Nonlinear Dynamics Analysis of Electric Energy Regeneration Device Based on Vibration Energy Recovery

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Abstract. A electric energy regeneration device using two one-way clutches is proposed to extend the range of vehicles. Under the influence of nonlinear factors, the system will be unstable. Aiming at this problem, considering the time-varying mesh stiffness, mesh damping, backlash and transmission error and the reserve clearance of one-way clutch, multiple DOF nonlinear dynamic model is established. The Runge-Kutta method is used to calculate the nonlinear differential equation. The response chart, kinematic phase diagram, Poincare map and bifurcation diagram are used to analyse the influence of excitation frequency, the reserve clearance and transmission error. The results show that as the meshing frequency changes, the system response changes from period-doubling bifurcation to chaotic motion, and the average efficiency of the device's electrical energy regeneration can reach 46.13%. In addition, the influence law of parameters on the damping characteristics of the device is revealed.

Introduction

The energy crisis has brought more and more attention to energy-saving and environmental protection technologies, and the research on the vibration energy recovery of electric vehicles has become a hot spot in current research. A mechanical electromagnetic energy regeneration device using two one-way clutches is proposed to extend the range of electric vehicles. The transmission system converts bidirectional vibration of the rack into unidirectional rotation of the input shaft of the generator, which greatly improve reliability and increase efficiently. The generator will be driven in one direction to convert the kinetic energy into electrical energy. Nonlinear parameters in the energy regeneration device will affect the stability of the system and the efficiency of electric energy regeneration. Through the analysis of the nonlinear parameters in the device, considering the time-varying mesh stiffness, mesh damping, backlash and dynamic transmission error of the meshing pair and the reserve clearance of the one-way clutch, using mass centralized method to establish the multiple degrees of freedom nonlinear dynamic model. The Runge-Kutta method is used to calculate the nonlinear differential equation. The time series response chart, kinematic phase diagram, Poincare map and bifurcation diagram are used to analyse the influence of parameters. The results show that as the meshing frequency changes, the system response changes from period-doubling bifurcation to chaotic motion, and the average efficiency of the device's electrical energy regeneration can reach 46.13%. In addition, the influence law of parameters on the damping characteristics of the device is revealed. The research results can improve the stability and the efficiency of electric energy regeneration device, and achieve the goals of prolonging the cruising mileage. It can lay a profound theoretical foundation and reality significance for the research of electric energy regeneration device.

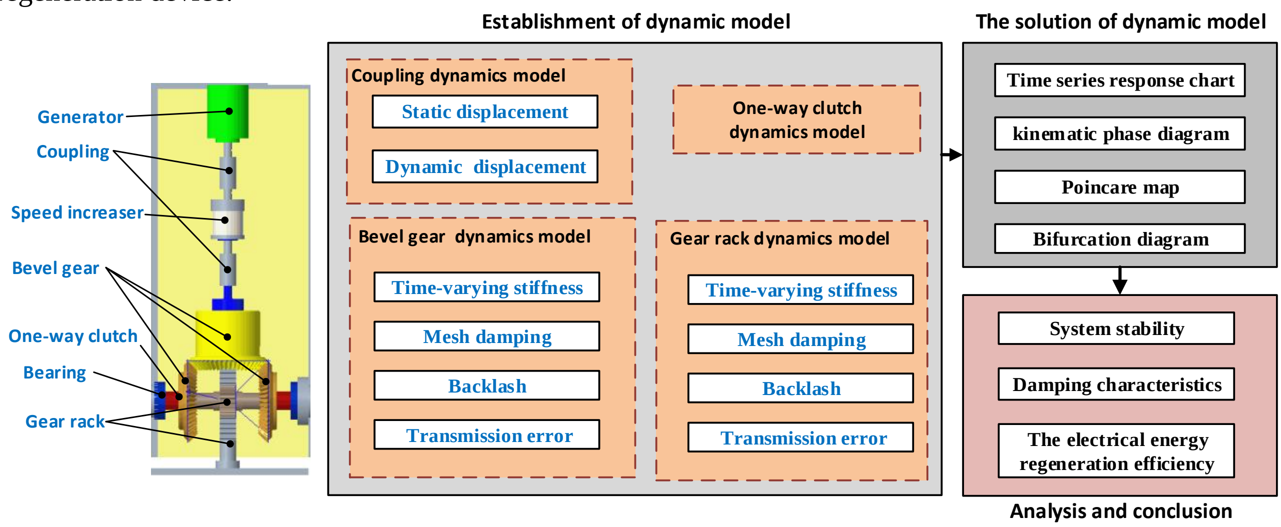

Figure 1: Flow chart of nonlinear dynamic analysis of electric energy regeneration device

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