HÖGSKOLAN VÄST

Edge Geometry Effects on Entry Phase by Forces and Vibrations

ADNAN AGIC

AKADEMISK AVHANDLING

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Abstract

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Intermittent machining is in general strongly related to the large impacts in the entry phase and related vibrations. The influence of the impact forces and vibrations on the cutting process is dependent on workpiece material, structural properties of the tool-workpiece system, cutting edge geometries and cutting parameters. Cutting forces adopt generally a periodic behaviour that gives rise to forced vibrations. In addition, self-induced vibrations may arise because of low rigidity and insufficient damping in the tool-workpiece system at specific cutting parameters. The ability of the cutting tool to carry the loads during the entry phase and minimize the vibrations is often the key parameter for an effective machining operation.
This research work is based on the experiments, analytical studies and modelling. It was carried out through six main studies beginning with a force build-up analysis of the cutting edge entry into the workpiece in intermittent turning. This was followed by a second study, concentrated on modelling of the entry phase which has partly been explored through experiments and theory developed in the first study.
The third part was focused on the influence of the radial depth of cut upon the entry of the cutting edge into the workpiece in a face milling application. The methodology for the identification of unfavourable radial depth of cut is also addressed herein.
Next, effects of the cutting edge on the vibrations in an end milling application were investigated. This study was related to a contouring operation with the maximum chip thickness in the entry phase when machining steel, ISO P material. The results of this work provide some general recommendations when milling this type of workpiece material.
After that, the focus was set on the dynamic cutting forces in milling. The force developments over a tooth engagement in milling showed to be strongly dependent on the cutting edge geometry. A significant difference between highly positive versus highly negative geometry was found. The implication of this phenomena on the stress state in the cutting edge and some practical issues were analysed.
Finally, the role of the helix angle on the dynamic response of a workpiece was investigated. The modelling technique using force simulation and computation of the dynamic response by means of modal analysis was presented. Extensive experimental work was conducted to compare the modelling and experimentally obtained results. The modelling results showed a similar trend as the experimental results. The influence of helix angle on the cutting forces and the dynamic response was explained in detail.
The research conducted in this work contributes to the deeper understanding of the influence of the cutting edge geometry and the cutting parameters on the force build up process during the entry phase. The presented studies investigate the force magnitudes, force rates and dynamic behaviour of the tools and workpieces when machining at the challenging entry conditions. The methodologies applied are focused on the physical quantities as forces and vibrations rather than the experimental studies that evaluate tool life. The methods and results of the research work are of great interest for the design of the cutting tools and optimization of the cutting processes.