Lean Manufacturing Systems and Cell Design

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**About the Authors**

**J T. BLACK**

J T. Black is professor emeritus of industrial and systems engineering at Auburn University, where he also served as the director of the Advanced Manufacturing Technology Center. He was born in Rahway, N.J., and lived in New York, Ohio, Pennsylvania and Delaware while growing up. He graduated from high school in Edgewood, Penn., and attended Lehigh University (B.S.I.E.), West Virginia University (M.S.I.E.), and the University of Illinois at Urbana (Ph.D.).

Black has been teaching manufacturing engineering since 1960, when he became an instructor in the industrial engineering department at West Virginia University. He has taught manufacturing processes and systems at West Virginia University, University of Illinois, University of Vermont, University of Rhode Island, Ohio State University, University of Alabama-Huntsville, and Auburn University.

J T. Black is the author of over 70 technical papers and numerous books on manufacturing processes and systems, including the widely held *Material and Processes in Manufacturing*, now in its 9th edition. He resides in Auburn, Ala., with his wife Carol. His other interest is tennis (he has been ranked #2 in 50 and 55 doubles and #1 in 60 doubles in Alabama).

Many people have asked him about his name. Black said his mother named him J (just the letter with no period) after a Pennsylvania Railroad (PRR) control tower. The towers coming out of Johnstown eastbound on the PRR are identified by letters, according to Black, and the 10th tower is J tower. Black's middle initial is T and it stands for Temple, after his Uncle Temple who was buried under a coal car during a train wreck at Horseshoe Curve. Black was the first of his generation to turn away from the railroad, much to the distress of many of his relatives, particularly his grandfather and his father, an electrical engineer for the PRR.

**STEVE L HUNTER**

Dr. Steve L. Hunter is an associate professor at Mississippi State University's Forest Products Laboratory. There, he is working with Mississippi and Southeast U.S. furniture manufacturers to improve their productivity and international stance. Hunter was born in Rome, Georgia. He earned a BS degree from Berry College in manufacturing engineering technology and a Master's Degree from Auburn University, with a major in manufacturing systems engineering and a minor in industrial engineering. He earned his Doctorate, again from Auburn University in
industrial and systems engineering manufacturing with a minor in ergonomics.

Hunter has been interested in manufacturing systems design since 1980 and has designed and implemented many lean production systems. His recent research has included the ergonomic ramifications of manufacturing system design using computer simulation. This research attracted the attention of NASA where he was honored as a NASA Fellow. He carried out primary human engineering research on the ergonomics effects of micro-gravity on astronauts for NASA’s Marshall Space Flight Center. Before NASA, Hunter taught manufacturing engineering courses at the University of Memphis. Earlier, he worked as a civilian at the Air Force and Naval Aviation depots serving as an engineering project manager. His work in lean production includes the design and implementation of many commercial manufacturing cells, as well as the design of an 18 cell system for manufacturing and assembly for the Navy. While working for the Department of Defense, Hunter won numerous outstanding service awards for his contributions to national defense. He is married and his wife is a nurse.
J T. Black dedicates this book to his wife Carol.
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J T. Black began teaching an engineering course on manufacturing system design in 1983 at the University of Alabama in Huntsville. He decided to call the course integrated manufacturing production systems. The course title suggested that the manufacturing system be integrated with critical control functions that normally reside in the production system.

Integrated manufacturing production systems became a strategy for the redesign of an existing factory into a factory with a future. This strategy is based on a linked-cell manufacturing system that provides for a continuous flow (or smooth movement) of materials through a plant. While some may disagree, there is strong evidence that the linked-cell system was invented at the Toyota Motor Company by vice president of manufacturing, Taiichi Ohno, who referred to it as the Toyota Production System. This system was simple and flexible for even complex products like automobiles. Many U.S. companies have since implemented the strategy in various forms.

In Lean Manufacturing Systems and Cell Design, the authors examine the implementation of lean manufacturing by many companies. The lean production strategy stands in marked contrast to the well-advertised computer-integrated manufacturing approach.

Recently much has been written about agile manufacturing, which means a company is able to respond quickly to changes in the marketplace and bring new products to market quickly by using advanced versions of computer-integrated manufacturing. However, computerizing an existing system does not make it agile or integrated. Companies that successfully implement some version of Ohno's system are agile. This book presents that experience in a logical ten-step methodology.

The ten-step method embodies lean manufacturing, setup reduction, and pull production-control methodologies. Quality control, production control, inventory control, and machine-tool maintenance are also integrated into the linked-cell manufacturing system. This methodology produces superior quality at a low cost, with minimum throughput time. It provides the proper structure for automation to solve quality or capacity problems. The new word for this is autonomaation.

The authors believe the linked-cell manufacturing system is the manufacturing system of the future. Common practice in the future will be to link manufacturing with assembly cells. In the 1990s, companies implemented manned cells that used multifunctional workers who walked from machine to machine. Cells are designed to be flexible so they can readily adapt to changes in product design and product demand. They can be readily integrated with the critical control functions. Cells that make families of parts using a set (or group) of manufacturing processes replace the functional job shop structure.

The last time an industrial revolution happened in manufacturing systems was in 1913 when the world came to Detroit to see the Ford Motor Company's moving assembly line. The linked-cell system Ohno invented was a logical extension of the Ford system. Ohno
studied and understood how the system of mass production functioned. However, he recognized that the Ford system was designed to handle large volumes of the same parts with no variety. Over time, a new system invented by Ohno emerged. This new manufacturing system evolved into a hybrid of the flow shop and the job shop designs. The Ohno system was designed to handle large or small volumes of a variety of parts using the same economies of volume as the Ford system. Many people now say that Ford invented lean production. This is simply not so; the inventor of lean manufacturing was Ohno, and he should be so recognized.

Ohno got the idea for his kanban system after visiting an American supermarket, where he observed people pulling goods from the shelves to fill their shopping carts. The empty space on the shelf was the signal for the stock person to restock by reordering cases of the consumed item. In effect, the shopper provided a totally flexible final assembly for the custom order. In applying this idea to manufacturing, Ohno developed a system whereby downstream use of parts dictated upstream production rates. The materials were pulled through the factory by consumption of parts in final assembly. An empty cart returned to the manufacturing point was the signal to make more parts. Ohno quickly discovered that it was more productive to move machines closer together so that the workers could make one, check one, and pass it on to the next machine. Thus, manufacturing cells evolved through the factory-wide desire to eliminate waste. There is no record of Toyota using group technology, a well-known method for finding families of parts around which cells can be designed.

Many decision-makers have resisted converting to lean manufacturing because it is not high-tech or they perceive that it may be difficult to implement. However, lean production may severely impact the political and social structure of the entire company. It takes many reasons for a company to undertake such an effort and many excuses for not doing it. However, this much is clear: companies that have the courage to undertake this change will be survivors—the factories with a future. Those who resist will become history.
There are many people who made significant contributions to this book. Co-author, Dr. Steve Hunter is one of the world’s experts in cellular manufacturing system design and implementation. He is now at Mississippi State University continuing his research into manufacturing system’s design while assisting the Mississippi furniture industry with the design and implementation of lean manufacturing systems.

Author J T. Black thanks his wife, Carol, who did all of the typing and helped with editing prior to submission. She also made many suggestions that greatly improved the readability of the final manuscript. Thanks also to Dr. Dan Sipper, Rich Wilson, Angeline Honnell, and Dr. Brian Paul who provided many suggestions for improvement.

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The axiomatic design material was extracted from the unpublished work of Nam Suh, a professor at MIT whose work on axiomatic design has long been admired. This text also reflects the work of David Cochran, a former student of Black, who is now on the faculty at MIT and leading the axiomatic systems design work there.

Two people inspired this book. Tom Gelb is an engineer at Harley-Davidson, who described with great passion the conversion of Harley-Davidson to lean manufacturing. The second great influence on the book was Dick Schonberger. Drs. Schonberger and Black presented many Just-in-time seminars in the early 1980s and they are considered pioneers in this field.

The authors would also like to thank the SME editorial staff Cheryl Zupan, Bob King, Chris McGorey, Kathye Quirk, Jon Newberg, Frances Kania, and Rosemary Csizmadia for their work on the book.
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