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Optimization of the Two-Mass Oscillator regarding the Accumulation of Energy at Mechanical Resonance

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Abstract: *In the considered two-mass oscillator, the excitation force is acting on one mass (small mass) and the reception of the energy occurs on the second mass (bigger mass). The two-mass oscillator will be optimized regarding the maximal energy accumulation of the second mass. The values of the stiffness of particular connecting spring elements, mass values, and amplitude of excitation force will be used as parameters of the optimization process. The continuously delivered energy to the oscillator will be compared with the energy impulses received from the second mass.*

Keywords: Mechanical resonance, vibration, energy accumulation , oscillator

1. Introduction

In this article, the task of optimizing the parameters for a dual mass oscillator was undertaken. In the example considered (Fig. 1), the masses are connected by means of 3 springs. The harmonic forcing F = F0 sin wt acts on the smaller mass m1, which vibrates with amplitude A1. The second mass vibrates freely with amplitude A2.

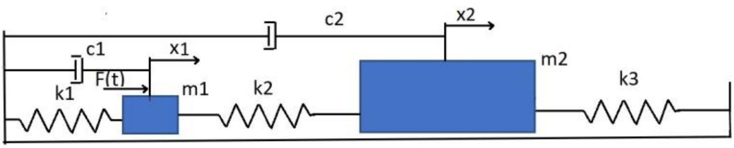
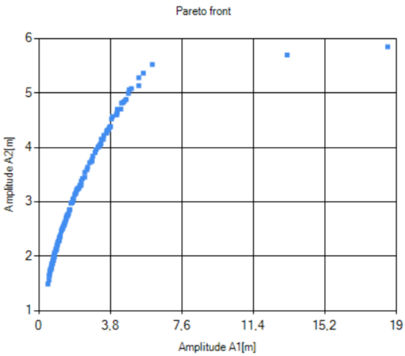


Fig. 1. The schematic view of the investigated two-mass oscillator

Based on known relationships, the amplitudes of A1 and A2 vibrations of both masses during resonance can be determined. From the point of view of a certain application, it becomes important to optimize the oscillator parameters such as the stiffness coefficients k1, k2 and k3 from the point of view of maximizing the amplitude of vibrations A2 at the assumed masses m1 and m2 and at the given amplitude of the exciting force. This type of topic has not been discussed so far.

2. Results and Discussion

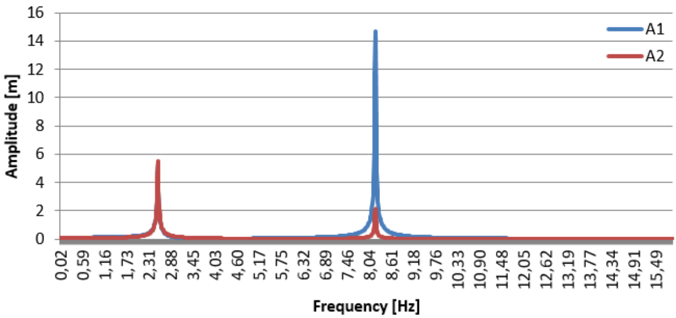
For optimization purposes Strength Pareto Evolutionary Algorithm was used. As multi-criteria and pareto algorithm, SPEA satisfied need of both minimalization of A1 amplitude and maximalization of A2, and possibility of choice of realizable solution (not only optimal one). Using mathematical formulas for A1 and A2 amplitude, algorithm is searching for close to optimal solutions and presenting them in form of pareto front.



Damping coefficient c1= 0.1 Ns / m,
Damping coefficient c2= 1 Ns / m,
Force amplitude F0= 100N,
Mass m2= 5 kg.
Spring stiffness withdrawn from 1 to 1800 N / m
The mass m1 was generated in the range of 0.1 to 1 kg.
Test startup parameters:
Number of generations: 50
Population size: 2500
Pareto set size: 1250
Crossover probability: 0
Mutation probability: 0.9

Fig. 2 Exemplary pareto front graph

Algorithm is working with fixed values of c1 and c2 damping and the amplitude of the external force F0, while stiffnesses k1, k2, k3 and masses m1 and m2 are changeable. Except minimalization and maximalization of goal functions solutions are also limited by natural frequency of system.



Optimal parameters:
k1= 200N/m,
k2= 1509N/m,
k3= 1261N/m,
m1= 0.73kg
m2= 5 kg,
A1= 5.35m,
A2= 5.47m.

Fig. 3 Exemplary amplitude dependency on frequency graph

The results of optimization have been confirmed experimentally.

3. Concluding Remarks

Based on the optimization, the configuration of the stiffness coefficients of individual spring elements at which the maximum amplitude A2 of the mass m2 occurs. The influence of the masses m1 and m2 as well as the damping coefficients c1 and c2 on the maximization of the objective function was also determined.

References

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