Vibration Assisted Machining

Theory, Modelling and Applications

Lu Zheng, Wanqun Chen, and Dehong Huo

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Vibration Assisted Machining

Theory, Modelling and Applications

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Preface

Precision components are increasingly in demand for various engineering industries, such as biomedical engineering, MEMS, electro-optics, aerospace, and communications. However, processing these difficult-to-machine materials efficiently and economically is always a challenging task, which stimulates the development and subsequent application of vibration-assisted machining (VAM) over the past few decades. Vibration-assisted machining employs additional external energy sources to generate high-frequency vibration in the conventional machining process, changing the machining (cutting) mechanism, thus reducing the cutting force and cutting heat and improving the machining quality. The effective implementation of the VAM process depends on a wide range of technical issues, including vibration device design and setup, process parameter optimization, and performance evaluation. The current awareness on VAM technology is incomplete; although ample review/research papers have been published, no single source provides a comprehensive comprehending yet. Therefore, a book is needed to systematically introduce this emerging manufacturing technology as a subject.

The main objective of this book is to address the basics and the latest advances in the VAM technology. The first chapter provides a brief introduction to VAM technology, including VAM process, benefits, and applications, as well as its history and development, so that the reader would have a general understanding of the subject. The second and third chapters aim to present a detailed description of the characteristics and design process for vibration devices. Chapter 2 overviews the current proposed vibration devices in the literature, and the features of each type vibration devices are critically reviewed. Chapter 3 focuses on the implementation and design of vibration devices and the corresponding design procedures are also discussed. Chapters 4 and 5 are dedicated to the effect of vibration and machining parameters on tool path/tool–workpiece separation and the surface topography generation. Chapters 4 and 5 are dedicated to the effect of vibration and machining parameters on tool path/tool–workpiece separation and its influence on the cutting performance. Chapter 4 covers the kinematic analysis of VAM, including the tool–workpiece separation type and the corresponding equations during the processing. Chapter 5 investigates the mechanisms of tool wear and burr generation under different tool–workpiece separation situations. Chapter 6 and 7 investigate VAM process through simulation modelling method. Chapter 6 models the cutting force using both numerical and finite element methods. Finite element modeling and analysis of VAM are detailed in Chapter 7 to deeply understand the cutting mechanism of VAM. The last chapter contains the modeling of surface topography

using homogeneous matrix transformation and cutter edge sweeping technology, and the results are verified by the machining experiments.

This book provides state of the art in research and engineering practice in VAM for researchers and engineers in the field of mechanical and manufacturing engineering. This book can be used as a textbook for a final year elective subject on manufacturing engineering, or as an introductory subject on advanced manufacturing methods at the postgraduate level. It can also be used as a textbook for teaching advanced manufacturing technology in general. The book can also serve as a useful reference for manufacturing engineers, production supervisors, tooling engineers, planning and application engineers, as well as machine tool designers.

Some of the research findings in this book have arisen from an EPSRC-funded project "Development of a 3D Vibration Assisted Machining System." The authors gratefully acknowledge the financial support of the Engineering and Physical Sciences Research Council (EP/M020657/1).

The authors wish the readers an enjoyable and fruitful reading through the book.

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