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Improving tool life in multi-axis milling of Ni-based superalloy with ball-end cutter based on the active cutting edge shift strategy

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Abstract

In milling of hard-to-cut materials such as Titanium and Ni-based superalloy, tool wear increases rapidly and the tool life can be as short as a few minutes. Moreover, tool wear will influence the workpiece geometrical accuracy and surface quality. Aiming at improving the tool life in multi-axis milling of freeform workpieces made of Ni-based superalloy with a ball-end cutter, this paper introduces a new multi-axis milling strategy for freeform surfaces based on the idea of shifting the active cutting edge on the cutter. The proposed machining strategy tries to use different cutting edges on the cutter to cut the material for different portions of the workpiece surface as each edge element can only be used in the cutting for a short time. The relationships between the tool orientation, active cutting edge and cutter-workpiece engagement are established, and the tool wear rate is approximated in predicting the tool life for each edge element in the milling process. Both the cutter edge and cutter contact curve are divided into several segments according to the maximum cutting length of each cutter edge segment. Tool orientation is then planned based on the shifted active cutting edge. Cutting experiments are performed and their results show that a large improvement of tool life can be achieved by the proposed machining strategy.

Keywords

Tool wear; Hard-to-cut material; Multi-axis milling; Ball-end cutter.

1 Introduction

When milling hard-to-cut materials such as titanium alloy or Ni-based superalloy, rapid tool wear has always been a major concern. In some cases, a cutter can only be used for a dozen of minutes before its failure (M'Saoubi et al., 2015). Detrimentally, tool wear seriously affects the geometrical/dimensional accuracy and finishing surface quality for many types of parts (e.g., blisks and casings of aero-engines) where machining accuracy and surface integrity are