

# Manufacturing System Throughput Excellence

Analysis, Improvement, and Design

Herman Tang



WILEY



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Eastern Michigan University  
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## About the Author

**Dr. Herman Tang** is a full professor in the School of Engineering at Eastern Michigan University. With over 16 years of hands-on industry experience at Chrysler (now Stellantis N.V.), he worked extensively on vehicle manufacturing system development, product launches at plants, and production improvement. Dr. Tang holds a PhD in Mechanical Engineering from the University of Michigan – Ann Arbor, an MBA in Industrial Management from Baker College, and Mechanical Engineering degrees from Tianjin University. He is the author of four books: *Automotive Vehicle Assembly Processes and Operations Management* (SAE, 2017), *Manufacturing System and Process Development for Vehicle Assembly* (SAE, 2018), *Engineering Research – Design, Methods, and Publication* (Wiley, 2021), and *Quality Planning and Assurance – Principles, Approaches, and Methods for Product and Service Development* (Wiley, 2022). In 2022, he received the Eastern Michigan University’s highest faculty honor, the Ronald W. Collins Distinguished Faculty Award.

## Preface

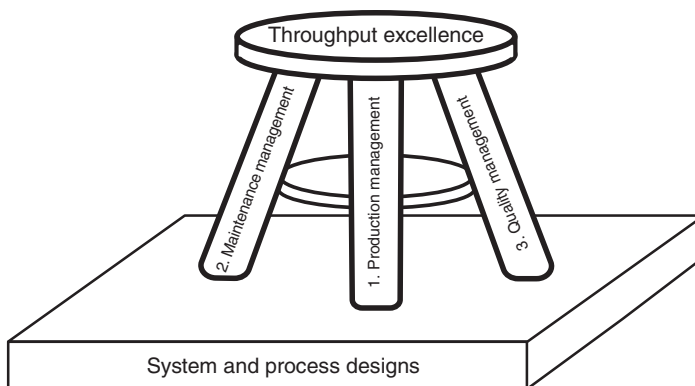
The primary objective and responsibility for manufacturing managers and engineers are to achieve throughput excellence. This involves establishing clear and measurable objectives and applying scientific principles and methods to attain them. Throughput excellence is not a onetime achievement but a continuous pursuit that demands commitment, guidance, and constant effort.

## Technical Focuses

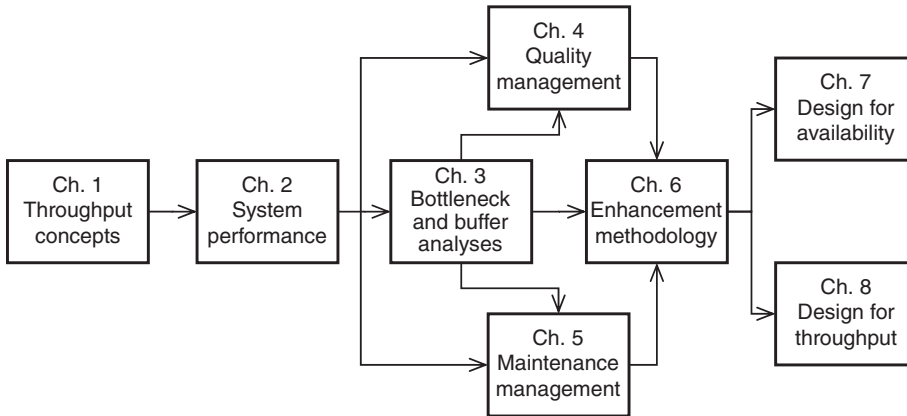
To excel in throughput, manufacturing management primarily revolves around four key elements: three main pillars and a common foundation, as illustrated in Figure 1. This book focuses primarily on the technical and methodological aspects of these elements and their financial implications.

The three pillars include production management, maintenance management, and quality management. These major, cross-disciplinary technical topics significantly impact the operational throughput performance of manufacturing systems in various ways. They also present various opportunities and challenges for improvement, both individually and collectively. System and process designs, constituting the foundation, are essential for achieving manufacturing excellence.

However, other crucial factors that influence throughput improvement projects, such as teamwork, leadership, and communication, are not covered in this book. While equally vital for achieving excellence, they fall beyond the scope of this book.



**Figure 1** Main pillars and foundation for throughput excellence.



**Figure 2** Contents and flow of this book.

The book is organized into eight chapters, encompassing the three pillars and the foundation of system throughput, as illustrated in Figure 2. Each chapter begins with general principles before delving into specific aspects and cases of manufacturing operations. While each chapter can be read and studied independently, it is recommended to follow the roadmap and cross-reference related chapters to acquire a better understanding of their interrelation and influence on manufacturing throughput performance. Armed with these principles and methods, you can cultivate a new mindset and habit of systematically pursuing manufacturing excellence.

## Intended Audience

This book serves as both a textbook and a training manual designed for current and aspiring manufacturing professionals. It is well suited for graduate and senior undergraduate students in engineering, manufacturing, operational management, and related courses. In addition, it proves valuable for practicing manufacturing professionals looking to systematically enhance their knowledge and skills in improving operations on the production floor.

Adopting an operational management, continuous improvement, and systems design perspective, the book addresses the processes and challenges of enhancing production throughput. It provides essential principles, processes, and tools to achieve and sustain optimal throughput in complex system settings. However, its primary focus is on system performance and does not delve into some other aspects of manufacturing management.

This book aims to bridge the gap between the latest academic research and the practices of manufacturing practitioners by emphasizing applications over theory. It presents a unique view of operational excellence for manufacturing professionals, graduate students, and researchers. Drawing on hands-on experience in both industry and academia, the author integrates engineering principles, business perspectives, research work, and practical practices for the work on the production floor. While not a purely theoretical work, the book can serve as a valuable reference for academic researchers interested in further exploration.

## Chapter Overview

As a comprehensive review of throughput management and enhancement in manufacturing operations, this book explores various subjects across eight chapters.

**Chapter 1: Throughput Concepts.** This chapter introduces the fundamentals of throughput in manufacturing operations, covering its cost perspective, time analysis, system characteristics, basic operational states, and the standalone state concept.

**Chapter 2: System Performance Metrics.** This chapter explains how to evaluate operational performance using various KPIs from ISO 22400. The chapter examines OEE and its weighting, introduces the process of KPI selection, and explores the financial and accounting implications.

**Chapter 3: Bottleneck Identification and Buffer Analysis.** Covering the understanding, identification, analysis, and management of bottlenecks in manufacturing systems, this chapter explores buffer functionality, effect estimation, and status analysis for system throughput.

**Chapter 4: Quality Management and Throughput.** This chapter delves into quality definitions, quality management, and cost analysis. It explores the quality contribution to system throughput, including the analysis of quality issues in both serial and parallel systems, appraisal approaches, and improvement tools.

**Chapter 5: Maintenance Management and Throughput.** Introducing maintenance principles and strategies, this chapter addresses the impact of maintenance on throughput performance. It includes a comparison of maintenance strategies, reliability-centered maintenance, maintenance performance, and total maintenance cost analysis.

**Chapter 6: Throughput Enhancement Methodology.** This chapter outlines various approaches for problem-solving and continuous improvement, focusing on key characteristics and processes for throughput performance. It reviews throughput analysis and addresses throughput project management.

**Chapter 7: Analysis and Design for Operational Availability.** This chapter presents system design processes and approaches for ensuring the reliability of manufacturing systems by design. It proposes throughput-focused FMEA, examines the reliability of serial and parallel systems, and addresses availability reinforcement.

**Chapter 8: System Design for Throughput Assurance.** This final chapter reviews design strategies for throughput performance, including buffer planning, total cost analysis, capacity balance via cycle time design, value assessment, and computer simulation.

## Book Features

This book presents the principles and methods of data-driven and bottleneck-focused approaches, emphasizing their applications to volume production manufacturing processes. While many examples are drawn from automotive manufacturing as a typical mass production setting, these approaches, with certain adjustments and adaptations, are applicable to other types of manufacturing processes, including low-volume and batch productions of discrete products.

To aid readers in comprehending and applying these principles and methods, the book incorporates a range of features crafted to facilitate learning and practical application. Each chapter concludes with 20 key takeaways, and each subsection, e.g., 2.4.3, has a brief summary for reference. Illustrated with 212 diagrams and 49 tables, this book succinctly demonstrates concepts and clarifies content through examples. Backed by about 270 cited sources, it provides a wide and rich exploration of throughput analysis, research, and improvement. This allows readers to uncover new opportunities for developing effective methods tailored to their specific situations.

Mastering the principles and methods of throughput improvement demands practical applications. To facilitate hands-on learning and in-depth understanding, each chapter includes analysis problems with solutions and 20 review questions for readers' exercise. The author, a seasoned manufacturing practitioner and researcher, also recommends engaging in a real throughput improvement project while reading this book or taking a related class.

The objective of this book is to equip readers with the knowledge and proven techniques necessary to attain throughput excellence and transform their production operations. Turn the page and delve into mastering those methods and techniques that can truly transform your production operations.



## Acknowledgments

### Industry and Academia Reviews

I express my sincere gratitude to Dr. Ziv Barlach (Chrysler, retired) and Carlos Zaniolo (Volvo Group) for their meticulous review and perceptive critique on the entire manuscript draft. I also appreciate the insightful feedback on some chapters and materials by senior professionals from various industries and academia, including Nick Deanes (APPLIED Adhesives), James Metzger (Emergent BioSolutions), Dr. Christopher Kluse (Bowling Green State University), Mike Rall (Dematic), Dr. David Tao (University of Michigan), Dr. Nasim Uddin (Global Automotive Management Council), and Dr. Jay Zhou (Ford, retired). Many others also provided valuable feedback.

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### All Supports

I have been fortunate to collaborate with and learn from my experienced colleagues, mentors, and superiors in real-world manufacturing settings. I remain perpetually grateful to the professors who taught and advised me throughout my undergraduate and graduate studies. Their contributions to my education, industry career, and academic research have been invaluable and have built a solid foundation for this book. I also appreciate the authors whose excellent works I have referenced in the book.

I thank Eastern Michigan University for supporting the preparation of this book manuscript with a 2023 Sabbatical Leave Award. Finally, I express my heartfelt gratitude to my wife for her understanding and support in bringing this volume to fruition.

### Your Feedback

Managing and improving manufacturing throughput benefit from a blend of art and science, calling for broad and diverse approaches. I have thoroughly considered them in this manuscript, drawing on my understanding, experience, and research in the field. I aspire for this book to serve as a valuable resource for those seeking to comprehend, apply, and advance manufacturing throughput practices.

I welcome and appreciate your insights, remarks, and feedback, which will contribute to the continuous enrichment of our knowledge and the refinement of this book. Please feel free to share your comments, critiques, and recommendations at [htang2@emich.edu](mailto:htang2@emich.edu) or [htang369@yahoo.com](mailto:htang369@yahoo.com). I will carefully review them for potential integration into future editions of this volume. I wish you immense success in your professional endeavors within the field of manufacturing.

## About the Companion Website

This book is accompanied by a companion website:

**[www.wiley.com/go/Tang/ManufacturingSystem](http://www.wiley.com/go/Tang/ManufacturingSystem)**



This website includes:

- Sample Syllabus
- Sample Instruction Schedule
- Solutions Manuals