ZERO INVENTORIES

Robert W. Hall
with the American Production and Inventory Control Society

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Foreword

The North American economy is facing one of its most serious challenges in overcoming a persistent and innovative foreign competition for consumer goods and services. Of all the foreign competitors, Japan has been the most successful. The Japanese have taken a large share of the North American market from North American manufacturers, and they have been able to beat North American companies on their own home field. This is a significant accomplishment when one considers the many obstacles that a foreign competitor must overcome to achieve this result. The higher cost of transporting the product to the marketplace is one; establishing a distribution network is another. The needs and desires of the customer in another culture and environment must be accurately evaluated in order to design a competitive product. The Japanese succeeded. They succeeded with products manufactured in high-volume, repetitive operations, a segment of industry in which North America was the recognized leader.

Japan is an overpopulated nation scattered over several islands in the Western Pacific. It has very few natural resources and must import most of its raw materials and energy-producing goods. It suffered severe damage in World War II, which ended with the most devastating blow of all—defeat.

The postwar leaders of Japan recognized their problems. They needed hard currency to pay for the imports they had to procure if they were to have a viable economy. The only way to acquire this currency was to export products to foreign markets and become competitive in those markets. The market segment they targeted was that of high-volume consumer products, as this offered the best opportunity to generate the amount of foreign exchange needed. They addressed the issue of producing these products at a cost that would allow them to compete successfully in foreign markets. Government, business, and labor all recognized the challenge and mounted a concerted effort to meet it.

The results are history. North American business leaders are now focusing their attention on Japanese methods. Conducting tours of Japanese manufacturers has become a growth industry in North America. Articles have been written and seminars conducted on Japanese techniques. Much of this attention is focused on production and inventory control.

The leading professional society in this field is the American Production and Inventory Control Society (APICS). For the 25 years of its existence, this organization has identified as its objective the education of practitioners in the body of knowledge of the field of production and inventory control. To satisfy this role, APICS has consistently applied itself to the task of defining (and redefining) the contents of this body of knowledge. It has recognized its responsibility to acquire an understanding of the principles and methods being employed by the Japanese. To accomplish this, a careful, analytic approach was required, one that examines broadly and deeply all facets of Japanese manufacturing.

This examination revealed that, while Japanese manufacturing had applied some innovative approaches to production and inventory control, there were many other factors involved. Product design, process planning, quality assurance, preventive maintenance, and management all contributed to the Japanese success story. They had accomplished much more than excellence in these specific disciplines; they had succeeded in integrating them so they complemented one another in the achievement of company objectives.

Professor Robert W. Hall is deeply involved in the APICS effort. He is a Professor at Indiana University, School of Business. He has been active in APICS, especially in the repetitive manufacturing area. He was a member of the original steering committee that organized production and inventory control practitioners who worked in the repetitive manufacturing industry. He has made several trips to Japan and has maintained a constant dialogue with members of the Japanese industrial and academic communities. He is the author of *Driving the Productivity Machine: Production and Inventory Control in Japan*

and *Kawasaki USA—A Case Study*, both published by the American Production and Inventory Control Society.

Bob Hall has not only studied Japanese manufacturers but has worked closely with American companies in an effort to transfer the technology developed by the Japanese to American business. This book contains the results of his extensive observations and analysis of the subject. It covers the many functions that must be orchestrated in order to realize the benefits that can be achieved. He is careful to look beyond the techniques the Japanese applied to the principles upon which they were based. As a result, the application of these techniques to North American business is more practical. The book will benefit all segments of manufacturing, not just high-volume, repetitive companies, for the philosophies driving successful Japanese companies can be applied to all business organizations.

The research and preparation for writing this book was supported by the APICS Educational and Research Foundation, Inc., a separate corporation founded by APICS and dedicated to sponsoring worthwhile projects, such as research and the development of educational materials, that will contribute to the body of knowledge in the field of production and inventory control.

The efforts of APICS to learn about Japanese manufacturing methods and to convert them to applications in North American business have been directed by the board of directors of that organization. This governing body of APICS consists of 24 members elected by its more than 51,000 members in North America. The board has been both sensitive and responsive to the necessity of aggressively applying resources to the analysis of Japanese technology. The dramatic results the Japanese have achieved in reducing inventory levels has stimulated APICS to spearhead the effort to move towards a "Zero Inventories" concept. Currently, the Society is organizing a campaign to make the lessons learned from the Japanese available to North American business. This book is part of that campaign.

I highly recommend this book. It can provide you with new ideas and concepts that can be of benefit to you and your company in competing in what has become an international marketplace.

J. P. Kelleher, CPIM*
President—1982
American Production and
Inventory Control Society

Preface

The goal of this book is to start manufacturing managers toward understanding and applying stockless production. The book certainly is not comprehensive because the subject is new both to the author and to American manufacturers generally. If those who have a serious interest in applying stockless production find it to be a "starter kit," it will serve its purpose. The experienced practitioner of stockless production will find it elementary.

Presenting stockless production in a logical order is very difficult. Almost every aspect of stockless production interacts with every other aspect, so that discussion of it in any depth tends to bounce from topic to topic. Some of the chapters may stand alone, but a complete story is told only by reading the book from front to back. Those with a special interest in stockless production concepts applied to relationships with suppliers will find the subject touched upon in many different places, for example.

Stockless production is simple and not hard to understand. However, it permeates every activity in manufacturing, so that understanding all of it requires consideration of many different specialized topics. A new vocabulary is necessary to express some of the ideas. Despite attempts by the American Production and Inventory Control

Society (and others), there has been no standardization of terms from plant to plant within the United States, and the same is true in Japan. It is particularly difficult to apply suitable terminology to ideas that are not in widespread practice in the United States. A glossary at the end of Chapter 1 will be of some help, but it is impossible to use the terms consistently.

Source material for this effort was gathered over a period of time but is still not adequate. The Japanese auto industry has integrated ideas from many sources into their version of stockless production. Since they pioneered in this, much of the material is from them. Not as much data were available from other industries. I especially regret that more could not be accumulated on applications in the electronics industry.

So many people have contributed to this work that it is impossible to name all of them. It is the result of visits and discussions with many manufacturing executives both in the United States and Japan who gave generously of their time to explain their practices and their industry: Edward Hay, John Kinsey, Larry Higgason, Kichiro Ando, Leonard Ricard, Susumu Okada, Yoshinori Yamada, Ken Wantuck, Leighton Smith, Roy Harmon, David Nelleman, Masukatsu Mori, Fujio Cho, Ed Reznicek, William Sandras. . . . I apologize to all those for whom time and space did not allow a listing.

Jinichiro Nakane deserves special thanks. He first introduced me to the ideas about five years ago and has patiently corrected my misunderstandings ever since. He has arranged visits, discussed the ideas, and illustrated their use, and through him we have had useful exchanges with the Japan Production and Inventory Control Society.

The book is much better for the efforts of four persons who reviewed this book and corrected oversights and contributed suggestions which were used:

John Kinsey, Hoover Universal.

Edmund Reznicek, Delco Manufacturing Company.

Leonard Ricard, General Motors Corporation.

William Sandras, Hewlett-Packard.

Barbara Lingle dedicated extra effort in typing the manuscript into a presentable format, much more than a nine-to-five contribution.

My wife, Kay, has over the past few years been very patient with my absences from home and has regularly taken care of all the problems that would distract me from the work.

After all this assistance, there are still errors in the book, some by oversight and some because we are venturing into a path of development about which much has yet to be learned.

Much of the inspiration for writing this came from the Repetitive Manufacturing Group of the American Production and Inventory Con-

trol Society, a small group dedicated to spreading the knowledge of stockless production in the United States and to advancing the practice of it wherever repetitive manufacturing may apply. The meetings and workshops of this group have contributed much toward understanding the problems of industry and developing ideas for resolving them in the United States.

The work has been sponsored by the Educational and Research Foundation of the American Production and Inventory Control Society. Both the foundation and the society are dedicated to research and education that will improve the quality of work in industry, primarily by improving production planning and control, and in any other way possible. Their generous support of a study trip to Japan and visits to American companies has made it possible to develop the background for this work. The officers of the foundation and of the parent society itself have been supportive, not only with funding, but also with their time and much encouragement.

The American Production and Inventory Control Society is dedicated to the people who must daily make industry work. Recently, everyone in America has become aware that much of American industry has a productivity problem, and sometimes the efforts of the people who work in industry have been maligned in the process. If you are among those who have to make industry work, this book is really dedicated to you—in the same spirit that the American Production and Inventory Control Society has from its beginning stood for bringing people in industry together to share their problems and their solutions.

Robert W. Hall
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Contents

1

Stockless production: Basic concepts

Zero Inventories connotes a level of perfection not ever attainable in a production process. However, the concept of a high level of excellence is important because it stimulates a quest for constant improvement through imaginative attention to both the overall task and to the minute details. That leads to practical actions which break out of previously accepted tracks of thought about production.

One such concept of an ideal total production system is most commonly called just-in-time production, a name which emphasizes producing exactly what is needed and conveying it to where it is needed precisely when required. The misimpression sometimes exists that just-in-time production and ideas associated with it apply only to automotive production or to high-volume manufacturing which is similar to it; but that is not true. Stockless production is a name sometimes used to mean the same thing, usually implying application in a broader context, and stockless production is the name used for the system throughout this book. Whatever it is called, the ideas need to be considered and understood in their entirety because they encompass every aspect of manufacturing management.

The goal of stockless production is to find practical ways to create the effect of an automated industry which will come as close as possi-

ble to this concept of ideal production. It is not an end in itself, because the pure ideal cannot be literally attained. It is a guide to constant improvement, by big steps and small ones, to bring ourselves ever closer to the ideal. It causes us to see problems we never before recognized and to develop better and better techniques to solve them. It constantly promotes the simplest, least costly means for every possible aspect of manufacturing practice. There is no point striving for lesser goals if effort can be spent in equally practical ways to change manufacturing into what it really can be.

Instantaneous conversion of raw material to finished product is, of course, not literally possible. The benefit comes from studying very carefully what we would want such a system to do and then seeking ways to transform the current production system into something approaching as closely as possible what we want. So what should such a system do?

1. Produce products the customers want.
2. Produce products only at the rate customers want them.
3. Produce with perfect quality.
4. Produce instantly—zero unnecessary lead time.
5. Produce with no waste of labor, material, or equipment—every move with a purpose so there is zero idle inventory.
6. Produce by methods which allow for the development of people.

The adoption of this philosophy removes many barriers in thinking, and that, in turn, leads to many new techniques for production. But stockless production is more than a set of established techniques to be installed. It is a fundamental way of thinking to transform overall manufacturing in the simplest way possible and to generate new and original techniques for doing so.

FLEXIBLE AUTOMATION: SHORT SETUP TIMES

The ability to produce one unit of whatever is wanted by the customer at any time requires flexible automation. Flexibility means that plants should be capable of switching very quickly from one product to another, or from one part to another, within the capability for which equipment is designed or modified. This means automation of setup processes as much as automation of running operations. The purpose is reduction of setup times. If possible, a piece of equipment should be able to change from running one part to another almost instantly.

Flexible setups can be accomplished through programmable equipment if the physical process of changing tools and attachments requires little time. Since programmable equipment costs money, a manufacturer should try to reduce the setup times as much as possible on the existing equipment, using simple methods and as little invest-

ment as possible. Any manufacturer is better off with short setup times than long ones if shorter setup times can be realized at little cost. Many kinds of equipment can be modified to attain very short, flexible setups at low cost.

MARKET-PACED RUN RATES + FLEXIBILITY = SMALL LOT SIZES

Producing only at the market rate of demand and without producing inventory means making parts and products in small quantities—building today only what is needed, nothing more. If parts are fabricated and flowed together into assembly, and if only one product at a time is demanded, then only one set of parts for one unit is demanded at a time. The ideal lot size is therefore one.

This is one of the most difficult parts of stockless production to accept. It is easy to become distracted by all the existing limitations that prevent a lot size of one from being realized and easy to think that larger lot sizes must be better. The existence of large lot sizes means only that we have not yet mastered the technology of production and transportation to make just one unit at a time when we want one.

If production needs to run only at market rate, then high-speed automation is not necessary. There is no reason to run a month of production in five minutes only to have the machine sit for another month. In such an instance, everyone sees that production does not have to be high speed unless the kinematics of the process require it, and even in that case a different process might be possible. The economics of lot sizing are not permanent economics, and the objective of management is to change the economics of running rates, setup times and transportation. Stockless production means looking for ways to change parameters, not accept them.

DEVELOPING THE MANUFACTURING PROCESS TO DO IT RIGHT THE FIRST TIME: PERFECT QUALITY

To have a fast flow of parts through production in small lot sizes, quality coming from each operation must be excellent:

No rework.

No substitutions of tools or materials.

No overproduction to allow for normal scrap.

No scrap for adjustments or "run-ins."

No damage in transit and handling.

If this can be done, then screening out defects by inspection after production is complete is unnecessary. In order to do it right the first

time, the process must be clearly understood. The emphasis goes into attaining process control so that any defect seen can be given an assignable cause and the cause eliminated. This is a process of constantly working to make the production process as error-free as possible. Through cutting inventories and lead times we pressure ourselves to reduce error rates to minuscule amounts, not by expecting people to become perfect but by making the equipment and procedures themselves as fail-safe as possible when operated by ordinary mortals.

This approach to quality extends beyond the physical processes themselves. It is an ongoing effort to reduce the variance (uncontrolled occurrences) in every part of manufacturing: planning, design, and execution—until waste and errors become virtually nonexistent. Even better than correcting the causes of defects which have already occurred is the practice of anticipating the causes and correcting them *before* they occur.

REDUCING PRODUCTION OPERATIONS TO THE MINIMUM NECESSARY

Sometimes complex equipment and systems are developed with insufficient basic thought on how to do what is needed at the right time without error. The objective is to eliminate unnecessary activity and complexity. Move material as directly as possible from its existing state to its finished state so that every move adds value to it. This is the basic precept of industrial engineering, but it can easily be obscured by traditions that violate it. The ideal of stockless production drives people to examine operations in detail for the purposes of

Eliminating waste of *time*. Nothing sits.

Eliminating waste of *energy*. Operate equipment only for a productive purpose.

Eliminating waste of *material*. Convert all of it to product.

Eliminating waste from *errors*. No rework.

There is no point in moving material from one point to another just so it can sit in a different place. Double-handling costs money for transport and checking. Also there is no point in executing any operation in production if it can be avoided, and that is true whether it is performed by simple hand tools or programmed equipment.

Shigeo Shingo gives an excellent example of eliminating an unnecessary operation.[1] Several years ago he studied the best ways to remove the flashing from die-cast parts. He tried to find a quick, direct way to remove the excess metal without destroying critical dimen-

[1] Shigeo Shingo, *Study of Toyota Production System* (Tokyo: Japan Management Association, 1981), p. 11.

sions or appearance. However, he saw Daimler Benz in West Germany using a process of vacuum die-casting which eliminated the formation of flashing. (Flashing is formed by metal entering the gaps left between die halves for air to escape. However, if a vacuum is drawn on the mold cavity just prior to the shot, the die halves can fit so closely that flashing is not formed.)

This is not particularly novel. Industry all over the world is in a constant search for operations that can be simplified or eliminated, and there are thousands of examples daily, some dramatic and some trivial. The major reason there are not many more of them is that the objectives of manufacturing are not always focused on accomplishing more of them. Stockless production gives careful and unswerving attention to simplifying operations.

Examples: A high-bay automated storage facility left almost empty when it was discovered that the plant could run without a stockroom. A monorail conveyor left idle when it was discovered that modified carts conveyed material with less throughput time. A numerically controlled, 12-station transfer machine eliminated when it was found too inflexible to modify for fast setup times.

Stockless production begins with the design of the product. A product that functions well must not only contain the features wanted by the customer, but it must also be produced well. The idea is to plan for production during design so as to make each product enter production as far down the learning curve as possible.

Stockless production extends to the design and modification of equipment. Simpler equipment is simpler to modify and maintain. By the laws of reliability, complex equipment is more likely to have downtime from failures that are difficult to diagnose. That does not mean that equipment should not use advanced technology, but only that it should not be more complex than is necessary. A robot with a full range of positional capabilities is not needed if the total task consists of two-dimensional repositioning. The logic of this is obvious, but it is often violated if engineers or managers are uncertain what really needs to be done and use equipment with capabilities not really needed.

Stockless production guides a balanced development of equipment and operations. It concentrates engineering on what is most important instead of on efforts that may turn out to be wasted. The principle is to first improve the operation until one is certain what is necessary, then improve the equipment and facilities.

PREVENTIVE MAINTENANCE TO IMPROVE PRODUCTION CAPABILITY

By stockless production concepts, scheduled equipment time includes time for checking and maintenance. Unless equipment must