World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:12, No:04, 2018

Response Regimes and Vibration Mitigation in Equivalent Mechanical Model of Strongly Nonlinear Liquid Sloshing

Authors : Maor Farid, Oleg Gendelman

Abstract : Equivalent mechanical model of liquid sloshing in partially-filled cylindrical vessel is treated in the cases of free oscillations and of horizontal base excitation. The model is designed to cover both the linear and essentially nonlinear sloshing regimes. The latter fluid behaviour might involve hydraulic impacts interacting with the inner walls of the tank. These impulsive interactions are often modeled by high-power potential and dissipation functions. For the sake of analytical description, we use the traditional approach by modeling the impacts with velocity-dependent restitution coefficient. This modelling is similar to vibro-impact nonlinear energy sink (VI NES) which was recently explored for its vibration mitigation performances and nonlinear response regimes. Steady-state periodic regimes and chaotic strongly modulated responses (CSMR) are detected. Those dynamical regimes were described by the system's slow motion on the slow invariant manifold (SIM). There is a good agreement between the analytical results and numerical simulations. Subsequently, Finite-Element (FE) method is used to determine and verify the model parameters and to identify dominant dynamical regimes, natural modes and frequencies. The tank failure modes are identified and critical locations are identified. Mathematical relation is found between degrees-of-freedom (DOFs) motion and the mechanical stress applied in the tank critical section. This is the prior attempt to take under consideration large-amplitude nonlinear sloshing and tank structure elasticity effects for design, regulation definition and resistance analysis purposes. Both linear (tuned mass damper, TMD) and nonlinear (nonlinear energy sink, NES) passive energy absorbers contribution to the overall system mitigation is firstly examined, in terms of both stress reduction and time for vibration decay.

Keywords : nonlinear energy sink (NES), reduced-order modelling, liquid sloshing, vibration mitigation, vibro-impact dynamics
Conference Title : ICVISA 2018 : International Conference on Vibro Impact Systems and Applications
Conference Location : London, United Kingdom
Conference Dates : April 24-25, 2018