Resonance steady states and transient in some non-ideal systems

Yuri V. Mikhlin[*] and Yana O. Lebedenko[*]

[*]*Department of aApplied Mathematics, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine*

Abstract. We study a resonance behavior of two system with a limited power-supply (or non-ideal systems, NIS). Namely, the NIS having the pendulum as absorber, and the NIS presented the portal frame are considered. The multiple scales method is used to describe such systems dynamics near the resonance 1:1. Transient in these NIS is successfully constructed using the rational Padé approximations. Tending of the transient to the resonance steady state with increase of time is shown.

Introduction

The systems with limited power supply (or non-ideal systems, NIS) are characterized by interaction of the source of energy and elastic sub-system which is under action of the source. For NIS the external applied excitation depends on the excited elastic sub-system dynamics. The most interesting effect appearing in non-ideal systems is the Sommerfeld effect [1], when the large amplitude resonance regime is appeared, and the big part of the system energy passes from the energy source such vibrations. Resonance dynamics of the systems with limited power supply is first analytically described by V.Kononenko [2]. Then different aspects of the NIS dynamics are investigations in numerous papers (see, in particular, an overview [3] and a book [4]). We analyze here a resonance dynamics of two 3-DOF non-ideal systems (Fig.1), namely, the system having the pendulum as absorber, and the system describing dynamics of the portal frame having the shaft supported by two bearings where two steel wires have essentially nonlinear characteristics. Both steady state resonance regimes and transient are constructed in such systems.

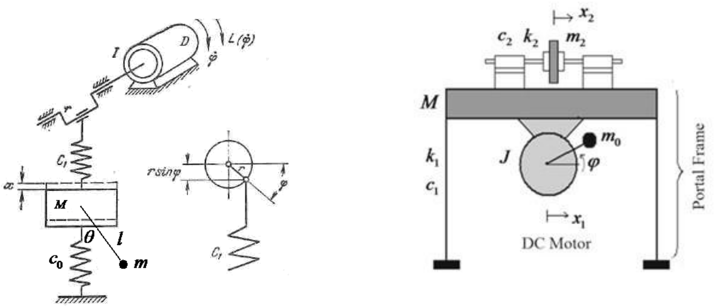

Figure. 1. Two models under consideration

Results and discussion

Dynamics of the system resonance behavior is described by the multiple scales method, where the small parameter characterizes a smallness of the absorber masses with respect to the masses of the system elastic part, a smallness of vibration components in variability in time of the motor rotation angle velocity with respect to the main constant component, a smallness of dissipation. Small nonlinearity in elastic forces is also taken into account. A steady state is constructed. Then a transient in the system is successfully constructed by Padé approximants containing exponents. Numerical simulation demonstrates both the good accuracy of the constructed steady state, as well an approach of the obtained transient to the resonance steady state with increasing time. It is also shown that the essential reduction of the resonance vibration amplitudes can be obtained by choose of the system parameters.

References

[1] Sommerfeld A. (1902) Beiträge zum dynamischen ausbau der festigkeitslehe. *Phys. Z.* 166-186.
[2] Kononenko V.O. (1969) Vibrating Systems with Limited Power Supply. Illife Books, London.
[3] Balthazar J.M. et al. (2018) An overviewon the appearance of the Sommerfeld effect and saturation phenomenon in non-ideal vibrating systems (NIS) in macro and mems scales. *Nonlinear Dynamics* **93**(1): 19–40.
[4] Cveticanin L., Zukovic M., Balthazar J.M. (2018) Dynamics of Mechanical Systems with Non-Ideal Excitation. Springer, Cham.
[5] Baker G.A., Graves-Morris P. (1981) Padé Approximants. Addison-Wesley, London.