Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

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“Modelling the Dynamics of Vibration Assisted Drilling Systems Using Substructure Analysis”

Department of Mechanical Engineering

Thursday, June 18, 2020
9:30 A.M.
Remote Defence

Supervisory Committee:
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Abstract

Vibration Assisted Machining (VAM) refers to a non-conventional machining process where high-frequency micro-scale vibrations are deliberately superimposed on the motion of the cutting tool during the machining process. The periodic separation of the tool and workpiece material, as a result of the added vibrations, leads to numerous advantages such as reduced machining forces, reduction of damages to the material, extended tool life, and enabling the machining of brittle materials. Vibration Assisted Drilling (VAD) is the application of VAM in drilling processes. The added vibrations in the VAD process are usually generated by incorporating piezoelectric transducers in the structure of the toolholder. In order to increase the benefits of the added vibrations on the machining quality, the structural dynamics of the VAD toolholder and its coupling with the dynamics of the piezoelectric transducer must be optimized to maximize the portion of the electrical energy that is converted to mechanical vibrations at the cutting edge of the drilling tool. The overall dynamic performance of the VAD system depends on the dynamics of its individual components including the drill bit, concentrator, piezoelectric transducer, and back mass. In this thesis, a substructure coupling analysis platform is developed to study the structural dynamics of the VAD system when adjustments are made to its individual components. In addition, the stiffness and damping in the joints between the components of the VAD toolholder are modelled and their parameters are identified experimentally. The developed substructure coupling analysis method is used for structural modification of the VAD system after it is manufactured. The proposed structural modification approach can be used to fine-tune the dynamics of the VAD system to maximize its dynamic performance under various operational conditions. The accuracy of the presented substructure coupling method in modeling the dynamics of the VAD system and the effectiveness of the proposed structural modification method are verified using numerical and experimental case studies.