
Preface

Machining dynamics plays an essential role in the performance of machine tools and machining processes, which directly affects the material removal rate, and workpiece surface quality as well as dimensional and form accuracy. However, despite its obvious technical and economic importance and tremendous progress in machining technology during the last few decades, machining dynamics still remains as one of the least understood manufacturing science topics. In industrial practices, machining parameters are still chosen primarily through empirical testing and the experience of machine operators and programmers. This approach is costly, and while databases have been developed from large numbers of empirical tests, these databases lose relevance as new tools, machines and workpiece materials are developed and applied. Furthermore, a better understanding of machining dynamics is becoming increasingly important for engaging in ultraprecision and micro manufacturing because of the machining accuracy, scale and complexity involved. Therefore, it is essential to systematically research the machining dynamics within the material removal and surface generation processes and machine operations with particular respect to the quantitative effects from machine tools, tooling, process variables and workpiece materials.

The advances in computational modelling, sensors, diagnostic equipment and analysis tools, surface metrology, and manufacturing science during the past decade have enabled academia and engineers to research the machining dynamics from a new dimension and therefore to have the potential for great industrial benefits, for instance, including:

- Analysis of the material removal dynamics, particularly the effects of cutting speeds and tooling geometry on the stress and temperature conditions at the tool-workpiece interface and thus the surface integrity and functionality.
- Multi-body dynamic analysis of the machine tool structure including the dynamic properties of interfaces between components such as spindles, slideways and drive systems, etc.

- Design of machine tool structures for dynamic repeatability, which is important in predictive control of the machine dynamic performance.
- Dynamic modelling of the machine systems (machine and machining processes) and on line/real time identification of the system modal parameters.
- Development of analytical solutions for the stability of complex contours machining and nonlinear models of interrupted machining.
- Development of novel algorithms (integrated with existing CAD/CAM/CAE tools) for compensation control of machining errors at real time.
- Ultraprecision and micromachining of various engineering materials with predictability, producibility and productivity.
- Modelling, simulation, control and optimization of precision machined surfaces including their surface texture, topography, integrity and functionality generation and formation.

This book aims to provide the state of the art of research and engineering practice in machining dynamics which is becoming increasingly important in modern manufacturing engineering. The book is concerned with machining dynamics in a comprehensive systematic manner and utilizing it proactively in manufacturing practice.

The advances in precision/ultraprecision machining, high speed machining, micro manufacturing, and computational modelling and analysis tools that have led to machining dynamics in the new context are the subject of the first chapter. The machine-tool-workpiece loop stiffness can place deterministic effects on the machining system's performance. Scientific understanding and comprehension of fundamentals of the loop and its dynamic behaviour in the process is central to the progress of this technology. Basic concepts and theory of machining instability and dynamics associated with the loop are therefore formulated in Chapter 2. Further advancements in the technology can be aided through a generalized theoretical understanding, scientific diagnostics and experimental analysis of machining dynamics as presented in Chapters 3 and 4. Following up those, a series of investigations are discussed on dynamics in tooling design, various machining processes, and design of precision machines. First, tooling design, tool wear and tool life are presented in Chapter 5. Machining dynamics in turning, milling and grinding processes are then studied in Chapters 6, 7 and 8, respectively. With the inexorable transition from conventional and precision machining, to ultraprecision and micro/nano machining, micro machining dynamics are starting to attract attention. Chapter 9 is devoted to the dynamics in ultraprecision machining using a single point diamond tool and the associated impact on nano-surface generation. Chapter 10 provides a dynamics-driven approach to precision machines design and thorough discussions on its implementation and application perspectives.

Owing to the diverse character of the subject, a single notation for the book has been difficult to achieve. For ease of working, therefore, a list of principal symbols and their meanings is included in the appropriate chapters as needed.

The diversity of the subject of machining dynamics has required that specialists in each of its main fields should prepare the chapters of this book. The comprehensive interest in the subject is evident, with 16 authors coming from 12 academic and industrial institutions. I am grateful to them all, for the benefit of their advice and expertise, and their patience in supplying with me their specialist chapters, and in many cases for lengthy subsequent dialogues.

This book can be used as a textbook for a final year elective subject on manufacturing engineering, or as an introductory subject on machining technology 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, and planning and application engineers, as well as industrial engineers.

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