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He (Herman) Tang

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Preface

I.1 Approach

Manufacturing engineering is more a practice than a pure science. The intent of this book is to review and discuss the comprehensive and sophisticated knowledge and practice of automotive manufacturing. This book studies the proven technologies and processes of automotive manufacturing, as well as its new advances. Hence, this book is fundamentals focused and applications oriented.

In automotive manufacturing, professionals are practicing with the knowledge of many subjects. This book covers most of the manufacturing areas. In addition, it may be considered 80% technical and 20% managerial in nature, which reflects my viewpoints on automotive manufacturing.

I am passionate about automotive manufacturing engineering, an appealing and dynamic engineering field, and having always been excited about learning new stuff. I recognize a significant gap between academic research and industrial practice as I worked in academia for 17 years and then over 16 years in the automotive industry. My appreciation of automotive manufacturing engineering motivates me to put my efforts into filling the gap by providing interdisciplinary review and discussion on manufacturing technologies and their advances.

This book's contents are limited as they are based only on the publically available sources. Moreover, practice variation may be significant from one automaker to another, and not all of the best practices are published. Hence, this book perhaps does not cover every practice preference for all automakers.

I.2 Organization and Content

This book is organized into seven chapters. Chapter 1 talks about overall automotive market, competition, and automakers performance. The following chapters address vehicle assembly operations, detailed processes, operations management, and continuous improvement.

As many would agree, automotive manufacturing is an interdisciplinary and broad engineering field. Some of the subjects could be a review for industrial engineering students but might be new approaches to mechanical engineering students, and vice versa. In addition, each of the chapters could be extended to a whole volume without major technical difficulty. Thus, this book is written to be concise, assuming that the

readers have a good understanding of the basic principles of multiple engineering and manufacturing subjects. It is advisable that readers refer to specific books for more details.

This book is aimed at future manufacturing engineering practitioners. The majority of this book's contents should be suitable to fourth-year engineering students and can be lectured in 40 classroom hours. This book also serves as a fundamental part, joining with my other book *Manufacturing System and Process Development for Vehicle Assembly*, for a master's level course. Most of both book materials have been taught as a graduate course at Wayne State University and for undergraduate students at several other universities.

This book can be used for industrial training and is a good reference for the entry level of automotive manufacturing engineers and all levels of nonmanufacturing professionals. This book may also serve as a practical manual for the execution and management of automotive manufacturing because much of the content is directly extracted and summarized from practice.

This book has a wide variety of examples, with 182 illustrations and 76 tables. In each chapter, there are end-of-chapter review questions and research topics. The latter are suggested for in-depth case study, literature review, and/or course project. Some chapters have analytical problems for practice. All end-of-chapter problems may be better considered as a guide and opportunity for more learning. In fact, most of them are open ended, as no perfectly correct answers exist.

Acknowledgement

Automotive manufacturing definitely requires team efforts, with no exception for preparing this book. First, I am deeply indebted to my mentors who significantly influenced the trajectory of my professional life at Tianjin University (studied and worked for 16 years), University of Michigan—Ann Arbor (worked and studied for 6 years), and Chrysler (worked for over 16 years). I have learned a lot from my colleagues in those three organizations. Thanks also go to the students from several universities, who provided feedback and helped this book preparation. This book manuscript editing is also supported by Eastern Michigan University. It is impossible to acknowledge all of my mentors, colleagues, and students for their contributions in a brief paragraph.

Special thanks go to the senior professionals in the industry and academia for their critiques and suggestions. The main reviewers are Dr. Ziv Barlach (consultant), Dr. Wayne Cai (General Motors), and Dr. Nasim Uddin (Global Automotive Management Council). In addition, Dr. Mariana Forrest (LASAP), Mr. David Haltom (Qoros Auto), Mr. Joseph Nguyen (consultant), and Mr. Dave Schroeder (A123 System), Dr. Xin Wu (Wayne State University), Mr. George Smith (Magna), and Dr. Alex Yeh (Sealy) kindly reviewed and commented on certain chapters. Special thanks go to SAE editing and publication teams for their excellent efforts. About 150 publications are cited in the book. I thank

the various organizations and authors who give permissions to use their materials in this book.

Developing this book has been much more challenging and time consuming than I initially expected. My family's understanding and support are definitely vital to bring this book to fruition. Just for example, the first draft was completed on December 30, 2009 during a family vacation trip.

Thank you for your interest in the principles and practices of automotive manufacturing engineering. Over the ten years of book development, I have realized that I can never perfectly complete this book because of the diverse practices, advances of technology, and my limited resources. Thus, your comments and suggestions on this book will be very important and highly appreciated. Please send them to htang369@yahoo.com. I will be carefully reviewing them for the future editions.

He (Herman) Tang
In Ann Arbor, Michigan
May 2016

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Chapter 1

Automotive Industry and Competition

The automotive industry plays a significant role in a national economy. In the United States, for example, the output of the industry is approximately 3% of the national GDP. A study concludes that 5.4 additional jobs can be created elsewhere in the US for every one job located at an automotive manufacturing firm [1-1]. Another example is the Germany automotive industry with being the number one in the European market in terms of production and sales. It is the largest industry sector in the country with around 20% national industry revenue [1-2]. The production volumes or sales of automobiles are often a decent economic indicator for a country or region.

The automotive market is sensitive to the overall economic situation. Between 2008 and 2010, for example, there were economic crisis in some industrial countries. As a result, the automotive market significantly shrunk. In North America (NA), passenger vehicle production is between 16 and 17 million units during the normal economic situation before the crisis. In 2009, however, vehicle production in NA was only 8.8 million.

1.1 Automotive Market Overview

1.1.1 Global Automotive Manufacturing

The global market size of passenger vehicles, including cars, sport utility vehicle, and light trucks, is roughly 85 million units. The 2015 sales were 82.9 million units, a 2.2% increase from 2014 [1-3]. The annual growth rate of light vehicle production has been about 2 to 3% since 1975, on average, except during special economic downturn time between 2008 and 2009, when the annual global sales of the passenger vehicles dropped to a level of 58 million units.

1.1.1.1 Global Market by Region: Figure 1.1 shows the vehicle sales in major countries [1-4]. The characteristics of the major countries and regions are discussed below.

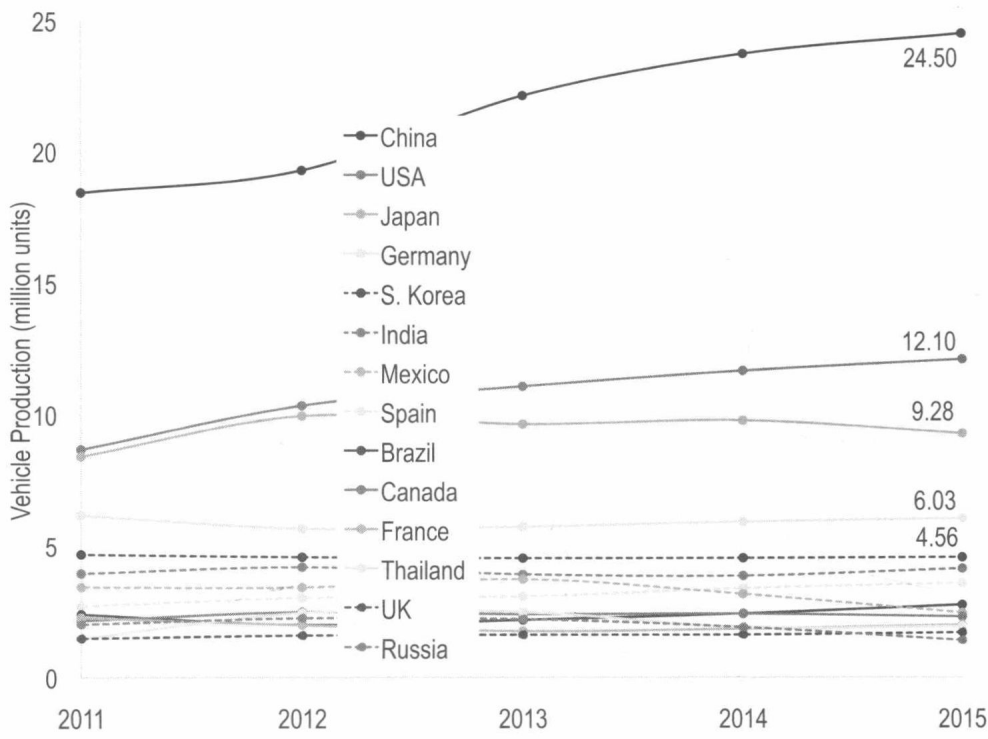


Figure 1.1 Sales of new passenger vehicles.

China's automotive industry is fast growing and dynamic. It has been the world's largest passenger vehicle producing country since 2009. Most Chinese-built vehicles are intended for the domestic market, but exports are gradually growing. Because of the government regulations, foreign automakers can only produce vehicles in China as a joint venture. In addition, Chinese domestic automakers, such as SAIC, Chang'an, Geely, and Dongfeng, have grown fast recently as well.

The European Union (EU) is the second largest producer of passenger vehicles in the world. Nine EU members produce more than 90% of the passenger vehicles in the EU. The major automakers are BMW, Daimler, Opel, and Volkswagen, headquartered in Germany; PSA Peugeot Citroën and Renault, headquartered in France; and FCA, headquartered in the UK. Furthermore, non-EU automakers, such as Ford, Hyundai, Kia, Mitsubishi, Suzuki, and Toyota, have significant manufacturing footprints in the EU areas. For export, the EU-produced vehicles vary from 25 to 35%.

The third largest vehicle production zone is North America, including the US, Canada, and Mexico. The NA passenger vehicle industry consists of 13 major manufacturers. The United States is the second largest single-country passenger vehicle market in the world next to China. Imported vehicle sales in the US have been 20 to 25% in recent years [1-5].

Japan is the world’s fourth largest producer of passenger vehicles and a leading global exporter. Japan is home to several well-known automakers, such as Honda, Mazda, Mitsubishi, Nissan, Subaru, Suzuki, and Toyota. No one produces foreign-based auto-maker’s passenger vehicles in Japan.

Korea is the world’s fifth largest passenger vehicle manufacturer. The foremost Korean automaker is Hyundai, including Kia owned by Hyundai. The second largest automaker in Korea is GM Korea. Interestingly, about 75% of vehicles built in Korea are exported.

1.1.1.2 Major Automakers: There are more than 100 automakers in the world. Table 1.1 lists the top twenty automakers worldwide based on their production volumes of passenger cars in 2014 [1-6]. The top ten automakers produced around 72.5% of passenger cars in the world.

Table 1.1 Top 20 automakers and their production (in million)							
	Automaker	HQ location	Production		Automaker	HQ location	Production
1	Volkswagen	Germany	9.77	11	BMW	Germany	2.17
2	Toyota	Japan	8.79	12	Fiat	Italy	1.90
3	Hyundai	Korea	7.63	13	Daimler	Germany	1.81
4	GM	US	6.64	14	SAIC	China	1.77
5	Honda	Japan	4.48	15	Mazda	Japan	1.26
6	Nissan	Japan	4.28	16	Mitsubishi	Japan	1.20
7	Ford	US	3.23	17	Chang'an	China	1.09
8	Suzuki	Japan	2.54	18	Geely	China	0.89
9	PSA	France	2.52	19	Fuji	Japan	0.89
10	Renault	France	2.40	20	Dongfeng	China	0.75

For large developed countries and regions, nonlocal-built vehicles are typically a small share of the market. In other words, automakers have their production sites close to the end markets to improve the local integration to better root in the enormous buying power. The quantity of local built vehicles in a region is affected by complex economic, technical, and political factors. It is often cited that transportation costs, currency fluctuation, and trade barriers are primary among these factors. Therefore, the vehicle sales can be different from the vehicle production, because of imports and exports.