Computational study of a piezoelectric actuated interface for optimal frictional damping performance in assembled structures

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Frictional interfaces and joints in assembled structures perform a fundamental role in dissipating vibration energy from critical components through friction damping. The nonlinear behavior of these interfaces is governed by physical parameters that can be studied and utilized as passive or controllable variables. Previous studies have shown the impact that normal load and shape manipulation have on specific types of joints and interfaces, concluding that the contact pressure distribution plays a significant role in the structural nonlinear behavior. This paper aims to present a new concept of active shape and contact pressure distribution control via piezoelectric actuators in a flat-on-flat interface design to optimize frictional damping.

Keywords Piezoelectrics, friction, damping, contact pressure.

1. Introduction

Aerospace, automotive and construction are examples where advanced technology industries use assembled structures that are demanded to be robust against high cycle fatigue, to increase life and reduce costs. Joints and contact interfaces can supply damping through friction, avoiding overhauls [1]. The damping performance in these interfaces can be improved, for example, by passively modifying the shape of the interface [2] or actively controlling the normal load [3]. This research shows the design and computational study of a newly actively controlled interface with piezoelectrics, that aims to improve the damping performance of the joint by modifying its shape, and consequently the Contact Pressure Distribution (CPD).

2. Methods

A general flat on flat surface is studied by placing a thin plate under a flat and rounded punch. The punch exerts both, normal and tangential loads into the upper surface of the plate. The interface is made "active" by placing three actuators underneath that would activate/deactivate based on a feedback control which tunes their voltage amplitude in time. Initially, fundamental static actuated patterns are studied to provide basic understanding of the interfacial response. The actuators, chosen for its precision, size, time response and force levels, are piezoelectric monolithic stacks.

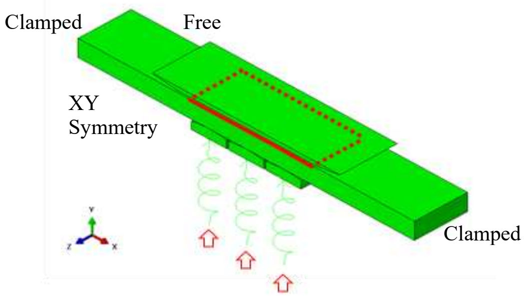

Figure 1. FE Model. Springs represents the actuators stiffness. Red arrows indicate the base excitation equivalent to voltage input. Dotted parallelogram marks the area used to extract relevant results displayed in fig.2.

3. Results

The CPDs, from the surface defined in fig.1, are illustrated in Figure 2 for three different patterns. 101: where the lateral piezos are activated and the center piezo is deactivated, 010, which is the opposite case and 111: all actuators activated.

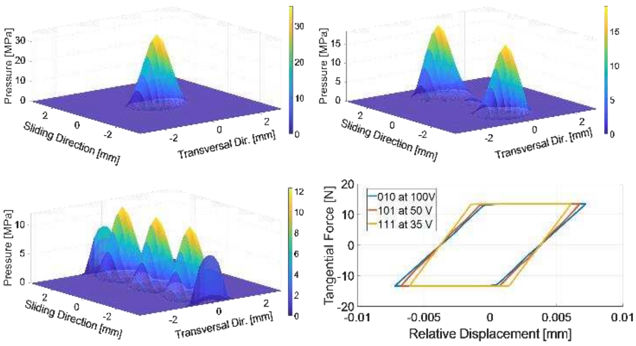

Figure 2: CPDs in a small patch of the contact punch-plate contact interface (indicated in fig.1) and their hysteresis loops at an equal input power.

4. Discussion

As expected, the total normal load in applied downwards by the punch is distributed into the contact points generated by the actuation of the piezoelectrics. It can be seen how the maximum pressure from the Hertzian-like CPD generated by the 010 pattern, of 34 MPa, distributes into more contact areas and decreases in intensity for the other patterns. These CPDs generate different condition of stiffness in the contact which causes different levels of energy dissipation, as presented in the different shapes of the hysteresis loops, thus modifying the response of the entire assembled structure.

5. References

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