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The Impact of Hybrid Manufacturing on the Design and Improvement of Production Processes: An Exploratory Study of the Opinions of a Sample of Workers in the Badoush Cement Factory - Expansion

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Abstract

The primary aim of the study was to determine the impact of hybrid manufacturing, along with its secondary-dimensions, on the design and enhancement of production processes at the expanded Badoush Cement Plant. The study problem is framed by raising a set of questions, including: Does the management of the researched plant embrace the dimensions of the independent variable (hybrid manufacturing) and the dimensions of the dependent variable (designing and enhancing production processes)? To fulfill the study's objectives and address its inquiries, the researcher adopted a descriptive methodology. Within this framework, a questionnaire was designed as a principal tool for data collection. A total of 245 questionnaires were distributed to a sample of employees at the Badoush Cement Plant. Following the statistical analysis of the data, the study arrived at several significant findings, foremost among which is the plant management's keen interest in augmenting the influence of hybrid manufacturing on the field-level design and enhancement of production processes. This focus stands to ameliorate the dimensions of designing and enhancing production processes more effectively. Additionally, notable recommendations include the plant management's commitment to an avoidance strategy (postponement) to differentiate between production operations by delaying certain crucial production activities until customer orders are received. Subsequently, the production process can be completed, aiming to diminish inventory and expedite meeting customer demands.

Keywords: *Hybrid Manufacturing, Design and Improvement of Production Processes.*

Introduction

The world today is witnessing significant and rapid transformations in the composition of companies, characterized by economic and technological growth. There is a diversity in customer needs and desires, along with an increased intensity of competition in global markets. These changes and shifts have not only resulted from modern technological advancements, but also from the growth and development of contemporary managerial concepts. Many advanced companies have successfully applied these concepts, placing companies in a continuous race to remain in the market and attain a distinctive competitive position. Iraqi industrial companies are facing challenges of competition and attempting to establish a presence in a market saturated with imported goods. These modern concepts emphasize that the establishment, evolution, survival, and downfall of companies are contingent on the adoption and implementation of new managerial

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concepts. This has drawn the attention of specialists and researchers in scientific and economic fields towards studying these concepts and their necessity for implementation in manufacturing companies. The significance of this study is evident in understanding these modern trends, notably hybrid manufacturing. This approach consists of two fundamental systems: lean manufacturing, which aims to enhance performance, reduce defects, and lower costs, and agile manufacturing, which strives to achieve quick responsiveness to customer demands by offering diverse products with high flexibility and low costs. These systems assist companies in rapidly designing and improving their production processes for optimal speed and performance.

The study comprises four sections. The first section presents the methodological framework, while the second section delves into the theoretical framework of the study. The third section is dedicated to testing the study's hypotheses. The study concludes with the fourth section, which addresses the conclusions and recommendations.

Section One: Methodological Framework

First: Research Problem

Industrial companies operating within the business environment aspire to achieve sustainable competitiveness. Their desires align with meeting customer requirements, such as waste reduction, cost minimization, and reduced waiting times. These goals can be realized through the adoption of modern production concepts, notably "hybrid manufacturing." The conservation of environmental resources is achievable only through a focus on waste reduction and minimizing inefficiencies. This is crucial for addressing environmental challenges and intense competition. Such efforts have a positive impact on the performance and efficient utilization of resources within these companies (Virmani, et al., 2018:427).

Today, the survival and longevity of most global companies hinge on innovation and increased productivity. For the management of the studied plant, adopting hybrid manufacturing to enhance production processes is essential for staying competitive and surviving in the market. Thus, the focal point of the field study revolves around identifying the main question: What is the impact of hybrid manufacturing on the design and improvement of production processes? Additionally, the study addresses the following secondary questions:

1. Does the researched plant's management adopt the dimensions of hybrid manufacturing?

2. To what extent are the employees at the studied plant aware of designing and improving production processes?

Second: Research Significance

Hybrid manufacturing has gained significant attention from industrial companies due to its impact on company success and, consequently, its societal implications. It aids companies in reducing time and effort spent on production processes. Moreover, it plays a role in understanding market sensitivities and customer needs by offering services through company-owned logistics services. Thus, the focus on designing and improving production processes using modern methods that minimize waste, preserve the environment, and do not harm future generations has become prominent.

Third: Research Objectives

1. Investigate the field perceptions of the sample regarding the dimensions of hybrid manufacturing at the level of the researched company.

2. Select suitable measurement models for the key study variables (hybrid manufacturing, designing and improving production processes) after presenting and analyzing models presented by authors and researchers within each variable.

3. Establish the logical relationship between the primary and secondary study variables through scrutinizing and examining the knowledge accumulations related to the variables. Extracting the intellectual foundation that logically supports and strengthens this relationship.

Fourth: Research Design and Hypotheses

The study's design is a specific map of its ideas, crafted by the researcher based on the study's unique requirements. In order to achieve the purpose and specific objectives of this study, the researcher has developed a specialized model. This model illustrates the key variables addressed in the study, and it serves as the foundation for formulating and clarifying the relationships between the study variables, as depicted in Figure (1).

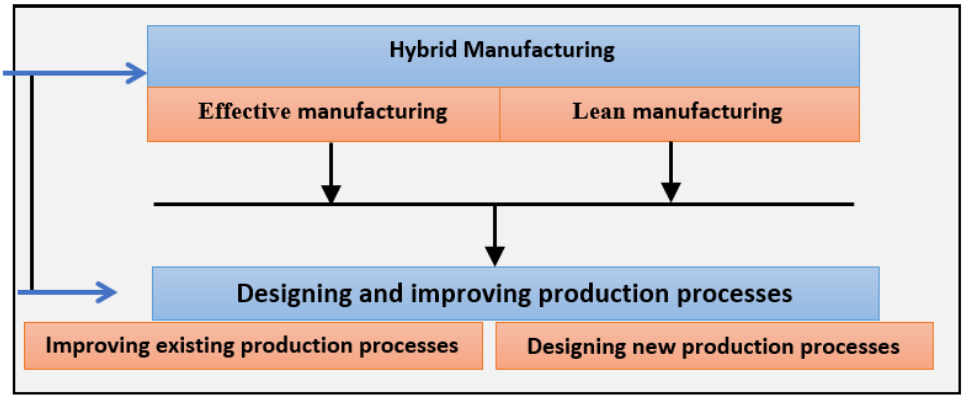

Figure (1): Proposed Research Framework

Fifth: Research Hypotheses

In line with the research objectives and for the purpose of testing its framework, a set of primary and secondary hypotheses has been formulated as follows:

1. Primary Hypothesis: There is a significant and statistically meaningful correlation between hybrid manufacturing and the design and improvement of production processes at the expanded Badoush Cement Plant, at both macro and micro levels.

2. Secondary Hypothesis: There is a direct significant effect of hybrid manufacturing on the design and improvement of production processes at the researched plant, at both macro and micro levels.

Sixth: Research Population and Sample

The process of selecting an appropriate field is a crucial factor in the success of the study, as it serves as the primary resource for obtaining important data. Accordingly, the expanded Badoush Cement Plant in Nineveh, which is under the Ministry of Industry and Minerals, was chosen for the study. The study was conducted at the Badoush Cement Plant, established on 14/7/1983. The plant is situated approximately 25 km north of Nineveh, 3 km from Badoush town, and 3.5 km from the river. Production in the plant began in 1986, with a production capacity of 3000 tons/day. The actual production capacity is 1500 tons/day of ordinary Portland cement. The plant operates using the dry method with preheating and precalcination, and all equipment and machinery are of Japanese and French origins. To gain a clear understanding of the plant, Table (1)

illustrates the number of distributed and received questionnaires along with the response rate.

Table (1): Number of Distributed and Received Questionnaires and Response Rate

Number of Distributed Questionnaires:	Number of Received Questionnaires:	Response Rate:	Number of Excluded Questionnaires:	Number of Valid Questionnaires:
255	250	96%	5	245

Source: The table is compiled by the researcher based on the results of the questionnaire.

Seventh: Statistical Methods Used in Data Analysis

A variety of statistical methods were employed, including:

a. Mean (Arithmetic Mean): Used to determine the level of response among the sample individuals regarding the study variables and paragraphs, and the standard deviation to measure the degree of dispersion of responses from their mean.

b. Variation Coefficient: This is the standard deviation divided by the mean. It's used to express the level of variability of responses from the mean among the sample individuals.

c. Relative Importance: This involves calculating the mean related to the maximum value of the Likert scale (i.e., 5). It's used to express the proportion of response or relative importance.

d. Confirmatory and Exploratory Factor Analysis: Utilized to assess the construct validity of the scale.

e. Pearson Correlation Coefficient: Used to verify the nature of the relationship between the three main study variables and their secondary dimensions.

Section Two: The Theoretical Framework

First Axis: Hybrid Manufacturing

First: The Concept of Hybrid Manufacturing

The concept of hybrid manufacturing was first applied in the year 2000. Hybrid manufacturing is a combination of lean and agile manufacturing. The hybrid manufacturing system has significant competitive advantages that enable production units to overcome potential competitive issues (Naveen, 2017:969). There are two main perspectives regarding lean and agile manufacturing, which are considered the foundation of hybrid manufacturing.

The first perspective argues that lean manufacturing and agile manufacturing are two mutually exclusive philosophies that cannot coexist. On the other hand, the second perspective believes that they are distinct philosophies and that agile manufacturing is an enhancement of lean manufacturing. Thus, agile manufacturing empowers companies to effectively respond to changing customer requirements and needs (Rajeev, 2018:423). It is defined as a system that enhances agility through lean and efficient systems, achieving high flexibility through optimal inventory utilization (Dulanji, 2020:1140).

Second: Significance of Hybrid Manufacturing

Hybrid manufacturing holds great importance in the global market due to its distinctive characteristic that provides competitive advantages for companies by compelling them to consider the time required for product delivery to customers (Mankute, 2013:723). It is a system characterized by multiple skills that seeks to discuss and solve all the problems that companies face in order to generate ideas and present novel concepts to the company

(Khan & Dalu, 2015:53). Additionally, (Albakri, 2021:51) states that the significance of hybrid manufacturing includes the following:

1. Hybrid manufacturing is considered one of the best comprehensive quality management programs. It serves as a fundamental weapon to confront market and company challenges. By developing its capabilities and knowledge, a company becomes capable of meeting future customer needs.

2. Hybrid manufacturing serves as a positive indicator of empowering companies to establish a strong market position. This enables them to obtain a larger market share compared to their competitors, implying that they will have more loyal customers.

Third: Dimensions of Hybrid Manufacturing.

Hybrid manufacturing has emerged as a significant system in recent times, characterized by its diverse dimensions that cannot be definitively defined. Many scholars and researchers have concurred on identifying the dimensions of hybrid manufacturing, which have been formulated after interpreting the study's foundations and aligning with the surrounding corporate environment. These dimensions have been delineated by (Nawanir, 2015:103), (Niraj, 2016:1), and (Al Bakri, 2021:35). The identified dimensions of hybrid manufacturing are as follows:

1. Lean Manufacturing: The business environment is undergoing rapid technological changes, along with a variety of customer needs and preferences, coupled with intensified competition in global markets. These factors compel companies to engage in a continuous race to maintain their market presence and achieve a distinctive competitive position. Consequently, companies strive to pursue excellence in performance to sustain their competitive edge (Niraj, 2016:1). (Erasmus, 2018:19) defines lean manufacturing as a philosophy of ideal production. Its ultimate goal is to eliminate all forms of waste within the manufacturing process, thus enhancing the manufacturing performance of industrial companies.

2. Effective manufacturing: The contemporary world of the current century witnesses monumental shifts and advancements in the manufacturing landscape. Companies rely on novel systems and technologies that aid in product manufacturing and in building capacity and competitive differentiation through enhanced flexibility and knowledge application (Abdelghani, 2016:61). (Al Khafaji, 2017:23) characterizes effective manufacturing as a philosophy of change that encompasses all organizational facets (organizational structure, technology, personnel) which contribute to achieving objectives. This is facilitated by empowering companies to remain competitive in a dynamically changing environment through swift responsiveness.

Second Axis: Designing and Improving Production Processes.

First: The Concept of Designing and Improving Production Processes.

Companies strive to maintain competitive operations by offering products that meet customer needs. Although the process can be under control, it may not necessarily align with production requirements, customer demands, and company objectives (Quality, 2004:181). (Sharif, 2005:81) defines the design and improvement of processes as a technique that directs the attention of senior management towards devising ways to motivate managers and workers, thus paving the way for reducing product costs. Similarly, (Al Azawi, 2006:24) characterizes the design and improvement of processes as a means to enhance the organization and management of separate sets of activities. This often entails introducing enhancements to the current system or incorporating new units.

Second: The Significance of Designing and Improving Production Processes.

The importance of designing and improving production processes becomes evident through its contribution to reducing errors that lead to resource wastage due to rework. It

represents a fundamental factor in determining the volume and quantity of demand for any company's products (Al Badi, 2010:35). The significance of designing and improving production processes encompasses the following points (Al Azawi, 2006:35) and (Al Nama and Sultan, 2018:76):

1. Achieving excellence and gaining competitive advantage through collaborative efforts between management and employees.

2. Increased pricing and returns result in higher profitability.

3. Enhancing production processes leads to efficient resource utilization and improved production process efficiency.

4. Timely delivery of results due to the regularity of production schedules, leading to faster introduction of new products.

Third: Dimensions of Designing and Improving Production Processes.

1. Designing New Production Processes.

After understanding the concept of designing production processes, the role of the design system in improving working conditions to satisfy internal customers and enhance the company's competitiveness becomes clear (Al Jashami, 2013:72). The importance of designing new production processes lies in directly enhancing the effectiveness of designs in the success and sustainability of companies, as well as their competitive approach. Additionally, it impacts several other functions within the company, including operations and marketing, ultimately leading to offering products that meet customer requirements (Stevenson, 2009:160).

2. Improving Existing Production Processes.

Improving existing production processes is a vigilant process undertaken by companies to address environmental challenges that affect their operations. The goal is to enhance these processes and align their products with required specifications, aiming to elevate the quality of products provided to customers (Willar, 2012:9). According to Sraun & Singh (2017:8), the focus of improving existing production processes primarily centers on employees. This approach has a significant impact on empowering and involving employees in enhancing production processes, ultimately boosting their self-confidence and yielding positive results for their company.

Section Three: Testing Hypotheses of the Study.

First: Testing the Correlation Hypotheses.

Within this section of the study, attention is directed towards one of the main aspects of the study's hypotheses outlined by the researcher in the study's methodology. This aspect pertains to the first primary hypothesis, which is considered one of the requirements for testing the analysis of the hypothetical study design. Building on this foundation, this section will examine the study's primary hypothesis along with its derived secondary hypotheses. This examination aims to interpret and determine the nature of the relationship between the study's variables.

Primary Hypothesis: There exists a statistically significant correlation between hybrid manufacturing and production processes. The results of hypothesis testing are illustrated in Table (2), which demonstrates the outcomes of hypothesis testing.

Table (2) Correlation Coefficients (Pearson (*))

Hypothesis		Variables		Simple Pearson Correlation Coefficient	Sig. (2-tailed)	Relationship Strength & Direction
		Independent	Dependent			
Secondary	1-1	Lean manufacturing	Designing production processes	0.634	(0.00)	Strong positive
	1-2	Effective manufacturing		0.753	(0.00)	Strong positive
First Primary		Hybrid Manufacturing	Improving production processes	0.785	(0.00)	Strong positive

* n = 313

From the above table, the process of a significant correlation becomes evident, reflecting a strong relationship at a significance level of 0.01, indicating a confidence level of 100% between hybrid manufacturing and the design and improvement of production processes. The correlation coefficient (Pearson) value reached 0.785. This result supports the validity of the primary hypothesis. It suggests that the more senior management focuses on hybrid manufacturing, the more effective the design and improvement of production processes become.

These findings imply the possibility of a synergistic effect between hybrid manufacturing, as indicated by its dimensions, and the design and improvement of production processes. Consequently, the first hypothesis, which posits a significant correlation between hybrid manufacturing and production processes, is accepted. Following this, the derived secondary-hypotheses from this primary hypothesis are analyzed, starting with:

1. Analyzing the relationship between lean manufacturing and the design and improvement of production processes.

From the above table (Table 2), it becomes evident that there is a process of a significant and positive correlation at a significance level of 0.01, indicating a confidence level of 100%, between lean manufacturing as a dimension of hybrid manufacturing and the design and improvement of production processes. The correlation coefficient (Pearson) value reached 0.634. This result supports the validity of the secondary-hypothesis derived from the primary hypothesis. This finding suggests that the more senior management focuses on lean manufacturing within the context of hybrid manufacturing, specifically by emphasizing the reduction of raw material costs and providing products on demand. Moreover, inspecting the product during the manufacturing process to eliminate unnecessary materials in order to achieve a smooth material flow. This philosophy aligns with lean manufacturing principles, utilizing techniques and tools to eliminate all forms of waste and non-value-adding activities in order to enhance the efficiency of the design and improvement of production processes.

Therefore, the acceptance of the derived first secondary-hypothesis from the primary hypothesis is appropriate. It states the presence of a significant and meaningful correlation between lean manufacturing and the design and improvement of production processes.

2. Analyzing the relationship between effective manufacturing and the design and improvement of production processes.

From the above table (Table 2), it becomes evident that there is a process of a significant and positive correlation at a significance level of 0.01, indicating a confidence level of 100%, between effective manufacturing as a dimension of hybrid manufacturing and the design and improvement of production processes. The correlation coefficient (Pearson) value reached 0.753. This result supports the validity of the second secondary-hypothesis derived from the primary hypothesis.

This finding suggests that senior management within the researched field is concerned with effective manufacturing. This indicates that the laboratory's management regularly works to adjust its vision to reflect quick responsiveness to anticipated changes by designing an integrated information system that connects various departments in the laboratory or business unit. This aligns with the laboratory's philosophy, which focuses on enhancing efficiency, productivity, and achieving competitive excellence. As a result, this leads to an increase in the effectiveness of designing and improving production processes.

Consequently, the acceptance of the derived second secondary-hypothesis from the primary hypothesis is appropriate. It states the presence of a significant and meaningful correlation between effective manufacturing and the design and improvement of production processes.

The second hypothesis (Causation Hypothesis) will now be detailed for analysis, and Table 3 below illustrates the results of testing this hypothesis and its secondary-hypotheses:

Table 3: Results of Testing the Second Primary Hypothesis and Its Secondary-Hypotheses

Hypothesis		Explanatory Variable and Its Dimensions	Constants		coefficient of determination (R^2)	(F) Calculated Value	(P-Value) Significance Level	Dependent Variable
			B	A				
Primary	4	Hybrid Manufacturing X	0.835	0.785	0.617	500.160	0.000	Designing and Improving Production Processes (Y)
Secondary	4-1	Lean Manufacturing (x1)	0.588	0.634	0.402	208.963	0.000	
	4-2	Effective Manufacturing (x2)	0.713	0.753	0.567	406.809	0.000	
n = 313								

From the above table (Table 3), the statistical significance of the study model becomes apparent through the calculated value of (F), which amounted to 500.160 at a significance level of 0.01, with a confidence level of 99%. This indicates the presence of an effect of hybrid manufacturing on the dependent variable (designing and improving production processes). This finding implies that the linear regression slope between the study variables is favorable and can be used to describe the causal relationship between the variables.

In the light of the results in the above Table 3, the constant ($\alpha = 0.785$) is evident. This constant indicates that even if hybrid manufacturing is equal to zero, there is still a presence of (designing and improving production processes) with a value of (0.785). Additionally, the value of ($\beta = 0.835$) suggests that a change of 1 in hybrid manufacturing will result in a change of (0.835) in (designing and improving production processes). Furthermore, the coefficient of determination (R2) can be observed as a descriptive measure, explaining the extent of benefit from the regression equation in estimating

values. It also allows us to determine the decrease in errors, thus contributing to the reliability and validity of the second hypothesis of the study.

Section Four: Conclusions and Recommendations

First, Conclusions:

This chapter presents a collection of theoretical and practical conclusions drawn from the study, summarizing the intellectual and applied efforts. The following are the presented conclusions:

First Axis: Theoretical Conclusions

1. The concept of hybrid manufacturing is derived from the integration of two essential systems: lean manufacturing and effective manufacturing. Lean manufacturing aims to eliminate waste processes, while effective manufacturing achieves rapid response to operations within a framework of continuous improvement, which forms the foundation for designing and enhancing production processes.

2. Designing and improving production processes have become crucial matters on a global level for numerous international companies interested in this business context. Simultaneously, this aligns with the evolving consumer pattern, which intensifies the importance of these activities. Consequently, this elevation in significance leads to an increase in waste generated. As a result, the growth of waste, the escalation of resource scarcity, and the availability of new technologies create an opportunity to transform waste into a valuable resource.

Second Axis: Field-Related Conclusions

1. There exists a significant correlation between the dimensions of hybrid manufacturing and the design and enhancement of production processes in the expanded Badoush Cement Factory at an overall level. This correlation demonstrates a strong positive relationship across the secondary-dimensions of hybrid manufacturing. The correlation coefficient between hybrid manufacturing and the design and enhancement of production processes reached 78.5.

This robust positive correlation extends to the secondary-dimensions of hybrid manufacturing. The correlations between all dimensions and the design and enhancement of production processes were positive, indicating a direct relationship. The highest correlation was observed between effective manufacturing and the design and enhancement of production processes, with a value of 75.3. This significant and strong correlation emphasizes the importance of these variables.

The researcher interprets these findings as indicating that the more the researched factory management emphasizes the practice of hybrid manufacturing processes, the more it contributes to enhancing design and improvement activities in production processes. This is particularly evident in the effective manufacturing dimension, reflecting the factory's adaptability and modification of various market factors and variables.

2. The study results indicate a significant and meaningful impact of hybrid manufacturing (lean manufacturing, effective manufacturing) on the design and improvement of production processes in the researched facility. The explanatory power of these dimensions accounts for 61.7% of the variations observed in the design and enhancement of production processes in the facility. The influence of "effective manufacturing" exhibited the highest impact, followed by "lean manufacturing." Therefore, the study adopts the following conclusions regarding the management of the researched facility that emphasizes the application of hybrid manufacturing dimensions while enhancing productivity within environmental protection criteria:

a) The study concludes the presence of a significant and meaningful impact of lean manufacturing on the design and improvement of production processes in the researched facility. The explanatory power of this dimension explains 40.2% of the variance in the design and improvement of production processes resulting from the influence of lean manufacturing. Based on this, the study embraces the conclusion that the facility should strive to provide machines and equipment in good condition when needed, while reducing losses and waste.

b) The study's results demonstrate a significant and meaningful impact of effective manufacturing on the design and improvement of production processes in the researched facility. The explanatory power of this dimension explains 56.7% of the variance in the design and improvement of production processes due to the application of effective manufacturing. Therefore, the study adopts this conclusion, emphasizing that the facility's management attributes clear importance to employees by granting them decision-making authority. Moreover, it underscores the emphasis on partnership relationships with suppliers that achieve cost reduction, increased profits, and inventory reduction, ultimately achieving customer satisfaction by meeting their requirements.

Second: Recommendations.

1. Embrace modern methods in the process of designing and improving production processes to minimize waste and reduce idle times with greater efficiency, by considering the following:

• Implementation Mechanism:

a) Establish dedicated departments within the researched facility to attain benefits that yield economic, social, and environmental advantages.

b) The facility's management should consistently provide support to the research and development department to keep pace with advancements in the cement industry.

2. We recommend that the researched facility recognize the necessity for inter-company collaboration aimed at integrating efforts to enhance the adoption of modern manufacturing systems and technologies. This can be achieved by fostering partnerships with both local and international companies, ultimately leading to the establishment of cutting-edge manufacturing systems.

• Implementation Mechanism:

a) Encourage the management of Badoush Cement Plant to keep up with advancements in production technology that rely on flexible production systems and software. These systems should be capable of easy updates in the shortest time possible.

b) Encourage the facility's management to minimize setup and preparation time to enhance production flexibility and achieve rapid product delivery to customers.

3. It is essential for the facility's management to adopt the latest innovative global marketing techniques, primarily through utilizing the internet for sales and marketing purposes to expand the reach of the facility's products geographically.

• Implementation Mechanism:

a) Activate and expand the network of relationships with other companies to increase experience sharing, knowledge exchange, and to facilitate dealings with suppliers and customers. This strategy contributes to achieving a competitive edge for the facility.

b) Support the facility's marketing department by establishing multiple marketing outlets in various locations across the country, rather than relying solely on direct sales centers. Increase digital advertising through satellite channels and social media platforms.

4. The facility's management should prioritize the strategy of "non-convergence" (delay) to segregate production processes. This involves postponing significant production activities until customer orders are received, followed by completing the production process. This approach aims to reduce inventory and accelerate meeting customer demands.

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