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ADVANCEMENT OF THE CLAMPING MECHANISM FOR A NOVEL TENSILE ENERGY DISSIPATION DEVICE EXPLOITING CUTTING DEFORMATION

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Abstract

The importance of the study and development of energy dissipation devices has long been recognized by the academia and industry alike. Compressive energy absorbing devices lend themselves to a plethora of practical applications and, correspondingly, these safety critical mechanical elements have experienced significant development. Tensile energy dissipation devices have been given less attention than their compressive counterparts. Nonetheless, there has been some effort in the way of tensile energy absorber development. In particular, a unique cutting energy absorber, based on pulling a ring of blades ploughing through a 3.175mm thick AA6061-T6 aluminum tube extrusion, has demonstrated an excellent force/displacement response, as well as the capacity to adapt to specific force/displacement and energy dissipation requirements. However, the range of forces in which this promising energy absorber could be tested was limited by the previously used testing apparatus, reaching a maximum pulling force of approximately 45kN before apparatus failure. To address this technical shortcoming, a novel collet-type clamping device which secures the tube through which the blade ring is pulled has been designed and analyzed in order to extend the force range capacity of the dissipation device well past its previous limitations.

The aluminum tube used in the energy absorber is radially clamped by the relative motion of two threaded tapers: one inside and the other outside of a cylindrical fixture made from spring steel, which itself holds the tube. An analytical model of the tube-clamp interface is developed based on an approximate displacement field derived from the simplification of the aforementioned geometry. From this displacement field, the stress state on the inner and outer clamping surfaces is determined, from which the maximum clamping force is found. A corresponding numerical model is constructed for simulation within the FE solver LS-DYNA®, including the simulation of the aluminum tube being pulled out of the clamp, which both confirms the analytical model and gives a more complete analysis of the mechanics of the clamp. Ultimately, it is determined that the maximum pulling force supported by this device is limited only by the strength of the aluminum extrusion, with maximum pulling forces of up to 150kN shown to be supported in the simulation. Given that the threaded tapers can be adjusted at will, it is supposed that this collet type clamping device can be used to secure virtually any material with an appropriate cylindrical face which is able to mate with the clamp.