Influence of Geometric Nonlinearity and Heating on the Dynamic Parameters of Free Natural Vibration of Nylon Springs with Negative Thermal Expansion

Justín Murín [a)], Vladimír Goga, Juraj Hrabovský, Juraj Paulech, Gabriel Gálik, and Vladimír Kutiš

Institute of Automotive Mechatronics, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava, Ilkovičova 3, 841 04 Bratislava, Slovak Republic

[a)] Corresponding author: justin.murin@stuba.sk

Abstract. The article is devoted to the study of the influence of geometric nonlinearity and heating on the parameters of free natural vibration of nylon springs (artificial muscles) with negative thermal expansion. The natural frequencies of free vibration of a spring with one degree of freedom of movement are determined using static deflection caused by mechanical and thermomechanical loading. The calculation models of static deflection include geometric nonlinearity as well as spring heating. The calculation models are based on the tensile characteristic of the spring, which consists of three parts. In the first part, the loading forces overcome the initial compressive prestress of the spring. The second, relatively short part is characterized by the linear response to the spring load. The third part of the characteristic represents the nonlinear course of spring elongation caused by the strengthening of the linear stiffness of the spring. The computational model for calculating elongation and thermal shortening is based on the Update Lagrange Formulation (ULF) of finite displacements and includes all three parts of the measured spring characteristic. A significant influence of geometric nonlinearity and spring heating on its natural frequency is found. The results of this innovative computational model are compared with the results of the calculation using the classical linear spring model and are also verified by measurement.