International Congress on Science and Engineering
HAMBURG – GERMANY
March 2018

Empirical Study Regarding Effect of Cutting Speed on Flank Wear

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Abstract

Spindle Speed Variation (SSV) is a well known technique to stifle regenerative chatter vibration both in turning and milling operations but a lack of knowledge regarding the effects of non stationary cutting conditions is still limiting its diffusion in the industrial scenario. In this paper an experimental study regarding the effects of Spindle Speed Variation technique on tool wear in steel turning is presented. The experimental tool wear tests were arranged and performed following a full factorial design: the cutting speed and the cutting speed modulation were the main investigated factors. The flank wear width was the main considered process response and it was monitored continuously during wear tests up to the end of the tool life. The effects of the factors were analyzed through the Analysis of Variance approach (ANOVA).

Key words: Spindle Speed,Chatter, Flank wear, Tool life

Introduction

In several production systems, when heavy and/or extensive machining operations are required, it is of paramount importance to maximize the Machine Material Removal Capability (MRC). The regenerative chatter mechanism occurrence (Altintas and Weck [1]), entailing high tool/workpiece vibrations, bad surface finishing quality and unacceptable tool wear rate, limits the achievable Material Removal Rate (MRR) and the overall machine tool productivity. The Stability Lobes Diagram (SLD), based also on tool/workpiece dynamic compliance evaluation, can be considered a useful instrument to maximize the chatter free depth of cut, i.e. Siddhpura and Paurobally in [2]. Spindle Speed Variation (SSV) is a well-known technique (Inamura and Sata, [3]) to suppress regenerative machine tool vibrations: the continuous modulation of the spindle speed breaks the energy injection that flows from the cutting process to the machine tool due the regenerative effect thus avoiding the vibration growth. SSV is very promising, even comparing it with other chatter suppression technique (i.e. active solutions or tools with variable tool pitch for milling operations), basically due to its flexibility and the absence of additional devices. In the scientific literature, different modulating spindle laws (i.e. Yilmaz et. al, [4] and Insperger et. al [5]) were analyzed evaluating both the cutting process stabilizing properties and the industrial feasibility, considering commercial Numerical Controls (NC) and spindle drives. Mainly for this last reason, the Sinusoidal Spindle Speed Variation (SSSV) seems to be the most