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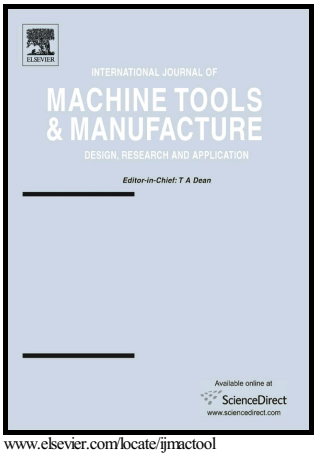

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PII: S0890-6955(16)30361-3
DOI: http://dx.doi.org/10.1016/j.ijmachtools.2016.10.003
Reference: MTM3201

To appear in: *International Journal of Machine Tools and Manufacture*

Cite this article as: Weijian Huang, Xi Li, Boxing Wang, Jihong Chen and Ji Zhou, An Analytical Index Relating Cutting Force to Axial Depth of Cut for Cylindrical End Mills, *International Journal of Machine Tools and Manufacture* http://dx.doi.org/10.1016/j.ijmachtools.2016.10.003

An Analytical Index Relating Cutting Force to Axial Depth of Cut for Cylindrical End Mills

Weijian Huang[a], Xi Li[a*], Boxing Wang[b], Jihong Chen[a], Ji Zhou[a]

[a]National NC System Engineering Research Center, School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China

[b]National CAD Support Software Engineering Research Center, School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China

312405151@qq.com
li_dawn@hust.edu.cn
[*]Corresponding author. 1037 Luoyu Road, Wuhan, China.

Abstract

In milling processes, the ever-changing cutting force has great effects on machining quality. A novel cutting force model for cylindrical end mills, discretizing the end mill along its circumferential direction, is described in this paper. An analytical index is established for simplifying the prediction for the cutting force and estimating the fluctuation of it based on the model. The influences of the axial depth of cut on the cutting force and the fluctuation are studied based on the proposed index. The predictions of the analytical index are verified by milling experiments.

Keywords: Cylindrical end mill; Analytical index; Cutting force; Fluctuation

1. Introduction

Milling process is an indispensable machining method in modern manufacturing. The scientific problems in it have always been the focus of research since the variation mechanism and the conversion process of the physical quantities like force, heat, deformation, etc are complex [1]. The interaction between the cutting edges and the workpiece is rapid and complex, in which force change is the source of all other physical changes. Therefore, the research and the analysis of the cutting force have attracted much attention.

The idea of modelling the cutting force acting on helical end mills was suggested by Altintas [2, 3]. The end mill is discretized along its axial direction and becomes a series of paper-thin disks. The cutting process at each infinitesimal cutting edge on the disks is regarded as oblique cutting process. The cutting forces acting on the infinitesimal cutting edges are calculated using milling force coefficients.

Most of the researchers [4~6] focused on the method of modelling the cutting force but only a few analyzed the relation between the machining parameters and the cutting force. The influences of the radial depth of cut, the feed rate and the cutting speed on the surface integrity and the cutting force were studied by Ghani [7]. The relation between the depth of cut and the cutting force was analyzed by Yang [8].

The idea developed by Altintas [1, 2, 3], discretizing the end mill along its axial direction, is convenient and universal for predicting the cutting force. A novel cutting force model for cylindrical end mills, discretizing the end mill along its circumferential direction, is presented for analyzing the influences of the cutter geometry and the machining parameters on the cutting force in this paper. An analytical index for milling processes with cylindrical end mills is established for revealing the relation between the axial depth of cut and the cutting force. The analytical results are verified by milling experiments. For simplification, tool eccentricity and deflection are not considered in this paper.