HÖGSKOLAN VÄST

Regenerative Chatter Vibration in Indexable Drills: Modeling and Simulation

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Abstract

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An indexable insert drill is a drill which uses cutting inserts to make holes. Undesirable sound generated by this type of drill has always been considered as a problem in workshops. The focus of this thesis is to investigate the mechanism behind these vibrations, to model it and to provide guidelines for reducing the sound in future drill designs. Primary investigations show that the main sound-generating mechanism is a self-induced vibration due to a coupled torsional-axial deformation in the drill which leads to the torsional-axial chatter vibration. The first step of simulating regenerative chatter vibrations in a drill is to model the static cutting forces. In this thesis, a model is proposed to estimate static cutting forces in indexable drills by dividing the cutting edges into small elements. Since, using this model, forces can be calculated separately on each insert, it is possible to consider insert differences in estimation of the cutting loads. Torsional-axial coupling has been discussed and subsequently a time-domain model is proposed to simulate chatter vibrations. The resulting model is a system of delay differential equations with variable delays. The delay varies with time and is dependent on the state of the system. Variations in the time-delay, tool jump-out and backward motions of inserts have been included in the proposed time-domain simulation. A set of experiments was conducted to verify the model. Finally, a number of different strategies to alleviate the problem of chatter vibration are explored and their feasibilities for use in future products are discussed.