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Experimental Research on Active Vibration Control of Elastic Plate and Damage Degradation of Actuator

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Abstract: Achieving more effective real-time vibration control of structures has been an ongoing exploration in the field of vibration engineering, and the actuator is an extremely important part of vibration active control research. In this paper, we propose a simplified iterative learning control algorithm using the real-time response of the controlled system as the control input, and build a vibration active control experimental system based on NI CompactRIO and LabVIEW platform. In the experiment, the control efficiency of the negative velocity feedback method and the iterative learning control method are compared with the elastic airfoil plate as the object. The verification results show that the vibration suppression efficiency of the latter can be improved by more than 62% compared with that of the former. At the same time, the experiments simulate the damage degradation process during the actuator life cycle, and we obtain that the decay of the actuator performance will be greatly accelerated when the damage degradation of the actuator is assumed to be linear and the damage rate is more than half. In addition, the vibration active control experimental system can obtain better vibration suppression performance at high frequency excitation under the same setup.

Keywords: Elastic airfoil, Vibration active control, Iterative learning control, LabVIEW

1. Introduction

One of the popular topics in ACSR research is the active control of vibration of laminated piezoelectric smart structures, which focuses on: numerical simulation of smart structures, numerical solution of dynamics problems and their experimental validation, design of controllers and their optimization, and optimization of piezoelectric sensor/actuator positions.
Yang et al.[1] proposed an optimal iterative learning control (ILC) for a linear discrete-time system to optimize cumulative quadratic linear indicators in the iterative domain and proved its stability, convergence, robustness, and optimality. Bai et al.[2] combined P-type iterative learning (IL) control, fuzzy logic control and artificial bee colony (ABC) algorithm to design a novel optimal fuzzy IL controller for active vibration control of piezoelectric smart structures.
There is still room for exploring the efficiency and convenience of real-time vibration control of piezoelectric intelligent structures in engineering applications. In this study, a simplified iterative learning control algorithm using only the real-time response of the controlled system as the control input is proposed, and the experimental platform and software are designed for the experiments, taking the elastic airfoil plate as the experimental object. And then, the experimental results are com-

pared and analyzed to verify the advantages of the scheme. Finally, the influence of the performance decay on the control effect during the actuator damage degradation is experimentally investigated, and the data sets are compared and summarized.

2. Results and Discussion

The conventional negative velocity feedback control method is used as a comparison to verify the effectiveness of this vibration active control system and the iterative learning control law. In view of the fact that many papers have achieved excellent vibration suppression by various methods, this paper does not seek to maximize the vibration suppression effect, and the method comparison shows that the iterative learning control scheme used in this paper can improve the vibration reduction efficiency by more than 62% compared to the conventional negative velocity feedback scheme.

Table 1. Experimental real-time amplitude

Conditions / Response amplitude(g)	Before control	Feedback control	Iterative learning control
First order frequency	1.920	1.691	1.312
Second order frequency	0.879	0.679	0.369

Table 2. Experimental real-time amplitude

Output Voltage / Response amplitude(g)	5V	4V	3V	2V	1V
First order frequency	1.312	1.383	1.467	1.686	1.839
Second order frequency	0.369	0.432	0.527	0.675	0.772

When the damage to the piezoelectric sheet is relatively minor, the overall effect of vibration suppression is only slightly reduced, while in the case of larger damage to the piezoelectric sheet (the linear damage rate of the actuator is more than half, i.e., the output control voltage at the software side is reduced by more than half of the original voltage), the performance of the piezoelectric sheet decays significantly faster. At the same time, in the case of the same damage to the actuator, the control system has a better active vibration suppression performance to a certain extent when the high frequency excitation.

3. Concluding Remarks

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