Optimization of the Tuned Mass Damper for Chatter Suppression in Turning

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Abstract: The tuned mass damper(TMD) has been successfully applied to the vibration control in machining, while the most widely adopted tuning is equal peaks, which splits the magnitude of the frequency response function(FRF) into equal peaks. However, chatter is a special self-excited problem and a chatter-free machining is determined by FRF at the cutting zone. A TMD tuning aiming at achieving the maximum chatter stability is studied, and it is formulated as an optimization problem of maximizing the minimum negative real part of FRF. By employing the steepest descend method, the optimum frequency and damping ratio of TMD are obtained, and they are compared against the equal peaks tuning. The advantage of the proposed tuning is demonstrated numerically by comparing the minimum point of the negative real part, and is further verified by damping a flexible mode from the fixture of a turning machine. A TMD is designed and placed on the fixture along the vibration of the target mode after performing modal analysis and mode shape visualization. Both of the above two tunings are applied to modify the tool point FRF by tuning TMD respectively. Chatter stability chart of the turning shows that the proposed tuning can increase the critical depth of cut 37% more than the equal peaks. Cutting tests with an increasing depth of cut are conducted on the turning machine in order to distinguish the stability limit. The tool vibrations during the machining are compared to validate the simulation results. The proposed damping design and optimization routine are able to further increase the chatter suppression effect.

Key words: tuned mass damper, frequency response function, chatter suppression, optimization, turning

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