENTERING THE EXCITATION INTO A MECHANICAL SYSTEM WITH DYNAMIC ELIMINATORS OF VIBRATION

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Summary System consists of many objects connected by visco-elastic elements. The objects are equipped with freely rotating vibrators that can eliminate or increase the object's vibration. The paper presents the possibility of elimination the object's vibration. As the result of object's vibration there are vibration forces that push the free elements to a new positions. The authors will discus the relations that describe dynamical properties of the system.

In the earlier papers [1-3] the author showed the possibility of compensation the periodic excitation by dynamic eliminator for one object. Dynamic forces excited the object's vibration. There were a freely rotating vibrators (pendulums, balls or rollers) and they were going to the position for which the vibration of the system vanished. Forces generated by free elements compensated the excitation - the system showed to be balanced.
In the paper we are going to explain the possibility of compensating the excitation that acts on more complex system. The system is showed in Fig.1. There are many objects and each of them has two freely rotating vibrators (pendulums). It is assumed that all object are the same with a mass *M*. Also visco-elastic properties, *c* and *k*, of the elements connecting the objects are the same. A monoharmonic excitation is applied to all objects or only one of them.

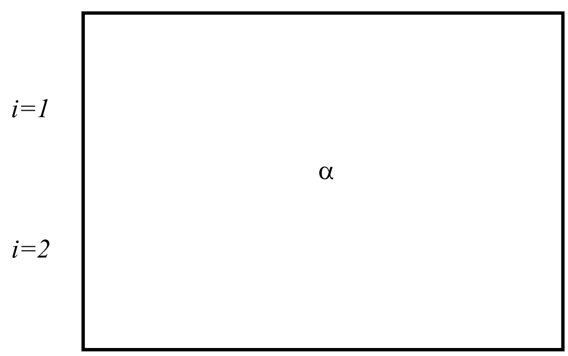

Fig.1. Objects with the pendulums as the vibrators

The motion of the *ijth* object is defined by an equations

$$M\ddot{x}_{ij} + c(2\dot{x}_{ij} - \dot{x}_{i-1,j} - \dot{x}_{i+1,j}) + k(2x_{ij} - x_{i-1,j} - x_{i+1,j}) = P_{oij}\cos(\omega t) + mR((\omega + \alpha_{ij1})^2\cos(\omega t + \alpha_{ij1}) + (\omega + \alpha_{ij2})^2\cos(\omega t + \alpha_{ij2})),$$

$$M\ddot{y}_{ij} + c(2\dot{y}_{ij} - \dot{y}_{i,j-1} - \dot{y}_{i,j+1}) + k(y_{ij} - y_{i,j-1} + y_{i,j+1}) = P_{oij}\sin\omega t + mR((\omega + \alpha_{ij1})^2\sin(\omega t + \alpha_{ij1}) + (\omega + \alpha_{ij2})^2\sin(\omega t + \alpha_{ij2})), \quad (1)$$

where *i* is a number of the row and *j* is a number of the column of the object's position.
The position of the vibrators are defined by an angles α_1, α_2 with respect to the coordinate system, *0xy*, rotating with the same velocity as the excitation. The motion of the vibrators, *1* and *2*, of the *ijth* object is governed by

$$mR\ddot{\alpha}_{ij1} = m(\ddot{x}_{ij}\sin(\omega t + \alpha_{ij1}) - \ddot{y}_{ij}\cos(\omega t + \alpha_{ij1})) - n\dot{\alpha}_{ij1}, \quad (2)$$

$$mR\ddot{\alpha}_{ij2} = m(\ddot{x}_{ij}\sin(\omega t + \alpha_{ij2}) - \ddot{y}_{ij}\cos(\omega t + \alpha_{ij2})) - n\dot{\alpha}_{ij2},$$

where *m* and *R* are the mass and the radius of the pendulum.
If the pendulums are able to compensate the excitation of the *ith* object then the vibrators should move in synchronous way with the excitation and go to the final positions

$$\alpha_{ij1f} = -\alpha_{ij2f} \qquad \cos\alpha_{ij1f} = \cos\alpha_{ji2f} = -P_{oij}/2mR\omega^2. \quad (3)$$

If the excitation is too large and the vibrators are not able to compensate the *ijth* object`s excitation then they vibrators occupy the position opposed to the excitation ($\alpha_f = \pm\pi$). They only compensate a part of the excitation and the object's vibration does not vanish. The rest of the excitation ΔP goes to the adjacent objects.

$$\Delta P_{oij}(t) = P_{oij} - 2mR\omega^2 . \qquad (4)$$

If the force transmitted to the next objects by the visco-elastic elements is also too large then again a part of it goes to the adjacent objects, etc. In this way the excitation spreads in the system in decreasing way.
To prove this hypothesis the detailed analysis should be done. In Fig.2 there is the results of the simulation of the system from Fig.1. It can be seen that the pendulums behave in the way as it was expected.

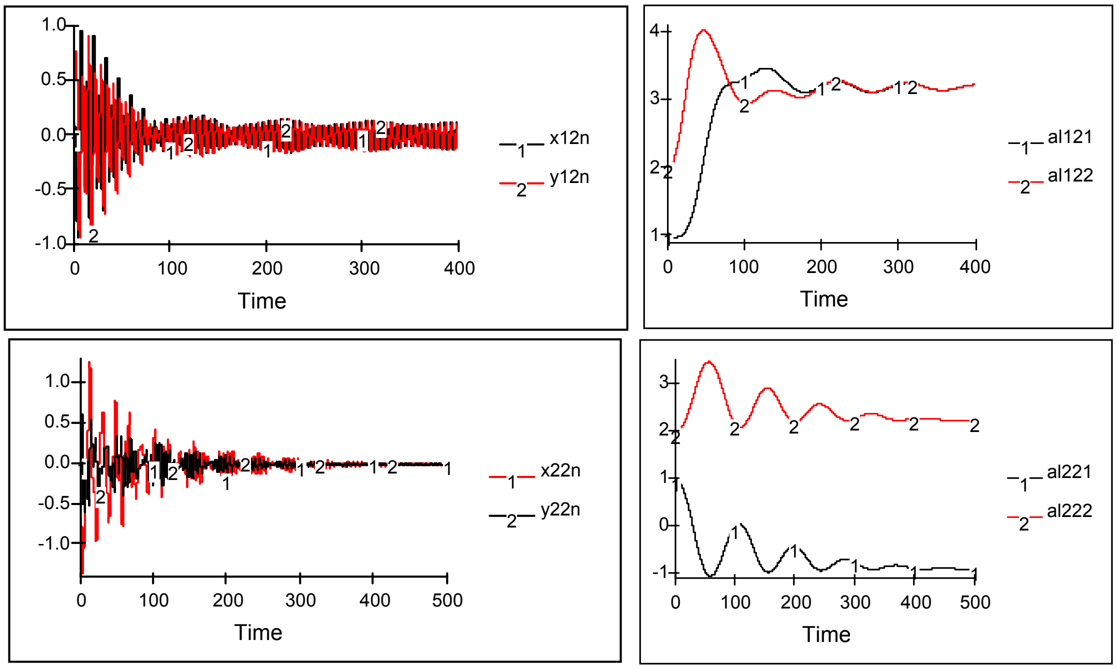

Fig.2. Vibrations of the objects *12, 22* and the positions of the theirs vibrators vs time

The vibrators of the object *12* go to the positions $\alpha_{121} = \alpha_{122} = \pi$ opposed to the excitation P_{o12} but they are not able to compensate object's excitation. The vibration of the object *12* through the visco-elastic element generates vibration of the object *22*. The vibrators of the object *22* change their position in such a way to eliminate the object's vibration. In this way the excitation is restricted to object *12* and its neighbors.
The vibrators will compensate the excitation if its frequency is greater than the natural frequency of the objects. In opposite situation the vibrators will increase the vibrations.
The resistance of the vibrators decreases the efficiency of the system.

References

[1] Majewski T., Synchronous vibration eliminator for an object having one degree of freedom. *Journal of Sound and Vibration,* 112(3), 1987

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[3] Majewski T., Synchronous Elimination of Vibrations in the Plane. Method Efficiency and its Stability. *Journal of Sound and Vibration*, No. 232-2, 2000, pp.573-586