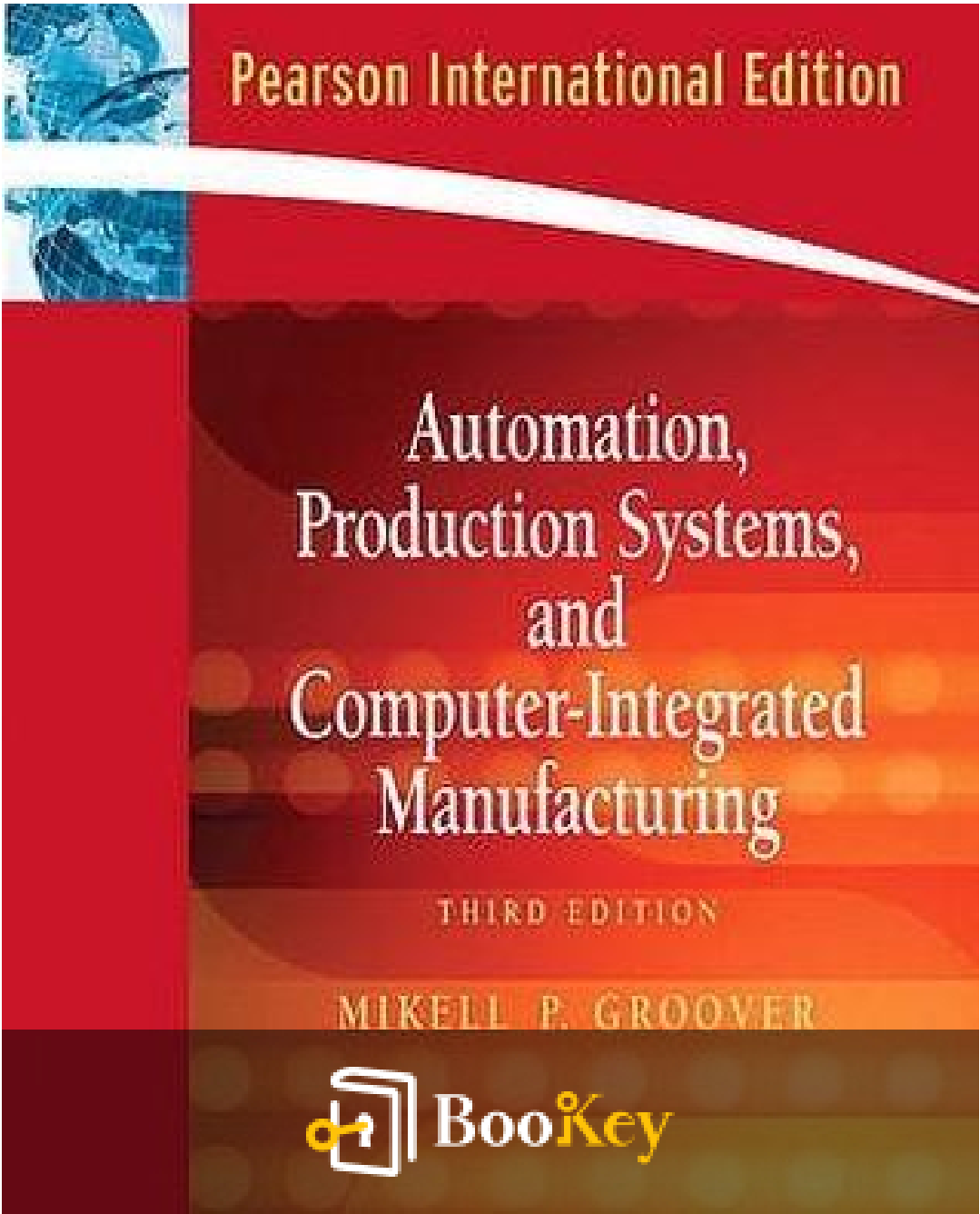


# Automation, Production Systems, And Computer-integrated Manufacturing PDF (Limited Copy)

Mikell P. Groover



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**Automation, Production Systems, And  
Computer-integrated Manufacturing Summary**  
Streamlining Manufacturing through Advanced Technologies and  
Integration.

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## About the book

"Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover delves into the transformative world of manufacturing processes where automation and advanced technologies converge to enhance productivity and efficiency. This comprehensive text provides an in-depth exploration of the principles of automation, the design and analysis of production systems, and the revolutionary role of computer integration in streamlining operations. By blending theoretical foundations with practical applications, Groover equips readers with the essential knowledge to navigate the complexities of modern manufacturing environments. Whether you are a student, engineer, or industry professional, this book serves as a vital resource that not only illuminates the intricacies of automated production systems but also inspires innovative thinking in a rapidly evolving field.

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## About the author

Mikell P. Groover is a renowned authority in the fields of industrial engineering and automation, best known for his contributions to understanding the integration of manufacturing systems with computer technology. With a solid academic background, including a Ph.D. in Industrial Engineering from the University of California, Berkeley, Groover has dedicated his career to both teaching and authoring influential texts that serve as vital resources in engineering education. His book, "Automation, Production Systems, and Computer-Integrated Manufacturing," is widely regarded for its comprehensive coverage of the principles and practices that define modern manufacturing processes, making complex topics accessible to students and professionals alike. Through his research and publications, Groover has significantly impacted the development and implementation of automation technologies in manufacturing, ensuring that his work remains at the forefront of the evolving landscape of industry.

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# Chapter 1 Summary: 1.1 Production Systems

As manufacturing processes evolved and products became more complex, specialization among workers emerged, leading to a greater emphasis on planning and coordination to manage manufacturing workflows effectively. Production systems, essential to modern manufacturing, encompass a combination of people, equipment, and procedures aimed at executing a company's manufacturing operations. These systems can be categorized into two primary components: facilities and manufacturing support systems.

1. Facilities refer to the physical elements of the production system, which include machinery, factory layouts, and the overall infrastructure where manufacturing occurs. The arrangement of equipment within the facilities is critical, as it influences the efficiency and workflow of operations.

Manufacturing systems within these facilities can vary from simple work cells consisting of a machine and a single worker to complex production lines featuring multiple machines and workers. These systems play a direct role in the handling of materials and interaction with the products being manufactured.

2. Manufacturing support systems consist of the procedures that enable a company to effectively manage production, address technical and logistical challenges, and maintain product quality. These systems encompass various functions, including manufacturing planning, control, and the integration

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and design of products. Although they do not directly interact with the product, they are vital for ensuring a smooth progression of materials through the manufacturing process.

The role of human participation in production processes can be categorized into three systems: manual work systems, worker-machine systems, and automated systems. Manual work systems involve human workers executing tasks without powered tools, relying instead on hand-operated tools. Worker-machine systems leverage the strengths of both humans and machines, wherein a worker controls a powered machine to enhance productivity and task execution. On the other hand, automated systems operate independently of human presence, utilizing programmed instructions and control systems, with degrees of automation ranging from semi-automated, which require occasional human interaction, to fully automated systems, capable of running extensive production cycles with minimal human oversight.

Furthermore, the strengths and abilities of humans and machines differ significantly. Humans can adapt to unexpected situations, devise innovative solutions, and generalize from experience, while machines excel in consistency, power application, data storage, and performing repetitive tasks efficiently.

Lastly, the effective operation of the manufacturing facilities hinges on a

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series of interconnected activities. The sequence typically starts with business functions that act as the communication bridge between the company and its customers, followed by product design, manufacturing planning, and manufacturing control. This comprehensive approach ensures that production orders align with customer demands, whether they stem from specific requests, proprietary products, or forecasts of market needs. Overall, these interconnected systems optimize the manufacturing process, enabling companies to maintain competitive advantages in a continually evolving landscape.

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## Critical Thinking

**Key Point:** Emphasizing Collaboration and Coordination in Complex Tasks

**Critical Interpretation:** As you delve into the intricacies of modern manufacturing processes, you might find inspiration in the essential lesson about the power of collaboration and coordination. Imagine how, just like a well-orchestrated production system, your life can thrive when you align your unique strengths with others—whether in a project at work, learning in a classroom, or even within your family. By recognizing that each individual brings distinct skills to the table, you can foster an atmosphere where collective effort propels you toward shared goals, making complex challenges not just manageable, but an exciting opportunity for innovation. Just as effective manufacturing relies on interdependent systems, your pursuits in life can flourish when you embrace teamwork, planning, and a willingness to adapt, reminding you that great accomplishments are often crafted through cooperation.

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## Chapter 2 Summary: 1.2 Automation in Production Systems

Chapter 2 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover delves into the essentials of manufacturing planning and control, highlighting the critical functions that guide production operations in a contemporary manufacturing environment.

Manufacturing planning initiates with the flow of information from product design, which encompasses several key activities including process planning, master scheduling, material requirements planning, and capacity planning. Process planning focuses on outlining the necessary sequence of processing and assembly operations to produce specific parts, with the manufacturing engineering department ensuring the technical details, such as tooling, are meticulously planned. At the heart of manufacturing planning lies the master production schedule, detailing which products will be made, their delivery dates, and the quantities required. Material requirements planning plays a significant role in determining the necessary components, subassemblies, and raw materials, ensuring they are available when needed without exceeding production capacity. Capacity planning assesses the required manpower and equipment resources, ensuring that the production plan is viable given existing constraints.

Manufacturing control shifts the emphasis to managing and regulating the

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physical operations within the factory to bring manufacturing plans to fruition. This process utilizes shop floor control, inventory control, and quality control functions to oversee operational execution and resolve any issues that arise during production. Shop floor control is responsible for tracking products as they move through the various stages of processing, assembly, and inspection, while inventory control strives to balance the risk of stock shortages against the costs of excess inventory. Quality control maintains product integrity by implementing inspection processes throughout production and utilizing data-driven methodologies such as statistical process control (SPC) and Six Sigma to tackle quality-related challenges.

The implementation of automation within production systems is distinguished into two main segments: the automation of manufacturing systems, which involves reducing human involvement in operations such as processing, assembly, and inspection; and the computerization of manufacturing support functions, which aims to minimize manual effort in design, planning, and control. Automated manufacturing systems can be further categorized into fixed automation, programmable automation, and flexible automation, with each type offering different levels of flexibility and suitability for varying production volumes and product diversity.

Fixed automation is characterized by a predefined sequence of operations, making it efficient for high-volume production but inflexible in terms of

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product variety. In contrast, programmable automation offers adaptability to different product configurations through programmable sequences, while flexible automation allows for the production of various parts without downtime for changeovers, making it suitable for environments requiring a high degree of variability.

Computerized manufacturing support systems encapsulate the use of advanced computer technology to enhance various operational functions within a manufacturing firm. This integration, often referred to as computer-integrated manufacturing (CIM), encompasses the seamless flow of information, further facilitated by tools such as computer-aided design (CAD) and computer-aided manufacturing (CAM), which are crucial for modern manufacturing efficiency.

The necessity of automation is underscored by several compelling reasons. First, automation significantly boosts labor productivity and reduces labor costs, thereby enhancing competitive standing. Moreover, it helps mitigate labor shortages, alleviates the burden of monotonous tasks for workers, and promotes safety within the manufacturing environment. Additionally, automation improves product quality, shortens manufacturing lead times, and enables complex processes that are otherwise beyond manual capabilities. Ultimately, companies that opt against automation risk falling behind in competitiveness and operational efficiency.

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In summary, the intricate relationship among manufacturing planning, control, and automation serves not only to streamline production processes but also to foster an environment conducive to innovation, efficiency, and quality in the modern manufacturing landscape.

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## Critical Thinking

**Key Point:** The role of automation in enhancing productivity and efficiency

**Critical Interpretation:** Imagine stepping into your own life like a factory floor, where every task, every responsibility has an intricate plan just waiting to be executed. Embracing automation in your daily operations—whether it's through scheduling tools, reminders, or technology that streamlines mundane tasks—can transform your productivity like never before. Automation allows you to focus on the high-value tasks, the creative projects that truly matter to you, alleviating the burden of routine chores and granting you the freedom to innovate and thrive. In a world bustling with constant demands, the lesson from manufacturing planning underlines the genius of working smarter, not harder; by letting automation handle the repetitive and transactional aspects of your life, you can unlock a new realm of efficiency and creativity that propels you towards your goals with greater clarity and purpose.

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## Chapter 3: 1.3 Manual Labor in Production Systems

The influence of manual labor in modern production systems remains significant, underlining the continued necessity for human involvement alongside automation. Despite the dominant trend towards increased automation, individuals are essential not only for directly engaging in manufacturing operations but also for managing and maintaining production facilities. The discussion surrounding labor dynamics is divided into two key areas: manual labor in factory operations and labor in manufacturing support systems.

The integration of automation has historically replaced manual jobs in many sectors of manufacturing, a trend that shows no signs of reversing. This technological advancement is tempered by economic realities that still favor human labor in many contexts. For instance, countries with significantly lower wage rates, such as China, India, and regions in Latin America and Eastern Europe, present a challenging environment for justifying the investment in automation purely based on cost efficiency. Particularly following the implementation of agreements like the North American Free

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## Chapter 4 Summary: 1.4 Automation Principles and Strategies

In exploring automation within manufacturing contexts, it is crucial to recognize that despite advancements in technology, certain functions still necessitate human intervention. Skilled technicians remain essential for maintaining automated equipment, programming, and managing engineering projects. Additionally, plant management requires professionals who can oversee operations and adapt to a landscape increasingly reliant on technical expertise.

To approach automation effectively, Groover introduces three pivotal strategies: the USA Principle, Ten Strategies for Automation and Process Improvement, and an Automation Migration Strategy.

1. The USA Principle emphasizes a systematic procedure for enhancing processes. It involves three critical steps: first, understanding the current process by thoroughly analyzing inputs, outputs, and operations to identify strengths and weaknesses. Next, the focus shifts to simplifying the process by questioning the necessity of each step, exploring the elimination of redundancies, and optimizing the use of technology. Finally, automation may be applied only once the process is simplified, ensuring that the implementation is justified by enhanced efficiency and productivity.

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2. Following the USA Principle, Groover outlines ten strategies that serve as a roadmap for improving processes through automation. These strategies provide diverse methods to enhance productivity, whether or not automation is feasible.

- Specialization of operations advocates for tailored equipment to maximize efficiency in specific tasks.
- Combined operations reduce the number of separate machines by consolidating tasks within fewer stations.
- Simultaneous operations improve efficiency by performing multiple operations at once.
- Integration of operations connects multiple workstations for seamless workflow.
- Increased flexibility allows machinery to handle various products, minimizing downtime for setup.
- Improved material handling and storage through automation reduces inefficiencies.
- On-line inspection suggests incorporating quality checks into the production process rather than waiting until completion.
- Process control and optimization aim to enhance individual processes to achieve faster times and better quality.
- Plant operations control focuses on improving overall management and coordination within the factory.
- Computer-integrated manufacturing (CIM) elevates this integration across the entire enterprise, utilizing extensive computer systems and



networks.

3. The Automation Migration Strategy is instrumental for companies needing to swiftly launch new products. This phased approach begins with manual production using flexible single-station setups. As product demand grows and automation proves beneficial, the process evolves through the introduction of automated stations and eventually culminates in fully integrated automated systems. This strategy not only expedites product introduction but also allows for gradual automation tailored to demand fluctuations, making it a prudent choice for manufacturers wary of overcommitting to automation.

In conclusion, while automation presents vast opportunities for efficiency and productivity in manufacturing, it is paramount to remain cognizant of the need for human oversight and management throughout this transition. The methodologies outlined by Groover encourage a thoughtful, systematic approach to integrating automation, ensuring that enhancements in production systems are sustainable and purposeful.

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## Critical Thinking

**Key Point:** Apply the USA Principle in personal projects to achieve better efficiency.

**Critical Interpretation:** Imagine you are embarking on a personal project, perhaps organizing your workspace or planning a community event. By applying the USA Principle that Groover outlines—first understanding the current situation, then simplifying processes, and finally applying automation where appropriate—you can transform the way you approach tasks. Visualize diving deep into analyzing the way you currently manage your time and resources; identify the steps that consume most of your energy and exploration into whether they can be streamlined or eliminated altogether. As you simplify the process, you'll find that not only do you save time, but you also reduce stress and enhance your productivity. Embracing this systematic approach can inspire you to tackle various challenges, knowing that intentional reflection and thoughtful planning can lead to smoother execution and greater accomplishment in all areas of your life.

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## Chapter 5 Summary: 1.5 About This Book

This book presents a comprehensive exploration of production systems, highlighting their components, automation, and computer integration. The content highlights six significant technical categories essential for understanding production systems, meticulously organized throughout the text.

1. The first part introduces manufacturing operations, emphasizing fundamental mathematical models that serve to measure performance and costs. This foundational knowledge is crucial as it sets the stage for analyzing production efficiency and effectiveness.
2. In the second part, the focus shifts to automation and control technologies. Unlike the general discussions in the introduction, these chapters delve into specific technologies, such as industrial control systems, numerical control machinery, robotics, and programmable logic controllers. Each of these plays a pivotal role in modern automation.
3. The third part addresses the critical aspects of material handling and identification within both factories and warehouses, elucidating the technology involved in transporting, storing, and tracking materials. Effective management of these elements is essential for streamlining operations and enhancing productivity.

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4. The fourth part emphasizes the seamless integration of automation and material handling technologies into manufacturing systems. This integration varies, with some systems being highly automated, while others rely significantly on manual labor. Varied systems discussed include single-station work cells, production lines, assembly systems, cellular manufacturing, and flexible manufacturing systems.

5. Quality control emerges as a vital component in modern production systems, warranting a dedicated examination in the fifth part of the book. Chapters here explore statistical process control and various inspection technologies such as machine vision and coordinate measuring machines. The discussion accentuates that while quality control is an enterprise-level endeavor, its execution is grounded in the factory environment.

6. Finally, in the sixth part, the focus shifts to manufacturing support functions. This segment explores critical areas such as product design, supported by Computer-Aided Design (CAD), process planning, and diverse planning functions like Material Requirements Planning (MRP) and Enterprise Resource Planning (ERP). The book concludes with insights on just-in-time and lean production methodologies, which are increasingly relevant for contemporary manufacturing practices.

Each chapter builds on its predecessors, creating a rich tapestry of

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knowledge that interlinks various aspects of production systems. This structured approach equips readers with a thorough understanding of how automation and quality control contribute to efficient manufacturing processes, ultimately enabling modern businesses to thrive in competitive landscapes. The book serves as both an educational resource and a practical guide for understanding the complexities and innovations within production systems.

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# Chapter 6: MANUFACTURING OPERATIONS

Chapter 6 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover provides an extensive overview of manufacturing operations and principles. This chapter is crucial in understanding the different aspects of manufacturing, the industries involved, and the methods of production and assembly that contribute to the overall manufacturing process. Here's a detailed summary of the key concepts discussed in the chapter:

**1. Definition and Importance of Manufacturing:** Manufacturing is primarily defined as the transformation of raw materials through physical or chemical processes to create parts or finished products. This process not only impacts the geometry and properties of materials but also adds economic value. For instance, transforming iron ore into steel or sand into glass illustrates how materials are altered to enhance their utility and market value.

**2. Manufacturing Operations:** At the core of manufacturing are

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# Chapter 7 Summary: MANUFACTURING METRICS AND ECONOMICS

In Chapter 7 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover, the author explores critical metrics, performance indicators, and cost considerations essential for effective manufacturing management. This chapter is structured to provide a comprehensive framework for understanding production performance and associated costs, presenting key metrics through which manufacturing operations can be evaluated and improved.

**1. Production Performance Metrics:** The chapter introduces various metrics that allow manufacturers to assess their efficiency and effectiveness. It is essential to begin with cycle time, defined as the duration required for a unit to be processed or assembled. The cycle time ( $T_c$ ) is influenced by processing time ( $T_o$ ), handling time ( $T_h$ ), and tool handling time ( $T_t$ ). Production rate ( $R_p$ ) translates this cycle time into performance as an output measure per hour (pc/hr). The production rate varies across production types—job shop, batch, and mass production—each with its unique calculation methods. Consequently, an effective production system must consider both cycle time and production rates to optimize performance.

**2. Production Capacity and Utilization:** Production capacity refers to the maximum output a facility can achieve under specified conditions, while

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utilization measures how effectively a facility operates relative to its capacity. Factors influencing production capacity include the number of machines and operating hours per week. By analyzing capacity, organizations can determine how to scale operations in response to demand fluctuations, capitalizing on opportunities for increased production or identifying inefficiencies.

**3. Manufacturing Lead Time and Work-in-Process (WIP)** Manufacturing lead time (MLT) encapsulates the total time a part spends in the production system, including tangible processing efforts, delays, and non-productive periods. Work-in-process represents the inventory that resides within the production flow, signifying a capital investment that cannot be monetized until processing is complete. The chapter highlights the importance of controlling MLT and WIP to enhance customer satisfaction through reduced delivery times and minimized costs.

**4. Manufacturing Costs:** This section categorizes costs into fixed and variable types, detailing how each affects pricing strategies. Fixed costs remain constant regardless of production output, while variable costs fluctuate with production levels. For decision-making, particularly when evaluating automation versus manual operations, understanding the cost dynamics is critical as each method presents distinct cost benefits at different output levels.

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**5. Direct Labor, Material, and Overhead** Costs in manufacturing may also be broken down into direct labor, material, and overhead costs. Direct labor represents worker compensation; material costs pertain to the raw materials utilized in production, while overhead encompasses all indirect costs associated with running the manufacturing operation. Overhead is further segmented into factory and corporate categories, with various allocation methods available to assign these costs accurately to specific products.

**6. Cost of Equipment Usage:** Effective cost management requires recognizing the differing costs associated with various equipment used in production. The chapter emphasizes differentiating between labor and machine costs, particularly in assessing the total operational cost of a manufacturing cell. This detailed understanding guides better investment decisions and optimal resource utilization.

**7. Cost of a Manufactured Part:** The computation of the unit cost for manufactured products consolidates all production costs, including labor, material, and overhead, and defines the total cost necessary to arrive at a selling price based on marked-up cost structure. This section reinforces the interconnectedness between efficiency in production and the financial viability of manufacturing operations.

Through the exploration of these foundational topics, Chapter 7 provides a

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detailed and practical guideline for optimizing manufacturing performance and managing costs effectively, essential for any manufacturing organization striving for operational excellence.

Topic	Description
Production Performance Metrics	Introduces key metrics to assess efficiency, focusing on cycle time, production rate, and their relevance to different production types.
Production Capacity and Utilization	Defines maximum output (capacity) and measures operational effectiveness (utilization), emphasizing scalability and efficiency identification.
Manufacturing Lead Time and WIP	Discusses total production time (MLT) and in-process inventory (WIP), highlighting their impact on delivery times and cost management.
Manufacturing Costs	Classifies costs as fixed or variable and their effects on pricing strategies, useful for automation versus manual operation decisions.
Direct Labor, Material, and Overhead	Breakdown of manufacturing costs into labor, materials, and overhead, with emphasis on allocation methods for accurate cost assignment.
Cost of Equipment Usage	Highlights differences in costs associated with various equipment, guiding investment decisions and resource utilization.
Cost of a Manufactured Part	Describes the process of calculating unit cost for products, integrating all production costs and its importance for pricing.

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# Chapter 8 Summary: INTRODUCTION TO AUTOMATION

Automation represents the technological foundation that permits processes to operate independently of human intervention. Its inception traces back to 1946, linked notably to manufacturing contexts, where its essence was encapsulated by three fundamental components: power, instructions, and control systems. Each of these elements plays a critical role in the operation of automated systems, which have evolved from basic mechanical devices to complex, computer-controlled environments that govern industrial production.

**1. Basic Elements of Automated Systems:** Automation comprises three core components: power, a program of instructions, and a control system. Power primarily originates from electricity, enabling machinery to function and control commands. The program of instructions dictates operational parameters, ensuring tasks are executed systematically. Control systems, the brain of automation, facilitate the functioning of both machinery and manufacturing processes through mechanisms of feedback and predefined sequences.

**2. The Historical Evolution of Automation:** The historical development of automation outlines a trajectory that includes the advent of ancient mechanical devices and significant milestones such as the flying-ball

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governor designed by James Watt. The trajectory of technological progress laid the groundwork for contemporary automation, which now operates largely through computer technologies. Innovations have evolved rapidly since World War II, introducing devices such as numerical controls, industrial robots, and computerized control systems, each enhancing the complexity and capabilities of automated systems.

**3. Power Requirements and Automation:** Alongside the operational processes, power requirements extend to both the machinery and the controls. For processes like casting, injection molding, and laser cutting, specific power forms facilitate operations. Automated systems also necessitate power for material handling, controlling robotic devices for loading and unloading tasks, and managing control signals. This reflects a comprehensive consideration of energy needs across various production stages.

**4. Programming Frameworks:** The successful execution of a work cycle hinges on well-defined programs that encompass several operational categories, from basic set-point controls to intelligent programs that exhibit human-like decision-making capabilities. These programming paradigms ensure the automation can address both routine and exceptional circumstances, further enriching operational reliability and adaptability.

**5. Control Systems in Automation:** Control systems can be categorized

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as either open-loop or closed-loop systems. Closed-loop systems utilize feedback sensors to monitor output, adjusting operations in real time to ensure process fidelity. Open-loop systems, while simpler and often less expensive, do not have this feedback mechanism. Depending on operational requirements, the choice of control system significantly impacts the efficiency and accuracy of automated processes.

**6. Advanced Functions in Automation:** Beyond basic operations, automated systems increasingly implement advanced capabilities, such as safety monitoring and maintenance diagnostics. These functions incorporate sensors to facilitate safety and performance enhancements, ensuring systems operate without jeopardizing human operators or equipment. Maintenance diagnostics help identify and troubleshoot potential issues proactively, minimizing downtime.

**7. Error Detection and Recovery:** Automated systems must also manage unforeseen failures efficiently. A comprehensive framework identifies malfunctions and executes corrective actions to mitigate disruption and restore normalcy. The recovery strategies fall into categories that range from adjustments at the end of work cycles to immediate actions during operations, demonstrating the system's capacity for resilience.

**8. Levels of Automation:** The automation hierarchy encompasses various operational levels: device, machine, cell, plant, and enterprise

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levels. Each level represents specific functionalities and control responsibilities, facilitating an integrated approach to managing production processes. The device level comprises sensors and actuators, while the higher levels coordinate complex processes across multiple machines, culminating in enterprise-wide systems that manage overall business operations.

In summary, automation serves as a vital backbone in modern manufacturing, defined by its architectural components, historical evolution, power requirements, programming complexities, and advanced functionalities that maintain operational efficacy. The multifaceted nature of automation highlights its role in advancing industrial capabilities, thus shaping the future of production systems globally.

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## Chapter 9: INDUSTRIAL CONTROL SYSTEMS

Chapter 5 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover focuses on industrial control systems, particularly the role of digital computers in production control. This control is crucial for managing unit operations and integrating them within broader production environments.

1. In industrial contexts, there are two fundamental categories: **process industries** (which handle bulk materials like liquids and gases) and **discrete manufacturing industries** (which deal with individual parts and products). The methods and technologies employed for automation differ significantly, with tailored automation levels based on the requirements of each industry type.

2. The **levels of automation** highlight stark contrasts between the two industries. While process industries employ devices that manage continuous operations, discrete manufacturing utilizes machines that focus on controlling specific actions. At the device level, for instance, the sensors and

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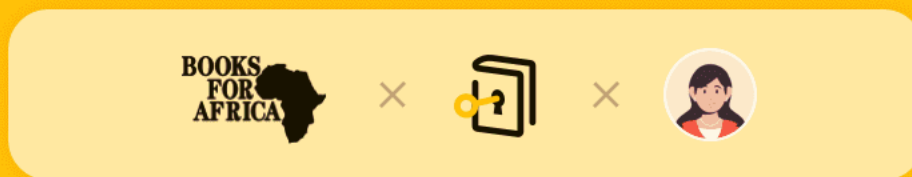
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# Chapter 10 Summary: HARDWARE COMPONENTS FOR AUTOMATION AND PROCESS CONTROL

In this chapter on hardware components for automation and process control, several critical elements necessary for effective computer-process interfacing are discussed. Four primary categories of components are identified: sensors, actuators, analog-to-digital (A/D) converters, and input/output devices primarily for discrete data.

1. Sensors serve as transducers that convert physical variables like temperature, pressure, or displacement into electrical signals that can be measured. They can be classified based on the nature of the stimulus they measure, distinguishing between analog sensors, which provide continuous outputs, and discrete sensors, which yield specific values (binary or digital). Active sensors generate a response without external power, whereas passive sensors require it. Calibration is essential for establishing the transfer function, defining how the sensor output relates to the physical variable measured.

2. Actuators translate control signals into physical changes, most commonly in mechanical forms such as movement or force. They can be classified into three categories: electric, hydraulic, and pneumatic actuators. Electric actuators encompass various motor types, including direct current (DC), alternating current (AC), stepper, and linear motors. Each type has unique



operational characteristics suited for different applications. Hydraulic actuators are praised for their ability to exert high forces but come with heavier equipment and cost implications. Pneumatic systems, while offering high-speed actuation, typically deal with lower force outcomes.

3. The conversion processes between analog and digital signals are crucial for interfacing. Analog-to-digital converters (ADCs) enable the transformation of continuous signals into digital data, involving sampling, quantization, and encoding steps. Factors such as sampling rate, conversion time, and resolution critically affect how accurately an analog signal is converted to digital form. Conversely, digital-to-analog converters (DACs) reverse the process, translating digital signals into continuous outputs.

4. Input/output devices for discrete data management relay information between the digital computer and external processes. Contact interfaces function as binary switches that read inputs or send outputs, representing distinct signal states (on/off). Pulse counters and generators effectively manage pulse signals from various digital transducers, counting and generating electrical pulses that can control devices like stepper motors.

Through these components, the chapter outlines the foundational technologies enabling automation and process control in modern manufacturing settings, highlighting the interplay between digital and analog systems and the importance of precise data acquisition and control

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mechanisms.

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## Critical Thinking

**Key Point:** The Role of Sensors in Our Lives

**Critical Interpretation:** Imagine waking up each morning to a world where the environment around you is perfectly attuned to your needs, all thanks to the hidden yet pivotal role of sensors. Just like they convert physical variables into actionable data, you too can harness the power of awareness and observation in your daily life. Each time you notice a change in your surroundings, whether it's the temperature of your coffee or the mood of a friend, you are acting like a sensor, translating those signals into meaningful actions. This chapter inspires you to embrace your own ability to perceive and respond, reminding you that by being alert and reactive to the small changes in your environment, you can enhance your interactions and make thoughtful decisions that lead to a more harmonious and fulfilling life.

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# Chapter 11 Summary: COMPUTER NUMERICAL CONTROL

Certainly! Below is a comprehensive summary of Chapter 11 from "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover, focusing on Computer Numerical Control (CNC) technology. The summary presents the essential principles and details in a continuous format without subheadings:

Numerical control (NC) represents a pivotal advancement in programmable automation, wherein machine tools execute pre-defined mechanical actions based on coded alphanumeric data. This data primarily delineates the positional relationship between the work head, typically a cutting tool, and the work part being machined. One significant advantage of NC is its adaptability: upon completing one job, the programming can be easily altered to accommodate different machining tasks, making it especially beneficial for low to medium production runs. The inception of NC traces back to the late 1940s, culminating in the first operational NC machine in 1952, thanks to collaborative efforts spearheaded by John Parsons and his associates.

The functionality of NC systems is anchored in three fundamental components: the part program of instructions, the machine control unit (MCU), and the processing equipment. The part program encapsulates a

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detailed, step-by-step guide, directing the actions of the processing equipment, often encoded in formats that can range from punched tapes to modern digital storage mediums. The MCU, typically a microcomputer in contemporary applications, translates each command from the program into mechanical actions, interfacing with the processing equipment to execute machining tasks.

The coordinate systems employed in NC are crucial for establishing the positioning framework for the work head relative to the work part. Two primary axis systems are distinguished: one for flat, prismatic parts utilizing the conventional Cartesian coordinates (x, y, z), supplemented by rotational axes (a, b, c) for complex machining, and another specifically designed for rotational NC systems, as used in lathes. The competence of these systems hinges on motion control, categorized primarily into point-to-point and continuous path control. Point-to-point control allows for rapid repositioning of the tool between designated points, while continuous path control enables smooth, simultaneous movement across multiple axes, essential for operations like milling and turning.

Interpolation is a technique integral to CNC machining, permitting the generation of non-linear tool trajectories through simplified geometric approximations. Various interpolation methods, including linear, circular, and helical, support complex path generation, facilitating the machining of intricate shapes. Additionally, the programming can be performed using

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different methods, ranging from manual part programming utilizing low-level machine language, to computer-assisted and CAD/CAM part programming, significantly enhancing the efficiency and precision of the process.

Computer numerical control (CNC) has evolved dramatically, with significant improvements in hardware and software, leading to sophisticated controls that not only execute complex machining programs but also include features like multiple program storage, on-machine editing, fixed cycles, and adaptive control, optimizing machining operations based on real-time performance. The integration of CNC has led to substantial productivity increases in applications, especially in the machining sector, where NC tools provide precision and reduce manual intervention.

The applicability of NC extends beyond traditional machine tools to include diverse processes such as sheet metal fabrication, welding, and assembly. It demonstrates notable advantages, such as decreased non-productive time, improved accuracy and repeatability, reduced scrap rates, and streamlined engineering changes. However, the adoption of NC technologies entails disadvantages, such as higher initial capital investment and the necessity for specialized programming skills, requiring shops to evaluate the trade-offs before implementation.

Positioning systems in NC can be classified into open-loop and closed-loop

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systems. The open-loop systems primarily use motors that operate based on predetermined control signals without feedback for verification, suitable for less demanding applications. In contrast, closed-loop systems leverage feedback mechanisms, typically employing optical encoders, to ensure accuracy in position, critical for precision machining.

The pursuit of precision in positioning systems is quantified by control resolution, accuracy, and repeatability, with control resolution emerging as the smallest discernible movement determined by both mechanical components and the digital system's bit capacity for positioning. Effective programming in NC incorporates thorough documentation and process comprehension, culminating in a robust manufacturing process powered by automation.

This chapter delineates a comprehensive view of NC technology, underlining its impact on enhancing operational efficiency and product quality across various manufacturing processes, steering towards a more automated and integrated future in production systems.

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## Chapter 12: INDUSTRIAL ROBOTICS

The chapter provides a comprehensive overview of industrial robotics, which encompasses various aspects from the anatomy of robots to their applications, programming, and precision in tasks. Here's a detailed summary of the key concepts covered:

**1. Definition and Characteristics of Industrial Robots:** Industrial robots are described as automated, reprogrammable manipulators capable of functioning in three or more axes. Their similarities with numerical control (NC) machines highlight their joint movement capabilities, controlled by dedicated digital computers. Robots are versatile, able to replace humans in hazardous environments, maintain consistent performance, and be reprogrammed for different tasks.

**2. Historical Context:** The development of robotics has roots in early inventions, notably by Cyril W. Kenward and George C. Devol, whose inventions laid groundwork for later commercialization, particularly by companies like Unimation, Inc. Joseph Engelberger played a pivotal role in

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# Chapter 13 Summary: DISCRETE CONTROL AND PROGRAMMABLE LOGIC CONTROLLERS

Chapter 9 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover delves into discrete process control, emphasizing the use of various control systems to manage industrial automation effectively. This chapter is structured around a variety of essential themes related to discrete control and programmable logic controllers (PLCs).

1. Discrete process control encompasses systems managing parameters that change discretely over time, dealing primarily with binary variables represented by digital signals. Inputs are collected via sensors, and outputs trigger actions in actuators based on the logic defined by the control system. Common elements include binary sensors, limit switches, and various actuators such as motors and valves. The primary purpose of these systems is to coordinate physical actions across the automation processes, illustrating essential applications in manufacturing and assembly.

2. The two main categories of discrete control systems include logic control, which responds solely to present input conditions without memory, and sequence control, which operates based on timing and sequence of operations. Logic control exemplifies the importance of immediate event responses using inputs like limit switches to dictate actions without

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considering historical data. Conversely, sequence control involves timed changes where outputs are triggered based on preset conditions or cycles.

3. Logic operations leverage fundamental elements known as logic gates—AND, OR, and NOT. AND gates output a positive signal when all inputs are active, while OR gates do so even if only one input is active. The NOT gate inverses input signals. These gates form the building blocks of Boolean algebra, which provides a mathematical framework to analyze both straightforward and complex logical statements through truth tables.

4. Ladder logic diagrams represent control logic visually, with horizontal rungs symbolizing control processes. This format assists operators familiar with electrical circuits in understanding complex control systems likely utilized in discrete control applications. Representational symbols denote electrical components like timers, counters, and output loads, enabling an intuitive grasp of system operations and facilitating troubleshooting.

5. Programmable Logic Controllers (PLCs) emerge as essential tools in automation, facilitating complex decision-making and operational tasks. Comprised of several components including a processor, memory unit, I/O modules, and power supply, PLCs serve to implement logic control, sequencing, timing, and arithmetic functions in industrial settings. Their versatility is evident in both discrete manufacturing and process industries.

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6. The PLC operates through a defined cycle involving input scanning, program execution, and output updating. This scan cycle ensures that the controller constantly evaluates the status of input signals, processes them according to the programmed logic, and adjusts output signals accordingly. While efficient, potential timing mismatches can occur if input values change abruptly between scans. Advanced PLCs counter this issue by introducing immediate input processing features.

7. Programming a PLC involves several languages, notably the widely adopted ladder logic diagram, which simplifies instruction entry for operators accustomed to traditional circuit design. Other programming languages specified under IEC standards enhance PLC capabilities, introducing more complex functions to address growing industrial needs, expanding their applications beyond simple ON/OFF control.

8. Personal computers (PCs) and programmable automation controllers (PACs) have evolved to challenge traditional PLC functions by integrating advanced computing capabilities and networking features. PACs cater to modern industrial requirements by combining conventional control with data processing, analog control, and more sophisticated programming, distinguishing themselves as highly adaptable solutions for contemporary manufacturing environments.

In conclusion, Chapter 9 articulates how discrete process control and

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programmable logic controllers form the backbone of automated industrial systems, demonstrating the essential symbiosis between logic operations, programming capabilities, and physical system interactions. As industry demands grow ever more complex, the evolution of these control systems into PCs and PACs illustrates a trend towards increased capability, flexibility, and integration of technologies in the field of automation.

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# Chapter 14 Summary: MATERIAL TRANSPORT SYSTEMS

Material handling is a critical aspect of manufacturing and logistics, involving the movement, protection, storage, and control of materials throughout various processes. This chapter outlines key aspects of material transport systems necessary for efficiently managing this complex task. The chapter is organized into several sections detailing types of equipment, their classifications, design considerations, and analytical approaches for improving efficiency.

**1. Definition and Importance:** Material handling is defined as the movement and control of materials during manufacture, distribution, consumption, and disposal. It significantly impacts production costs, with estimates indicating that it constitutes about 20-25% of total manufacturing labor costs in the United States. Efficient material handling ensures safe, timely, and cost-effective management of materials.

**2. Categories of Material Handling Equipment:** Material handling equipment can be categorized into five main groups:

- **Transport Equipment** This includes industrial trucks, automated guided vehicles (AGVs), rail-guided vehicles, conveyors, and cranes/hoists. Each serves different functions and operational needs within a facility.
- **Positioning Equipment:** Equipment such as industrial robots and



hoists that handle and position materials at specific locations.

- **Unit Load Formation Equipment:** This encompasses containers and the machinery to load them efficiently. The use of standardized containers enhances the logistics of moving multiple items simultaneously.

- **Storage Equipment:** Divided into conventional and automated storage systems, these are crucial for holding materials temporarily when necessary.

- **Identification and Control Equipment:** Utilizes labels such as barcodes and RFID for tracking and managing materials throughout their handling.

3. **Design Considerations:** Various factors play a role in the design of material handling systems, including:

- **Material Characteristics:** The physical properties of materials influence the choice of handling equipment.

- **Flow Rate, Routing, and Scheduling:** The design must accommodate quantities, the distance materials are moved, and timing to ensure efficiency.

- **Plant Layout:** Material handling must synergize with plant layout to optimize the flow, which can vary based on the arrangement chosen (process, product, or fixed-position layout).

4. **Unit Load Principle:** This principle advocates for handling materials as larger unit loads to enhance efficiency, reducing the number of trips



required and mitigating load handling times. It emphasizes standardization to align with equipment capacities.

**5. Material Transport Systems** The chapter details five categories of material transport equipment:

- **Industrial Trucks** Segmented into manual and powered types for moving materials.
- **Automated Guided Vehicles (AGVs)** These are self-propelled vehicles on designated paths that facilitate the internal movement of materials.
- **Rail-Guided Vehicles** These systems, operating on fixed rails, provide efficient transport for heavier loads.
- **Conveyors** Mechanical systems designed to move items continuously, with various types based on their structural features and operations.
- **Cranes and Hoists** Essential for heavy lifting and horizontal transportation within manufacturing environments.

**6. Analysis of Material Transport Systems** The analysis incorporates mathematical models to enhance the understanding of flow rates, delivery times, and overall system performance. The models can be adjusted to account for variables such as the number of vehicles, expected delays, and material flow characteristics.



**7. Vehicle-Based Systems** The analysis covers vehicle-based transport systems, examining factors like the delivery cycle, average travel distances, and the number of vehicles needed based on delivery requirements and operational conditions.

**8. Conveyor Analysis:** This includes single-direction and recirculating conveyors, investigating their operations, flow rates, and the influence of speed and design on efficiency. Principles developed by Kwo provide a framework for evaluating the feasibility of conveyor systems, emphasizing speed, capacity constraints, and uniformity.

Throughout the chapter, various examples illustrate the application of these principles in practical scenarios, encouraging the optimization of material handling systems to reduce costs, enhance efficiency and maintain safety standards. This comprehensive understanding of material handling systems is vital for anyone involved in the management and engineering of manufacturing and logistics processes.

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## Chapter 15: STORAGE SYSTEMS

The chapter delves into various aspects of material storage systems, detailing how they can significantly enhance efficiency and performance in manufacturing and distribution operations. The text is divided into sections that outline key concepts, methods, types, and analytical frameworks related to storage systems, which are essential for optimizing material handling and inventory management.

1. The primary function of material storage systems is to hold materials for a period of time and facilitate easy access when needed. Conventional and automated methods are utilized to enhance their efficiency, catering to various types of materials present in manufacturing operations, such as raw materials, work-in-progress, and finished products.

2. **Storage system performance** is evaluated through several metrics, including storage capacity, density, accessibility, throughput, utilization, and reliability. Storage capacity refers to the total volume or number of compartments available, while storage density measures how effectively

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# Chapter 16 Summary: AUTOMATIC IDENTIFICATION AND DATA CAPTURE

Automatic identification and data capture (AIDC) encompasses technologies that enable the direct entry of data into computer systems without the need for manual keyboard input, making it especially valuable in material handling and manufacturing settings. AIDC systems enhance efficiency by facilitating various operations such as shipping, order processing, and monitoring work-in-progress, crucial for both factory environments and industries such as retail, banking, and healthcare.

The drawbacks of manual data capture methods are significant: errors in data entry, time inefficiencies, and high labor costs. Manual entry typically has an error rate of one in 300 characters and is substantially slower than automatic methods, leading to inflated labor costs due to the attention required from human operators. AIDC addresses these issues by ensuring that data is collected automatically at the point of occurrence, thereby enhancing accuracy and timeliness while reducing dependency on human labor.

The process of automatic identification typically involves three key components:

1. **Data Encoder:** This converts characters into a machine-readable format.

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2. **Machine Reader/Scanner:** This device reads the encoded data and converts it into an electrical signal.

3. **Data Decoder:** This component transforms the electrical signal back into the original characters for further processing.

AIDC technologies encompass various methods, primarily categorized into six types: optical technologies (including bar codes and machine vision), electromagnetic methods such as radio frequency identification (RFID), magnetic types (like magnetic stripes), smart cards, touch techniques, and biometric systems. Each category offers different capabilities and applications tailored to specific needs.

Bar code technology is one of the most prevalent forms of automatic identification, consisting of linear (one-dimensional) and two-dimensional formats. Linear bar codes, extensively used in retail environments, represent data through a series of parallel lines, while two-dimensional bar codes can store significantly higher volumes of data but require specialized scanners for reading. The adoption of bar codes traces back to the grocery industry's choice of the Universal Product Code (UPC) as a standard in the early 1970s, promoting standardization across multiple sectors.

The function of bar code readers, which can be contact or noncontact-based, plays a crucial role in data capture. These devices interpret bar codes by emitting light beams that reflect off the printed codes and convert these

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reflected signals into an electronic format for analysis. As bar code technology advanced, so did the mechanisms for producing and reading these codes, leading to improvements in speed and efficiency in data acquisition.

In recent years, RFID technology has gained traction as it can potentially outperform bar codes in efficiency and data capacity. RFID tags, which comprise an integrated circuit and antenna, allow for the transmission of encoded information without requiring direct line of sight between the tag and the reader. New applications for RFID have emerged, fueled by corporate mandates for greater automation and tracking capabilities.

Alongside bar codes and RFID, other AIDC methods include magnetic stripes, which are often used in banking and access applications but are declining in factory settings due to the need for contact reading; optical character recognition (OCR), which reads text-based data but carries low accuracy rates; and machine vision systems that enable product recognition based on geometrical features, further illustrating the diverse capabilities of AIDC technologies.

In summary, the evolution of automatic identification and data capture technologies has revolutionized data management in various sectors, delivering significant benefits in terms of accuracy, speed, and cost-efficiency. The continuing development of these systems promises

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enhanced productivity and reliability in future operations across industries.

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# Chapter 17 Summary: OVERVIEW OF MANUFACTURING SYSTEMS

Chapter 17 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover provides an extensive overview of manufacturing systems, discussing their fundamental components and various classifications based on specific characteristics. The text details how automation technologies, material handling systems, and human resources interact within these manufacturing systems to enhance production efficiency.

## 1. Definition and Components of Manufacturing Systems: A

manufacturing system is characterized as an integrated assembly of equipment and human resources geared toward executing processing or assembly operations. Key components include production machines, material handling systems, computer control systems, and human workers. These systems enhance value through the transformation of raw materials into finished products.

## 2. Types of Production Machines:

Manufacturing machines can be categorized into three groups based on the level of worker involvement: manually operated machines where workers are continuously present, semiautomated machines that require partial human intervention, and fully automated machines that operate independently, needing human attention



only sporadically for maintenance tasks. Workstations—locations where specific operations occur—can consist of various configurations employing these different types of machines.

**3. Material Handling Systems:** Effective material handling is essential in manufacturing, and it includes loading, positioning, and unloading work units at each workstation. Additionally, it encompasses transporting units between workstations and storing them temporarily to ensure a continuous workflow. Often, mechanized transport systems are preferred to minimize human labor, although human operators are vital in workers' roles within manual and semiautomated systems.

**4. Computer Control Systems:** Modern manufacturing relies heavily on computer systems for the coordination of operations. These systems execute various functions, including scheduling, monitoring safety, maintaining quality control, and diagnosing failures. By facilitating communication and operational effectiveness, computer systems significantly enhance productivity in manufacturing environments.

**5. Human Resources:** In many manufacturing systems, direct labor is crucial to adding value during processing and assembly. Workers may perform hands-on tasks or oversee automated machines. Their roles can vary widely—from manual control to indirect assistance through programming and maintenance. As automation increases, distinguishing between direct

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and indirect labor roles becomes increasingly complex.

**6. Classification of Manufacturing Systems:** Manufacturing systems can be categorized based on several factors, including the types of operations performed (processing vs. assembly), the number of workstations (single vs. multistation systems), the level of automation (manned vs. automated), and the system's flexibility to adapt to variations in product styles.

**7. Types of Operations:** The types of operations in manufacturing systems vary greatly, influenced by factors such as the type of material processed, part size and weight, geometry, and complexity. This diversity affects the choice of processing and machinery required in a manufacturing system.

**8. Number of Workstations and System Layout** The number of workstations plays a foundational role in a manufacturing system's design and operational efficiency. A higher number of workstations contributes to increased production capacity, enabling specialization that leads to enhanced productivity, albeit with increased complexity in management and maintenance.

**9. Level of Automation:** The relationship between automation and labor is pivotal in determining a manufacturing system's efficiency. Lower manning levels correspond to higher automation levels, with workstations

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classified as either manned (requiring constant human oversight) or automated (allowing for intermittent human interaction).

**10. System Flexibility:** Flexibility denotes a manufacturing system's ability to manage variations in production without interruption. Systems showcasing high flexibility can easily adjust to new product types, thereby maximizing responsiveness to market demands.

**11. Classification of Manufacturing Systems:** The text identifies three primary types of manufacturing systems: single-station cells, multistation systems with fixed routing, and those with variable routing. Each of these classifications can exist as fully manned, fully automated, or hybrid systems, where both manual and automated stations coexist.

The chapter's comprehensive exploration of manufacturing systems illustrates how technology and human expertise converge to enhance production efficiency and adaptability. As manufacturing continues to evolve, understanding these principles is crucial for optimizing processes in modern production environments.

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# Chapter 18: SINGLE-STATION MANUFACTURING CELLS

Chapter 18 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover focuses on single-station manufacturing cells, which are foundational units in modern industrial production. These cells can be manned or automated, and they play a crucial role in processing and assembly operations across various production scenarios. The chapter explores the operational characteristics of these cells, their applications, and the analytical considerations required for their effective implementation.

**1. Manned and Automated Cells:** Single-station manned cells are characterized by one machine operated by a single worker. These cells excel in job shop and batch production due to their quick setup times, lower capital costs, ease of installation, minimal maintenance needs, and flexibility in changeovers. In contrast, single-station automated cells, comprising machines capable of unattended operation, necessitate periodic worker intervention for loading and unloading. These automated systems yield

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## Chapter 19 Summary: MANUAL ASSEMBLY LINES

Chapter 19 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover provides an in-depth exploration of manual assembly lines, highlighting their significance in manufacturing processes. This chapter delves into various aspects of manual assembly lines including their design, operation, and efficiency, as well as the analytical methods surrounding single-model, batch-model, and mixed-model lines.

1. Manual assembly lines are characterized by a series of workstations where workers perform specialized tasks to assemble products. This method is primarily employed for products that are similar or identical, and where the workload can be divided into smaller, manageable tasks. The productivity of manual assembly lines can be attributed to the principles of specialization of labor, interchangeable parts, work flow, and line pacing. Each of these principles enhances the efficiency of production by enabling workers to focus on specific tasks, ensuring compatibility of parts, facilitating seamless movement of work units, and setting production rates based on a cycle time.

2. Line design and layout are dictated by factors such as workstation configuration, work transport systems, and methods for coping with product variety. Workstations can be designed for either standing or sitting tasks, depending on the product size. Transport systems can be manual or mechanized, with the latter often providing more consistent production rates.

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Pacing of the line helps maintain a required production rate, while strategies for coping with product variety involve single-model, batch-model, and mixed-model lines. These models serve different needs based on production demand and variety.

3. When analyzing single-model assembly lines, essential concepts include cycle time, workload analysis, and the line balancing problem. The cycle time is determined by the required production rate and takes into consideration the efficiency of the line. Workload encompasses the total time needed for assembly, and line balancing seeks to assign tasks across workstations to ensure optimal utilization of labor while minimizing idle time.

4. A variety of algorithms exist to address the line balancing problem, including the Largest Candidate Rule, Kilbridge and Wester Method, and Ranked Positional Weights Method. Each of these methods provides a systematic approach to allocate tasks to workstations effectively, while balancing the workload among workers.

5. In considering workstation specifics, concepts such as time-distance relationships and manning levels are important. The manning level pertains to the number of workers assigned to each station, and varying this can lead to optimized production lengths and overall efficiencies.

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6. Factors beyond computational efficiency are also critical in assembly line design. Considerations for maintaining line efficiency include preventative maintenance, process analysis, sharing work elements, and managing work speeds. Implementing storage buffers can mitigate production variability and downtime, while zoning constraints can determine station organization based on task interdependencies.

7. Alternative assembly systems like single-station assembly cells and worker team systems present solutions to address common assembly line issues such as monotony and worker satisfaction. These systems emphasize flexibility, allowing for more complex tasks and a broader scope of responsibility.

8. Finally, the chapter addresses batch-model and mixed-model lines, adapting analytical methods for the distinct operations of each. In batch-model lines, products are produced in batches with scheduled changeovers, while mixed-model lines allow for simultaneous production of varied models, continuously adjusting to demand without traditional batching constraints.

This comprehensive examination of manual assembly lines reveals their importance in modern manufacturing, demonstrating how systematic design and planning can enhance productivity, efficiency, and worker satisfaction. The techniques discussed provide avenues for optimizing production

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through careful analysis of workflows, workloads, and workstations.

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# Chapter 20 Summary: AUTOMATED PRODUCTION LINES

Automated production lines are sophisticated systems designed for high-volume manufacturing of parts through multiple processing operations performed at linked workstations. These systems utilize mechanized work transport to ensure the efficient flow of parts from one station to another, significantly minimizing the need for manual labor, lowering production costs, and optimizing manufacturing space. Automated production lines, particularly in the context of machining operations, offer distinct configurations, advantages, and considerations that are essential for effective implementation.

## 1. Fundamentals of Automated Production Lines:

Automated production lines consist of numerous workstations connected via a transport system that moves parts sequentially through different operations. Common configurations include in-line, segmented in-line, and rotary setups. Synchronous transfer is the traditional method employed in these environments, although asynchronous systems provide enhanced flexibility and the capacity for temporary part storage. The use of palletized transfer systems, where parts are firmly held in fixtures, is vital for precise machining operations that demand high accuracy.

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## 2. Work Part Transport

The transport of work parts can be achieved through various mechanisms, including conveyors and walking beams, which aid in maintaining precise movement and positioning. This accuracy is especially crucial in machining operations where tight tolerances are mandated. The mechanism must also accommodate the geometry of the work part, ensuring that the parts are effectively conveyed through the designated operations.

## 3. Storage Buffers:

Incorporating storage buffers within production lines can enhance operational efficiency. These buffers serve several functions, including mitigating the impact of breakdowns at individual workstations, smoothing out variations in cycle times, and allowing for processes that require curing or other delays. The design of storage buffers may differ between in-line and rotary indexing machines, and their capacity is a critical factor in determining overall line efficiency.

## 4. Control of the Production Line:

Controlling these intricate systems involves executing three primary functions: sequence control to synchronize operations, safety monitoring for worker protection, and quality control to ensure product standards. The

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control systems, typically reliant on programmable logic controllers (PLCs) and personal computers, facilitate both operational integrity and data documentation for performance assessment.

## **5. Applications of Automated Production Lines:**

While machining processes, including milling and drilling, constitute the mainstay of applications, automated production lines are also crucial in other sectors such as assembly, welding, and plating. The design considerations for these systems must factor in expected production rates, part designs, and long-term product viability.

## **6. System Design Considerations:**

Designing an automated line requires collaboration between the customer and machine builders, where specifications are defined, and proposals for the system configuration are developed. Each proposal includes integrated machine components assembled to achieve operational requirements, highlighting the need for consideration of flexibility and potential future use of the machinery.

## **7. Analysis of Transfer Lines**

The design and operational analysis of automated production lines focus

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on several performance metrics, including line balancing, technology matching, and system reliability. Balancing the workload across workstations is essential to optimize efficiency and minimize idle times. Reliability assessments enable the identification of potential breakdown points and their impact on overall performance.

## 8. Performance Measures:

Evaluating the performance of automated lines involves considering production rates, efficiency ratios, and cost per unit produced. As the number of workstations increases, both line efficiency and production rates tend to decline due to the compounded impact of potential breakdowns and downtime, underlining the importance of reliability in maintaining efficiency.

Through a thorough understanding of automated production lines, manufacturers can significantly enhance productivity while effectively managing costs and maximizing resource utilization, paving the way for higher quality outputs in competitive manufacturing environments.

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## Critical Thinking

**Key Point:** The importance of efficiency in automated production processes

**Critical Interpretation:** Imagine stepping into your daily life with a mindset focused on efficiency, akin to that of an automated production line. Just as these systems optimize every part of the production process to minimize waste and enhance output, you can apply the same principles to your own life. Think about how you organize your tasks or set up your workspace; by designing your daily routines to flow seamlessly from one activity to another, you can reduce wasted time and increase your personal productivity. This chapter inspires you to recognize that every action counts and that efficiency isn't just about getting things done faster, but about creating a smooth workflow that allows you to achieve your goals more effectively. Embrace the idea that with the right structure and mindset, you can transform your own life's processes, just as automated systems do in manufacturing, leading to greater success and satisfaction.

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# Chapter 21: AUTOMATED ASSEMBLY SYSTEMS

Chapter 21 of "Automation, Production Systems, and Computer-Integrated Manufacturing" focuses on Automated Assembly Systems, discussing their principles, configurations, and performance metrics. Below are the key takeaways summarized logically.

**1. Understanding Automated Assembly:** Automated assembly systems utilize mechanized devices to perform assembly tasks in a structured environment, significantly enhancing productivity. Advances in robotics have particularly influenced this area, as robots are often key components within these systems. While manual assembly methods will continue to exist, the potential for productivity gains through automation is considerable when specific criteria are met.

**2. Automation Criteria:** There are several essential conditions that must be fulfilled to justify the implementation of automated assembly systems. They include high product demand requiring mass production, stable product designs that minimize redesign costs, a manageable number of

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# Chapter 22 Summary: GROUP TECHNOLOGY AND CELLULAR MANUFACTURING

In Chapter 22 of Mikell P. Groover's "Automation, Production Systems, and Computer-Integrated Manufacturing," the focus is on group technology (GT) and cellular manufacturing, two approaches that aim to enhance efficiency in manufacturing processes, especially in batch production settings. Below is a detailed summary of the chapter's key concepts.

**1. Part Families and Machine Groups:** Group technology identifies and groups similar parts into families based on design and manufacturing characteristics. By organizing parts into families—often reducing thousands of part numbers into about 30 unique groups—manufacturing processes can achieve significant efficiency increases. This organization facilitates the arrangement of machines into specialized cells for part families, a method known as cellular manufacturing.

## 2. Group Technology (GT) Definition and Historical Context

Established concepts of group technology trace back to the mid-20th century, emerging as a response to inefficiencies in traditional batch production systems. GT promotes reorganization of factory layouts to minimize material handling, reduce lead times, and enhance the production flow.

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**3. Part Family Identification Techniques** Companies can identify part families using several methods:

- **Intuitive Grouping:** This straightforward method relies on the experienced judgment of staff to group visually similar parts.
- **Parts Classification and Coding:** This more systematic and sophisticated approach uses codes to define each part's attributes, allowing for better organization and retrieval of design and manufacturing information.
- **Production Flow Analysis (PFA):** PFA focuses on the operation sequences of parts rather than their designs, facilitating the grouping of parts based on similar processing routes.

**4. Cellular Manufacturing:** Cellular manufacturing applies group technology principles by organizing equipment and workstations into cells dedicated to specific part families. This cellular arrangement shortens manufacturing lead times, reduces setup and handling times, improves scheduling, boosts quality, and generally enhances worker satisfaction due to collaborative work environments.

**5. Composite Part Concept:** This concept helps design cellular manufacturing systems by thinking of a hypothetical, all-encompassing part that includes every design and manufacturing attribute found in a part family. Machine cells are then designed to efficiently produce all members of that family.



6. **Machine Cell Design:** The design of machine cells varies based on the number and type of machines, as well as the degree of automation and material handling. Four configurations are commonly identified:

- Single-Machine Cell
- Group-Machine Cell with Manual Handling
- Group-Machine Cell with Semi-Integrated Handling
- Flexible Manufacturing Systems (FMS)

7. **Key Machine Concept:** This principle emphasizes that certain machines in a cell may be more critical due to their operational capabilities or costs. Keeping these key machines busy is paramount, often guiding the overall design of the cell.

8. **Applications of Group Technology.** GT principles find application in manufacturing, where they can improve various processes such as scheduling, tooling, and production planning. Additionally, group technology aids in product design by reducing engineering costs through effective design retrieval systems, helping prevent unnecessary part proliferation.

9. **Performance Metrics and Analysis of Cellular Manufacturing:** The chapter discusses quantitative methods for analyzing cellular manufacturing systems, including throughput rates, lead times, and work-in-process

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metrics. Formulas are provided to calculate utilization rates of machines and the average manufacturing lead times based on various production scenarios.

**10. Rank-Order Clustering:** This is a data-driven technique used for determining the optimal grouping of machines and parts based on their interaction patterns, which helps establish logical part families and their respective machine groupings.

In summary, Chapter 22 provides a thorough examination of the principles, applications, and performance analysis of group technology and cellular manufacturing, highlighting their significance in modern manufacturing strategies aimed at enhancing productivity and operational efficiency.

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# Chapter 23 Summary: FLEXIBLE MANUFACTURING CELLS AND SYSTEMS

## Summary of Chapter 23: Flexible Manufacturing Systems

Chapter 23 explores the concept of Flexible Manufacturing Systems (FMS), highlighting their significance, components, applications, and performance analysis.

**1. Definition and Flexibility of FMS:** An FMS is defined as a highly automated machine cell designed to enhance manufacturing efficiency. It utilizes computer control, CNC machines, and automated material handling, allowing for the processing of various part styles simultaneously. FMS is flexible because it can adjust production quantities and styles in response to demand fluctuations. Key factors that determine flexibility include the capacity to identify different part styles, quick changeovers in production schedules, and the ability to recover from errors or equipment malfunctions.

**2. Types of FMS:** FMS can be categorized based on operation types (processing or assembly), the number of machines (single-machine cells, flexible manufacturing cells, and flexible manufacturing systems), and the level of flexibility designed (dedicated versus random-order systems). Each type serves specific production needs and is tailored for particular



applications.

### 3. **Components of FMS:** FMS consist of three fundamental components:

- **Workstations:** Functioning automated or manual stations handling the production processes.
- **Material Handling and Storage:** Systems that transfer parts between stations while providing temporary storage to maintain workflows.
- **Computer Control System:** A network controlling all operations, managing parts flow, scheduling, and performance monitoring.

4. **Application Considerations:** FMS is applicable in diverse manufacturing contexts, particularly where variability in part styles is expected. Successful implementation requires careful planning considering part families, processing requirements, and production volumes. Benefits of FMS include improved machine utilization, flexibility in production changes, reduced floor space, and minimized lead times and inventory.

5. **Performance Analysis:** The chapter discusses various analytical models for evaluating FMS performance including deterministic and queueing models, as well as discrete-event simulations that allow for a deeper understanding of system dynamics. A significant focus is on the bottleneck model which identifies the production system's limiting factors, enabling practitioners to optimize workstations and enhance overall system



output.

**6. Alternative Manufacturing Approaches:** The chapter concludes with discussions on contemporary manufacturing strategies such as mass customization, which aims to produce tailored products efficiently, reconfigurable manufacturing systems (RMS) designed to allow quick alterations in production capacity and functionality, and agile manufacturing which emphasizes adaptability and speed in responding to market changes.

Through this comprehensive analysis of FMS, the chapter provides invaluable insights into modern manufacturing techniques, encouraging industries to adopt flexible and responsive practices to meet evolving production demands.

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## **Chapter 24: QUALITY PROGRAMS FOR MANUFACTURING**

The chapter on Quality Control Systems outlines various aspects and methodologies related to quality assurance in manufacturing, tracing the evolution of quality control from traditional practices to modern standards. This summary encompasses key principles and concepts related to quality management and improvement mechanisms featured in the text.

1. The concept of quality in manufactured products captures two critical dimensions: 'product features'—which denote the design attributes that appeal to customers—and 'freedom from deficiencies,' which refers to the absence of defects and conformance to specifications. While the design department is responsible for the desirable features of a product, ensuring freedom from deficiencies predominantly falls on manufacturing processes.
2. Traditional quality control (QC) was largely reactive, focusing primarily on inspection at the end of production processes. Quality was the responsibility of the inspection department, which employed statistical

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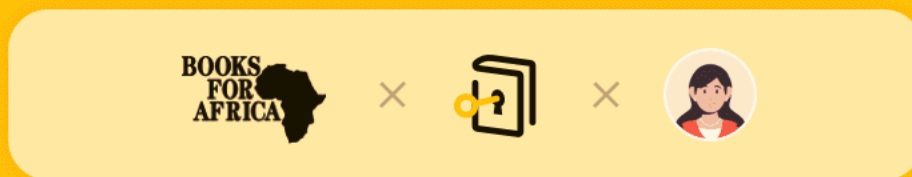
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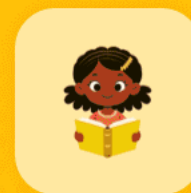
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# Chapter 25 Summary: INSPECTION PRINCIPLES AND PRACTICES

The discussion on inspection plays a crucial role in quality control within manufacturing processes. It is primarily concerned with the examination of products, components, sub-assemblies, or raw materials to determine their conformity to design specifications established by product designers. This chapter outlines key principles regarding inspection fundamentals, sampling versus 100% inspection, automated inspection methods, and the evaluation of inspection systems.

**1. Inspection Fundamentals:** Inspection is vital for ensuring product quality. Traditional manual inspection methods have significant drawbacks, including high costs, long lead times, and the inability to rectify defects post-production. To improve this, new methodologies promote complete automation of inspections alongside in-process evaluations through sensors and statistical analysis tools. This ensures that product quality is continually monitored, enhancing production efficiency and reducing defect rates.

**2. Types of Inspection:** There are two main types of inspections.

Inspection for **variables** involves measurable attributes of a product (like dimensions), while inspection for **attributes** deals with conforming versus non-conforming classifications, which can be determined through visual checks or gauges. Inspection for variables provides more detailed insights,

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allowing for process adjustments, while attribute inspection, though quicker, offers limited information.

**3. Sampling versus 100% Inspection:** The text outlines two approaches to inspection: sampling inspection and 100% inspection. Sampling inspection reduces costs and time by evaluating only a portion of the batch but carries inherent statistical risks, such as producer's risk (Type I errors) and consumer's risk (Type II errors). On the other hand, 100% inspection theoretically ensures all defects are caught but can be resource-intensive and still prone to human error. The decision between sampling and full inspection depends on factors such as defect rates, inspection costs, and the anticipated impact of defects on overall production costs.

**4. Automated Inspection:** Automation minimizes human error and enhances speed and efficiency in the inspection process. Fully automated systems can execute inspections at every production stage, facilitating immediate corrections and data collection to inform process improvements. However, it's important to balance the costs of implementing an automated system with the anticipated benefits in quality control.

**5. Inspection Timing:** The timing of inspections relative to the production process is crucial. Inspections can occur off-line (after production), on-line/in-process (during production), or on-line/post-process (immediately after production). Each method has pros and cons regarding

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immediate corrective actions and cost implications. Process monitoring, which focuses on controlling measurements of processing parameters rather than products themselves, can be an effective strategy, especially in industries where real-time quality control is feasible.

**6. Final versus Distributed Inspection:** Effective inspection strategies might involve distributed inspection systems, whereby checks occur at multiple points throughout production to catch defects before they compound during processing. Alternatively, final inspection conducts a single comprehensive check at the end of production. Each method has its vulnerabilities in terms of defect identification and associated costs.

**7. Analysis of Inspection Systems:** The chapter discusses mathematical models helpful for evaluating inspection systems. These models analyze defect rates across production processes, weighing the cost implications of various inspection strategies. A well-designed inspection system can drastically reduce wasted resources and improve overall product quality.

**8. Decision-Making on Inspection:** Finally, assessing whether to inspect or not involves calculating expected damages from defects and inspection costs. The optimal strategy balances these factors, often hinging on a critical defect rate that guides the decision to employ full, sampling, or no inspection at all.

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In summary, a robust inspection strategy must integrate various methods and technologies, accounting for the production context, cost implications, and desired quality standards to foster efficient manufacturing with minimized defects. The utilization of both modern automated inspection systems and judicious sampling techniques can lead to improved quality assurance while optimizing operational efficiency.

Topic	Description
Inspection Fundamentals	Inspection ensures product quality; traditional manual methods have drawbacks like cost and long lead times. Automation and in-process evaluations improve monitoring and reduce defects.
Types of Inspection	Two types: Inspection for variables (measurable attributes) provides detailed insights, while inspection for attributes (conforming vs non-conforming) offers limited information but is quicker.
Sampling vs 100% Inspection	Sampling inspects part of a batch to save costs but has statistical risks; 100% inspection catches all defects but is resource-intensive and prone to human error. Decision depends on defect rates and costs.
Automated Inspection	Automation reduces human error, increases speed/efficiency, and allows immediate corrections. Balancing implementation costs with quality control benefits is crucial.
Inspection Timing	Inspections can be off-line, on-line/in-process, or on-line/post-process. Each type has pros and cons related to corrective actions and costs. Process monitoring can be effective for real-time control.
Final vs Distributed Inspection	Distributed inspection checks at multiple points to catch defects early; final inspection checks at the end. Each has vulnerabilities in defect identification and cost implications.
Analysis of	Mathematical models evaluate defect rates and costs of inspection



Topic	Description
Inspection Systems	strategies. A well-designed system can reduce waste and improve quality significantly.
Decision-Making on Inspection	Deciding on inspection involves weighing expected defect damages against costs, seeking an optimal balance based on critical defect rates.
Summary	A robust inspection strategy integrates methods and technologies to enhance manufacturing efficiency while minimizing defects through automated systems and careful sampling techniques.

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## Chapter 26 Summary: INSPECTION TECHNOLOGIES

Chapter 22 focuses on inspection technologies utilized in manufacturing, highlighting the importance of accurate measurement and quality control. This summary encapsulates the key elements of the chapter, which examines traditional and modern measurement techniques, with an emphasis on advanced technologies.

1. Inspection Metrology is the foundation of measurement processes, defined as comparing an unknown quantity to a known standard using a consistent system of units. This discipline encompasses seven basic quantities—length, mass, time, electric current, temperature, luminous intensity, and matter—from which other physical quantities are derived. For manufacturing, particularly, length measurements (including dimensions like diameter, straightness, and surface roughness) are critical and rely on accurate and stable standards.

2. The characteristics of measuring instruments include accuracy—how closely a measured value aligns with the true value—and precision, which reflects the repeatability of measurements. Instruments must be selected based on factors including speed of response, operating range, and cost. Calibration is vital for maintaining precision and involves checking instruments against known standards.

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3. Inspection techniques are classified into two primary categories: contact and noncontact methods. Contact inspection methods involve direct physical interaction with the part being inspected, utilizing tools such as micrometers or calipers. While these methods are accurate, they often face limitations regarding speed and the potential for damaging delicate surfaces.

4. Modern techniques, particularly noncontact inspections, harness sensors positioned at a distance to gauge object features. Within this category, optical inspection methods like machine vision use light to capture and analyze images, enhancing speed and preventing surface damage. Nonoptical inspections employ electrical fields or ultrasonics to reveal material characteristics without physical contact.

5. Conventional measuring and gaging uses manually operated devices for determining linear dimensions, angles, and surface characteristics. Despite the rise of electronic gaging and computerized methods, traditional tools remain integral to various inspection processes.

6. Coordinate Measuring Machines (CMMs) exemplify the transition to automated and precise measurement systems in manufacturing. CMMs utilize a probing mechanism to evaluate the dimensions and geometrical characteristics of parts in three-dimensional space. They exhibit high accuracy and can optimize inspection time by reducing the need for multiple setups.



7. Functionality of CMMs involves multiple components, including the probe head, mechanical structures, and digital control systems. Programming for CMMs can be manual or computer-controlled, with offline programming allowing parallel job processing while CMMs perform inspections.

8. CMM applications extend beyond dimensional measurement to include validation of gauges and fixtures and auditing incoming parts for quality assurance. Their precision and reliability make them particularly suited to applications with repetitive inspection needs or inherent complexity in part geometry.

9. Surface measurement, an integral part of inspection technologies, focuses on assessing surface roughness and related characteristics. Techniques include using stylus instruments to provide quantitative values for texture, which can also involve optical methods that offer speed benefits but must consider correlativity with stylus measurements.

10. Machine vision systems enable automated image processing, aiding in dimensional measurements, defect detection, and surface verification. Image acquisition involves capturing images through digital cameras, followed by data digitization, processing, and interpretation, allowing for automated inspections and real-time decision-making in manufacturing routines.

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11. Various noncontact methods complement machine vision, employing techniques such as laser scanning for component geometry analysis and automated inspections to increase efficiency. Acoustic and electrical field measurement techniques also play a role, providing nondestructive methods for assessing material properties and integrity.

Through these diverse methodologies, inspection technologies demonstrate a significant evolution towards more automated, efficient, and precise systems, driving quality assurance processes in modern manufacturing environments.

Key Element	Description
Inspection Metrology	Foundation of measurement processes, involving comparison against known standards. Key quantities include length, mass, and others relevant to manufacturing.
Characteristics of Measuring Instruments	Instruments should be accurate and precise, selected based on speed, range, and cost. Calibration is essential for maintaining precision.
Inspection Techniques	Classified as contact (physical interaction) and noncontact methods (sensors). Contact methods are accurate but can damage surfaces.
Modern Inspection Techniques	Noncontact methods, including optical (machine vision) and nonoptical inspections, prevent surface damage and improve speed.
Conventional Measuring and Gaging	Manual tools still play a crucial role in measuring dimensions and characteristics despite advancements in electronic methods.
Coordinate	Automated systems with high accuracy for measuring parts in



Key Element	Description
Measuring Machines (CMMs)	three-dimensional space, optimizing inspection time.
Functionality of CMMs	Includes probe heads, structures, and control systems; programming can be manual or computer-controlled.
CMM Applications	Beyond dimensional measurement, they validate gauges and audit incoming parts, ideal for complex geometries.
Surface Measurement	Focuses on assessing surface roughness; techniques include stylus and optical methods for quantitative texture values.
Machine Vision Systems	Automates image processing for dimensional measurement, defect detection, allowing real-time decision-making.
Noncontact Methods	Include laser scanning and acoustic measurement for efficient, nondestructive assessment of component geometry and material integrity.

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# Chapter 27: PRODUCT DESIGN AND CAD/CAM IN THE PRODUCTION SYSTEM

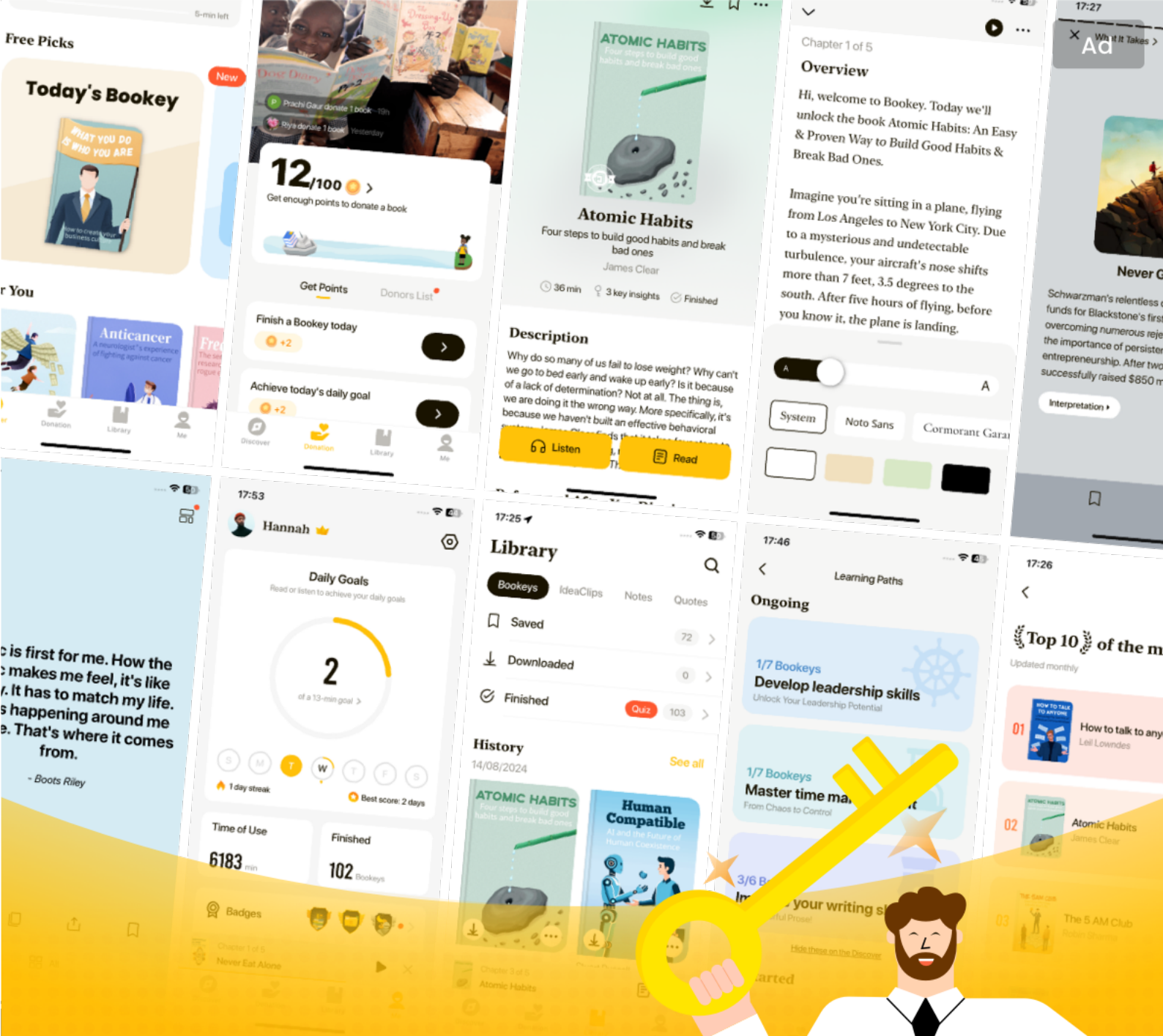
Chapter 23 delves into the integration of product design and manufacturing systems through advancements in computer-aided technology. This chapter emphasizes the need for manufacturing support systems that enhance productivity and communication at the enterprise level, combining various dimensions of engineering and business processes.

**1. The Significance of Product Design and CAD:** At the core of any successful production system lies effective product design. A well-conceived design is paramount in determining a product's commercial viability. Notably, the design phase significantly influences production costs, shaping the economically feasible execution of the product. The design process is iterative, encapsulated in six phases: recognition of need, problem definition, synthesis, analysis and optimization, evaluation, and presentation.

**2. Role of Computer-Aided Design (CAD):** CAD facilitates the design

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# Chapter 28 Summary: PROCESS PLANNING AND CONCURRENT ENGINEERING

In this chapter dedicated to process planning and concurrent engineering from "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover, several essential concepts and methodologies are outlined for effectively transitioning from product design to manufacturing. The chapter elaborates on numerous stages of process planning, delineating the necessary steps and considerations involved in producing parts and assemblies, as well as the overarching principles of concurrent engineering and advanced manufacturing planning.

**1. Process Planning Overview:** At its core, process planning serves as the crucial link between the design and manufacturing stages of a product. It entails determining the optimal sequence of processes and assembly steps needed to create a product, guided by design specifications and technological capabilities of the manufacturing plant. This planning involves key decisions such as the interpretation of design drawings, selection of processes and equipment, tooling requirements, and workload standards.

**2. Process Planning for Parts and Assemblies:** For individual parts, a route sheet is formulated, documenting operations in sequential order, detailing the machinery and tooling involved. The choice of process heavily depends on the starting materials specified by the product designer. The

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fabrication process follows a logical sequence from basic processes, such as casting or molding, through secondary processing, property enhancement, and finishing operations. Conversely, assembly planning factors in production volumes, complexity of the assembly, and the method employed, which might be manual or automated.

**3. Make or Buy Decision:** A significant consideration in process planning is whether to manufacture a part internally or purchase it. Factors influencing this decision encompass production costs, available technical expertise, production quantities, supplier reliability, and capacity constraints. The implications of each choice must be carefully weighed against potential idle equipment and labor costs.

**4. Computer-Aided Process Planning (CAPP):** The realization of effective process planning necessitates automation, leading to the emergence of CAPP systems. These systems mitigate inconsistencies associated with manual planning and increase productivity. CAPP is categorized into retrieval systems, which store and modify existing process plans for similar parts, and generative systems that autonomously create new process plans based on logical procedural input.

**5. Concurrent Engineering:** This concept represents an integrative approach to product development, wherein design and manufacturing engineers collaborate closely throughout the design phase, allowing for early

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input on manufacturability and assembly considerations, ultimately reducing time to market. This approach embodies principles of design for manufacturing and assembly (DFM/A), where decisions made during the design phase greatly impact product lifecycle costs and manufacturability.

**6. Design for Manufacturing and Assembly (DFM/A):** The intertwining of design with manufacturing objectives emphasizes that decisions regarding material selection, part geometry, and assembly methods are foundational in determining manufacturing efficiency and overall product cost. Adopting DFM/A involves organizational changes that foster cooperation between design and manufacturing teams, as well as adherence to specific design guidelines intended to improve ease of fabrication and assembly.

**7. Advanced Manufacturing Planning:** This aspect of planning addresses long-term objectives, focusing on future product lines and the necessary resources for their production. It entails evaluating new technologies and their implications on existing manufacturing capabilities. The activities in this domain incorporate assessing and integrating new technologies, managing investment projects, facilities planning, and conducting research and development in manufacturing processes.

In summary, this chapter establishes that effective process planning is integral to the manufacturing function within an organization. It highlights

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the importance of a collaborative approach throughout product development, guided by systematic planning processes that leverage technological advancements and optimize production efficiency. By integrating these principles, manufacturers can better respond to market demands and enhance the competitiveness and quality of their products.

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# Chapter 29 Summary: PRODUCTION PLANNING AND CONTROL SYSTEMS

Chapter 29 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover discusses various aspects of Production Planning and Control (PPC), focusing on techniques for effective production management. The chapter outlines essential processes that include aggregate production planning, master production scheduling, material requirements planning (MRP), capacity planning, shop floor control, inventory control, and advancements leading to Manufacturing Resource Planning (MRP II) and Enterprise Resource Planning (ERP).

**1. Overview of Production Planning and Control (PPC):** PPC plays a crucial role in manufacturing by managing logistics, ensuring timely production alignments, and reconciling resource requirements with production schedules. It leverages computing power to process vast amounts of operational data vital for coordinating production output with resource availability.

**2. Production Planning Process:** The production planning is an integrated function that entails:

- Aggregate production planning, determining output levels for major product lines.
- Master production scheduling (MPS), detailing quantities of individual

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goods to produce.

- Material requirements planning (MRP), which calculates the needed raw materials and components based on the MPS.

- Capacity planning to identify labor and equipment resources needed for manufacturing.

**3. Production Control:** This function ensures that the necessary resources are available to execute plans effectively. Control systems help track production progress against the schedule and manage inventory levels, employing techniques like shop floor control, inventory management tools including the economic order quantity, and integrating associated functions.

**4. Material Requirements Planning (MRP):** MRP transforms the MPS into a detailed schedule for raw material components. It addresses independent demand (forecasting final products) and dependent demand (determining materials based on finished items). Inputs to the MRP system include the MPS, engineering data, and inventory records. MRP outputs lead to planned order releases and performance reports which are critical for operational efficiency.

**5. Capacity Planning:** Essential for aligning production schedules with actual production capabilities, capacity planning involves reassessing resource layouts. It consists of three stages: Resource Requirements Planning (RRP), Rough-Cut Capacity Planning (RCCP), and Capacity

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Requirements Planning (CRP). Whether it's adjusting employment levels, utilizing temporary workers, increasing shifts, or considering long-term investments in machinery and facilities, these strategies seek to address capacity constraints.

**6. Shop Floor Control:** This encompasses the stages of order release, scheduling, and monitoring order progress. A robust shop floor system ensures transparency in production statuses and facilitates data-driven decision-making through the use of Manufacturing Execution Systems (MES).

**7. Inventory Control:** Balancing inventory costs against customer service levels is critical. The chapter differentiates between inventory methods for independent and dependent demand items and discusses tools like economic order quantities and reorder point systems to optimize inventory management.

**8. Manufacturing Resource Planning (MRP II):** Building upon traditional MRP, MRP II includes capacity planning and feedback, enhancing visibility and coordination within the production process. It involves comprehensive integration of various operational aspects beyond materials alone.

**9. Enterprise Resource Planning (ERP):** ERP systems centralize and

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integrate all organizational functions through a unified database, addressing multiple business processes such as sales, finance, and production within a cohesive framework. The open-standard architecture of ERP systems allows for modular functionality and adaptability, enabling organizations to customize their systems according to specific operational needs.

Through this exploration of PPC, the chapter illustrates the evolution from basic MRP systems to sophisticated ERP frameworks, emphasizing the importance of data integrity and real-time responsiveness in manufacturing operations. The discipline of accurate recording and timely updating of transaction events is highlighted as paramount to the successful implementation and effectiveness of these planning and control systems.

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## Chapter 30: JUST-IN-TIME AND LEAN PRODUCTION

In the exploration of Chapter 26 from "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover, the focus unfolds on **Just-In-Time (JIT)** and **Lean Production**, concepts that have deeply influenced modern manufacturing systems initiated by Toyota. The chapter succinctly summarizes key components and principles that dictate efficient production methodologies, particularly in minimizing waste and enhancing product quality.

**1. Defining Lean Production:** Lean production is characterized by achieving more with fewer resources, which encompasses reducing time, space, labor, and machinery while simultaneously improving product quality. Developed by Toyota in response to the unique post-war economic conditions of Japan, this system stands in stark contrast to traditional mass production methods, promoting flexibility and customer satisfaction.

**2. Elimination of Waste:** At the core of lean production is the elimination of "muda," the Japanese term for waste. Taiichi Ohno identified

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## Chapter 31 Summary: A

In Chapter 31 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover, several critical concepts in production and manufacturing technologies are explored, providing a comprehensive overview of automation systems, methodologies, and their applications.

- 1. Automation Fundamentals:** The chapter commences with a clear definition of automated assembly systems, outlining their importance in modern manufacturing operations. These systems enhance efficiency by reducing human intervention, which allows for higher speed and accuracy in production processes.
- 2. Types of Automation:** A distinction is made between various types of automation, including fixed, programmable, and flexible automation. Each type is discussed in terms of application scenarios, strengths, and limitations, providing readers with a thorough understanding of which system may best suit particular manufacturing needs.
- 3. Advanced Manufacturing Techniques** The discussion delves into advanced manufacturing methods such as additive manufacturing, highlighting their revolutionary impact on traditional production processes. The chapter emphasizes how these technologies can lead to reduced waste,

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lower costs, and the ability to fabricate complex designs that were previously unattainable.

**4. Quality Control and Inspection:** Quality assurance is addressed with mention of acceptable quality levels (AQL) and acceptance sampling techniques. The text emphasizes the importance of maintaining quality throughout the production process, ensuring that the final output meets stringent standards.

**5. System Components:** A detailed exploration of critical components of automated systems is presented, including sensors, actuators, and control systems. The chapter elucidates how each component contributes to the functionality and reliability of the overall system, with discussions on active sensors and adaptive control methodologies used to enhance system responsiveness.

**6. Control Methodologies:** The principles of adaptive control are covered extensively. This section discusses how adaptive techniques are used in machining processes to adjust operational parameters automatically, enhancing efficiency and precision over time.

**7. Robotics Integration:** The integration of robotics in manufacturing is another pivotal theme, examining the roles of various robotic configurations, such as articulated and cartesian robots. The capabilities of

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these robots in completing complex assembly tasks and their programming requirements are detailed, showcasing their flexibility and applicability across diverse industries.

**8. Production Planning:** Aggregate production planning is identified as an essential process that aligns production capacity with customer demand. Techniques for optimizing resources and scheduling are explored, enabling companies to enhance their competitiveness in the market.

**9. Future Trends:** Finally, the chapter touches on trends like agile manufacturing, which emphasizes flexibility and speed in production. The necessity for manufacturers to adapt quickly to changes in consumer preferences, fueled by advances in technology, is underscored as a key driver for success in the contemporary manufacturing landscape.

By rigorously detailing these aspects, Chapter 31 presents a rich tapestry of insights into automation, production systems, and computer-integrated manufacturing, signifying their critical roles in shaping the future of industry and manufacturing practices.

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## Chapter 32 Summary: C

In Chapter 32 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover, several fundamental principles and concepts related to automation and manufacturing systems are explored, providing a comprehensive understanding of key topics.

- 1. Automation Overview:** Automation is introduced as a multifaceted concept fundamental to modern manufacturing, streamlining operations and improving efficiency. Various forms of automation, such as automated production lines and computer-integrated manufacturing (CIM), are discussed, emphasizing their role in enhancing productivity and enabling flexible production systems.
- 2. CAD and CAM Technologies** The chapter elaborates on Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM), highlighting their integration in design and manufacturing processes. These technologies facilitate precision and efficiency in production planning, allowing for rapid prototyping and resource management.
- 3. Cellular and Batch Production:** Cellular manufacturing layouts are reviewed, showcasing their efficiency in handling diverse manufacturing

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processes. This contrasts with batch production systems, where items are produced in groups, emphasizing the importance of layout and design in optimizing workflow and decreasing bottlenecks.

**4. Automated Storage and Retrieval Systems:** Automated storage and retrieval systems (AS/RS) are examined for their role in improving material handling and inventory management. The integration of these systems helps reduce search times, minimize storage costs, and enhance overall efficiency within manufacturing environments.

**5. Control Systems:** The significance of control systems, including computer numerical control (CNC) and process control systems, is articulated throughout the chapter. These systems are crucial for maintaining operational consistency, ensuring quality, and facilitating real-time adjustments in automated processes.

**6. Quality Control and Inspection:** Automated inspection systems are discussed as vital to maintaining quality standards. Various methods, including statistical process control (SPC), are reviewed for their effectiveness in identifying defects and ensuring product quality across manufacturing processes.

**7. Economic Factors:** The chapter addresses economic considerations, such as cost estimation and investment in capital goods. It highlights the

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balance required between automation expenses and the expected return on investment through increased efficiency and reduced labour costs.

**8. Flexible Manufacturing Systems (FMS):** The chapter encompasses the functionality and benefits of flexible manufacturing systems. These systems are capable of adapting to changes in product design and production volume, thereby enhancing a manufacturer's ability to respond quickly to market demands.

**9. Industry Trends and Evolution:** The historical context of automation is provided, tracing its evolution from manual processes to sophisticated automated systems. This serves to illustrate how foundational developments have influenced contemporary manufacturing techniques.

Overall, the chapter encapsulates the intricate relationship between various aspects of automation, production systems, and computer-integrated manufacturing, presenting a cohesive view of the advancements and strategic implementations that drive efficiency in today's competitive manufacturing landscape. Through its detailed explanations and interconnections of subjects, it serves as a valuable resource for understanding the complexities inherent in automated production environments.

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## Chapter 33: F

Chapter 33 from "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover covers a range of important concepts and techniques relating to automation, manufacturing systems, and production processes. The chapter's insights into these domains can be synthesized into several key principles for enhanced understanding.

**1. Cycle Time and Production Efficiency:** A fundamental aspect of any production system is cycle time, which defines the duration needed to complete a process from start to finish. Cycle time is influenced by various factors including automated assembly, flexible manufacturing systems, and manual assembly lines. Understanding and optimizing cycle times are critical for enhancing overall production efficiency and meeting customer demands.

**2. Design Principles for Manufacturing:** The chapter outlines various design strategies that promote efficiency and quality in manufacturing processes. Design for Assembly (DFA), Design for Manufacturing (DFM),

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# Chapter 34 Summary: I

Chapter 34 of "Automation, Production Systems, And Computer-Integrated Manufacturing" focuses extensively on several critical aspects of industrial automation and robotics, emphasizing a range of key principles and applications.

**1. Industrial Automation Overview:** The chapter begins by establishing a foundational understanding of industrial automation, defining the scope of automated systems compared to traditional manufacturing methods. It elaborates on the evolution from manual labor towards a more automated environment, underscoring the Industrial Revolution's pivotal role in this transformation.

**2. Robotic Systems in Manufacturing:** A significant part of the chapter is devoted to industrial robotics, where major points include the importance of accuracy and repeatability in robotic operations. The text outlines the various applications of robotics, ranging from automated assembly to flexible manufacturing cells, highlighting the economic justifications for integrating such technologies into production processes.

**3. Components and Configurations:** The discussion transitions into specific components of robotic systems, including end effectors, joint drive systems, and their various configurations (body-and-arm, wrist



configurations) essential for effective operation. This section also emphasizes the significance of sensors in enhancing robot functionality and the importance of understanding mechanical joints and links for better design and application.

**4. Automated Inspection Techniques** The chapter further explores inspection processes, comparing automated methods with traditional techniques. It delineates the advantages of using contact and non-contact inspection methods, as well as the importance of accuracy in quality control measures to maintain product standards.

**5. Flexible Manufacturing Systems:** Additionally, the chapter explains flexible manufacturing systems (FMS), presenting their defined characteristics along with the benefits they provide in terms of efficiency and adaptability in production. It examines the components and configuration of FMS and discusses the planning and design considerations necessary for implementation.

**6. Human-Machine Interaction:** It also touches on the dynamics between human operators and machines, discussing the limits of automation, potential for human error, and the importance of human resources within manufacturing environments. The text highlights the need for careful integration of human oversight in heavily automated systems to mitigate risks associated with reliance on technology alone.



**7. Historical Context and Future Trends** Lastly, the chapter provides a retrospective understanding of the historical notes surrounding automation, identifying key milestones in technology's evolution within manufacturing. It concludes by addressing future trends related to automation, suggesting that advancements in robotics and AI technologies will continue to shape the manufacturing landscape.

In summary, Chapter 34 offers a comprehensive exploration of industrial automation and robotics, focusing on their evolution, applications, components, and the interplay between human resources and technology. It presents a clear view of the current state of manufacturing systems while anticipating future innovations that promise to further refine and enhance production efficiency.

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## Chapter 35 Summary: M

In Chapter 35 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover, the author delves into various concepts and practices fundamental to modern manufacturing processes, automation, and system integration, providing a comprehensive overview of principles in the field.

- 1. Manufacturing Systems and Methods:** The chapter outlines the classification and components of manufacturing systems, emphasizing flexible and reconfigurable systems. The distinction between mass production and mass customization highlights the approach to meeting varied consumer demands, accompanied by specific methodologies for product design and process planning.
- 2. Machine Control and Automation:** The text dives into the Machine Control Unit (MCU) and the importance of logic control in automating manufacturing processes. Understanding ladder logic diagrams and the role of programmable controllers is essential for managing production lines effectively. The discussion on robotics emphasizes advancements in intelligent robots and the integration of machine vision for enhanced operational efficiency.
- 3. Production Planning and Scheduling:** The significance of materials

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requirements planning (MRP) and master production schedules is underscored. The chapter details various methods employed in job sequencing and order scheduling, illustrating how efficient planning results in optimal resource allocation and reduced manufacturing lead times.

**4. Line Balancing and Assembly Systems:** Attention is given to line balancing techniques within manual and automated assembly operations. This includes mixed-model assembly lines that cater to product variety while maintaining efficiency, along with algorithms developed to enhance the performance of both manual and automated lines.

**5. Inventory and Logistics Management:** The chapter describes inventory control practices and their critical role in manufacturing efficiency. Emphasis is placed on logistics and internal material handling systems, which are vital in maintaining a smooth flow of materials within the factory, impacting overall productivity.

**6. Quality Assurance and Measurement:** Measurement and metrology's importance in manufacturing processes are examined, focusing on statistical quality control (SQC) and techniques for ensuring that products meet stringent quality standards.

**7. Cost Management and Economic Considerations:** Manufacturing costs are dissected, considering material costs, labor, and operational

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expenses. The chapter advocates for systems that optimize these factors, thus facilitating effective decision-making in the make-or-buy processes.

**8. Technological Innovations** The role of innovations such as CNC machining, laser measurement, and automated material handling systems is discussed. Modern practices incorporate advanced technologies for increased accuracy, efficiency, and flexibility in manufacturing operations.

In summary, Chapter 35 is an extensive exploration of manufacturing systems, addressing the integration of automation technologies and the strategic management of production processes. The principles delineated within cover critical aspects such as system design, control units, production planning, logistics, quality assurance, cost management, and technological advancements, all aimed at enhancing productivity in manufacturing environments. This comprehensive discourse equips readers with essential insights crucial for navigating the complexities of contemporary manufacturing.

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## Chapter 36: P

In Chapter 36 of "Automation, Production Systems, And Computer-Integrated Manufacturing" by Mikell P. Groover, the author presents a comprehensive exploration of topics essential for understanding the intricacies of production systems, automation, and manufacturing processes. The chapter is structured around several key principles that blend theoretical knowledge with practical applications.

**1. Fundamentals of Numerical Control (NC):** The chapter delves into Numerical Control, highlighting its defining features, advantages, and historical significance. It discusses both direct and distributed numerical control systems, focusing on their components and applications in machine tools. This section emphasizes the transformative impact of NC in enhancing precision and efficiency in manufacturing.

**2. Automation and Inspection Technologies** A significant portion is dedicated to various inspection methods, including on-line and off-line inspection techniques. The text evaluates non-destructive testing (NDT) and

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## Chapter 37 Summary: Q

Chapter 37 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover offers an extensive examination of various facets concerning production systems, automation, and quality control within the manufacturing realm. Here, various principles and insights are synthesized into a coherent summary.

1. The chapter unveils the fundamentals of production systems, distinguishing between manual labor and automated automation. The definition of production systems is simplified into their basic components: operational processes and support mechanisms, underscoring the growing importance of automation to enhance efficiency and minimize human error.
2. A pivotal focus is placed on the mechanisms of programmable logic controllers (PLCs), which are essential for modern automated production lines. The text details their historical development, definition, and programming capabilities, emphasizing their role in enhancing process efficiencies and controls in manufacturing.
3. The discussion extends to quality control, establishing quality as a critical parameter impacting both productivity and customer satisfaction. Various methodologies such as inspection procedures, ISO 9000 standards, and concepts of process capability are examined, highlighting how variations in

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processes can affect overall quality outcomes.

4. Additionally, user-defined programs play a substantial role in production systems. It covers NC part programs, work cycle programs, and robot programming, drawing a clear connection between the effectiveness of automation and the intricacies of programming.

5. The importance of production capacity is addressed, covering the various mathematical models and strategies for capacity planning. The text elaborates on how organizations can adjust and optimize their production capabilities to meet market demands while maintaining a sustainable operational flow.

6. The principles of production flow analysis and leveling are discussed, illustrating how these methodologies contribute to minimizing waste and maximizing efficiency in production lines. This section reflects on the critical balance between operational dynamics and resource utilization.

7. Product design and management are explored, elaborating on tools such as CAD and concurrent engineering which aid in fostering innovation and streamlining the product development lifecycle. The interplay between product complexity and variety is also explored, showcasing how these factors impact production strategies.

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8. Lastly, the chapter addresses the importance of maintenance practices, including preventive and predictive maintenance, which are central to operational reliability and longevity of production equipment. The continuous monitoring and assessment of processes ensure that manufacturers can preemptively tackle issues before they escalate, thus safeguarding their production flow.

In essence, this chapter serves as a comprehensive resource, weaving together the intricate relationship between automation, production systems, quality control, and maintenance within the manufacturing landscape. Through its explorative discussions, it provides valuable insights for practitioners and scholars alike seeking to enhance their understanding and application of these concepts in real-world scenarios.

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## Chapter 38 Summary: S

Chapter 38 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover provides an extensive overview of key concepts and tools central to modern manufacturing systems. The chapter touches on various elements that enhance production efficiency, quality, and management.

- 1. Scatter Diagrams and Statistical Tools** The use of scatter diagrams is emphasized as an important tool for visualizing relationships between variables, which can aid in identifying trends in production data. This statistical analysis is fundamental to quality control and process improvement, facilitating decision-making based on empirical evidence.
- 2. Manufacturing Paradigms and Technologies** The chapter discusses the evolutionary changes in manufacturing, highlighting the Second Industrial Revolution and the subsequent impact of scientific management principles. Innovations in machine design, such as semiautomated machines, contribute significantly to productivity and precision.
- 3. Automation in Production:** Automation plays a critical role in contemporary manufacturing, with the use of sensors and automated guided vehicles being prevalent. These technologies streamline operations by reducing manual labor and enhancing safety through real-time monitoring of

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processes.

**4. Control Mechanisms:** Different methods of sequence control, such as sequence function charts, are introduced to manage manufacturing processes efficiently. The chapter also delves into servomotors and their role in precise motion control, vital for robotics and automated systems.

**5. Quality Management Systems:** The narrative extends to quality engineering techniques, including Six Sigma and Total Quality Management, which focus on reducing variation and improving product quality. Tools like quality function deployment help align product designs with customer requirements.

**6. Scheduling and Planning:** Effective scheduling is crucial for optimizing resource utilization in production environments. The text discusses the significance of rough-cut capacity planning and resource requirements planning, ensuring that production meets demand without excessive inventory build-up.

**7. Manufacturing Layouts:** The chapter emphasizes the importance of efficient plant layouts, such as robot-centered designs that minimize waste and enhance workflow. These layouts are crucial in facilitating smooth operations and ensuring timely production cycles.

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**8. Error Analysis and Reliability:** Attention is drawn to understanding and mitigating random errors and variations in production. By assessing reliability and repeatability of equipment, manufacturers can maintain operational consistency and uphold standards.

Through these principles, the chapter underlines how integrating advanced tools and methodologies can significantly improve manufacturing operations, driving efficiency, quality, and adaptability in a competitive landscape. The comprehensive nature of this exploration underscores the dynamic interplay between technology, management, and production processes in modern manufacturing systems.

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## Chapter 39: U

Chapter 39 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover delves into various essential concepts and methodologies that underpin modern production systems and automation technologies. This chapter provides a comprehensive overview of key elements that contribute to efficient and effective industrial operations.

**1. Automation Strategies:** The chapter emphasizes the importance of developing well-structured automation strategies that align with organizational goals. It discusses various frameworks and methodologies that can be employed to enhance production efficiency, including the principles of Total Productive Maintenance (TPM) that advocate for a culture of proactive and preventive maintenance.

**2. Manufacturing Process Optimization:** It explores critical techniques for optimizing manufacturing processes which include time studies and the implementation of the Toyota Production System. These approaches focus

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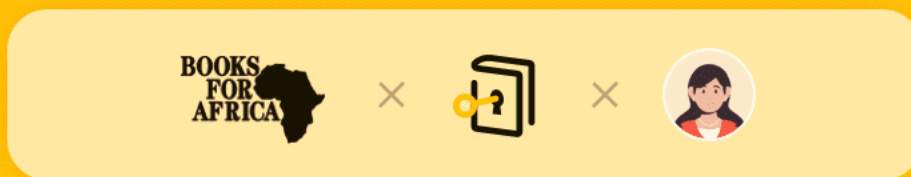
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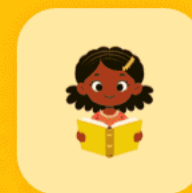
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## Chapter 40 Summary: Z

Chapter 40 of "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover provides a comprehensive overview of key concepts related to manufacturing systems, focusing on the principles and methodologies that underpin efficient production processes.

1. **Workload:** Defined as the total amount of work assigned to a worker or system, workload management is crucial across various manufacturing formats, including flexible manufacturing systems, manual assembly lines, and single-station cells. Efficient workload distribution enhances productivity, ensuring that each station operates at optimal capacity and contributes to the overall efficiency of the production process.
2. **Workstations:** The chapter discusses various types of workstations, considering aspects like automation, computer-aided design, and cellular manufacturing. Automated assembly workstations illustrate the integration of technology in improving speed and accuracy in production, while manual assembly lines highlight the importance of human involvement in complex assembly tasks. Each workstation type is designed to accommodate specific tasks and workflows, contributing to a seamless manufacturing environment.
3. **Work-in-Process (WIP):** WIP refers to items in various stages of manufacturing but not yet completed. Effective management of WIP is

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essential for maintaining production flow and preventing bottlenecks. This concept is significant across different systems, including cellular manufacturing and flexible manufacturing systems. Properly controlled WIP can lead to reduced lead times and increased efficiency.

4. **Utilization:** Utilization measures how effectively manufacturing resources, including equipment and labor, are employed. The chapter emphasizes the importance of maximizing utilization for improved productivity. It explores how metrics such as overall equipment effectiveness (OEE) help assess and enhance machine and labor performance in manufacturing environments.

5. **Worker Involvement:** The importance of worker participation in the manufacturing process is highlighted, with a focus on how empowering employees can lead to enhanced productivity and job satisfaction. Concepts like worker teams and visual management practices are discussed as strategies to increase engagement and streamline operations, ultimately fostering an atmosphere of continuous improvement.

6. **Vision Systems:** The chapter also delves into vision systems, such as vision-guided robotics, which enhance the capabilities of manufacturing systems. These technologies allow for improved quality control through visual inspection and facilitate automation in tasks that require precision and adaptability. Advances in machine vision are reshaping traditional

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manufacturing practices, enabling better accuracy and efficiency.

Throughout the chapter, principles of efficiency, continuous improvement, and the integration of technology in manufacturing systems are layered intricately, forming a cohesive narrative on modern production techniques. The interrelation of concepts such as workload, workstations, WIP, utilization, and worker involvement constructs a framework for understanding the complex dynamics that drive successful manufacturing systems today. The chapter serves as a vital resource for understanding how modern industrial practices are evolving to meet the demands of efficiency and flexibility in production.

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