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Abstract

The nonlinear vibrations control of a vertically supported Jeffcott-rotor system is investigated within this article. A modified version of the controllers based on the saturation phenomenon is connected to the system via quadratic coupling nonlinearity. Time-delays in the control loop are included in the considered model to explore their influences on the controller performance and stability chart. Asymptotic analyses are sought to obtain an approximate solution to the time-delayed differential equations simulating the whole system dynamics. Bifurcation control is conducted by means of bifurcation-diagrams. The analyses illustrated that the proposed controller can suppress the system vibrations effectively, but the system may lose its stability via Hopf bifurcations if time-delays exceed a specific value. The limits of the time-delays at which the system solution remains stable have been determined. Then, the acquired results are simulated numerically by utilizing the **ODE45** and **DDE23** Matlab solvers. The nature of the system motion is analyzed by constructing Poincare-map, frequency-spectrum, and whirling-orbits. The numerical results showed that the system has chaotic and quasi-periodic motions in addition to the periodic ones. Finally, the optimal control parameters are reported and a comparison with recently published articles is included.

Keywords Jeffcott-rotor, Saturation phenomenon, Time-delays, Hopf-bifurcation, Periodic, Quasi-periodic, and chaotic motions, Poincare-map, frequency-spectrum.

Nomenclature

$q_1, \dot{q}_1, \ddot{q}_1$	Dimensionless displacement, velocity and acceleration of oscillations at q_1 direction.
$q_2, \dot{q}_2, \ddot{q}_2$	Dimensionless displacement, velocity and acceleration of oscillations at q_2 direction.
$q_3, \dot{q}_3, \ddot{q}_3$	Dimensionless displacement, velocity and acceleration of the controller that connected to q_1 direction.
$q_4, \dot{q}_4, \ddot{q}_4$	Dimensionless displacement, velocity and acceleration of the controller that connected to q_2 direction.
μ_1, μ_2	Dimensionless linear damping coefficients of Jeffcott-rotor system.
μ_3, μ_4	Dimensionless linear damping coefficients of saturation-based controller.