Performance evaluation of piezoelectric sensor/actuator on active vibration control of a smart beam

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Abstract: In this paper, performance of piezoelectric sensor/actuator pair and self-sensing piezoelectric actuator on the investigation of vibration characteristics and active vibration control of a smart beam are presented. The performance of piezoelectric patches on actuation and sensing is evaluated by investigating the vibration characteristics of the smart beam via various excitation mechanisms and transduction systems. For active vibration suppression of the smart beam, robust controllers are designed and experimentally implemented by using a piezoelectric sensor/actuator pair and self-sensing piezoelectric actuator. Finally, experimental results for active control of free and the first-resonance forced vibration of the smart beam are presented.

Keywords: smart beam, piezoelectric sensor/actuator, self-sensing actuator, system identification, robust controller, active vibration suppression

1 INTRODUCTION

The common sources of mechanical stresses on aerospace structures are dynamic loads and, in fact, dynamic load cycles can damage or cause a reduction in service life of aerospace structures. Therefore, the investigation of vibration characteristics of aerospace structures is one of the most important design phases of structures which are frequently experiencing dynamic loading conditions. In essence, there are tremendous amounts of numerical and experimental studies focused on investigation of the vibration characteristics and attenuation of vibration levels of aerospace structures. When the frequency of the dynamic loading matches the natural frequency of the structure, resonance occurs, and it may cause severe structural vibrations. In this situation, these severe vibrations may damage components of aerospace vehicles as these structures are generally lightweight and have low-stiffness characteristics.

The undesirable effects of induced vibration in aerospace vehicles can be exemplified by research studies for fighter-jets, helicopters and satellites. Over the past decade, research studies have shown that severe vibrations in the form of buffet can damage the components of a fighter-jet [1]. Since the flight envelope of these aerial vehicles includes many highly acrobatic manoeuvres, and speeds higher than the speed of sound, severe vibrations occur and may damage their components. The cracks in the component of fighter-jets may cost millions (US dollars) to be replaced and maintained [2]. On the other hand, helicopters are vehicles whose structures are under dynamic loading in all their flight envelope because of their rotary elements such as main rotor, tail rotor and various transmission units. Their cabin crew is regularly exposed to a high level of vibration in all flight zones and, therefore, there has been research focusing on the investigation of vibration characteristics of a helicopter seat and its effects on cabin crew health [3, 4]. Among these studies, it is mentioned that vibration of a helicopter seat causes excitation at the natural frequency of the spine and abdominal cavity of the cabin crew and exposure to these types

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