iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** IV **Month of publication:** April 2024

DOI: https://doi.org/10.22214/ijraset.2024.60221

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

Survey and Analysis of Current Manufacturing Trends in the Global Market: A Practical Investigation

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Abstract: Manufacturing has undergone a significant digital transformation in recent years, driven by technological advancements and evolving consumer demands. To remain competitive and overcome today's challenges, manufacturers have prioritized agility and adaptability. The ongoing march of technology, connectivity, and automation enhancements is poised to continue reshaping the industry. One notable trend is the increasing use of collaborative robots (cobots) in manufacturing. Advances in robot technology have fueled innovation across various areas of manufacturing facilities. Industrial cobots are expanding the possibilities of automation in functions such as maintenance, machine tending, material handling, quality control, and material removal. The primary benefits of cobots in manufacturing include safety improvements, higher production efficiency, solutions to the skills gap and labor shortages, among others. Despite labor shortages, continued supply chain disruptions, and fluctuating demand, the manufacturing industry remains resilient. Production levels of industrial goods have surpassed pre-pandemic levels. The industry is undergoing a generational shift from traditional machine-based assembly lines to "smart factories," leveraging robotics, the Internet of Things (IoT), data analytics, augmented reality (AR), and other cutting-edge technologies. This movement, commonly referred to as Industry 4.0, represents the next stage in the digitization of manufacturing. It is driven by advancements in automation and connectivity, enabling manufacturers to operate more efficiently, respond quickly to changing market demands, and optimize their production processes. Industry 4.0 holds the promise of greater flexibility, productivity, and competitiveness for manufacturers in the digital age.
Keywords: Digital Transformation, Cobots, Smart Factories, Robotics, Automation

I. INTRODUCTION

Manufacturing is the process of converting raw materials into finished products through a combination of methods, human effort, and machinery, all executed according to a meticulously crafted plan aimed at optimizing cost efficiency. In large-scale manufacturing, pivotal assets like assembly line procedures and cutting-edge technologies are deployed to facilitate the efficient mass production of goods. These assets enable the seamless coordination of resources and the implementation of advanced techniques to ensure consistent output and meet the demands of the market. The effectiveness of large-scale manufacturing operations is crucial for businesses to maintain their competitive edge in the global landscape. Through the utilization of economies of scale and the adoption of innovative production methodologies, manufacturers can drive productivity, minimize expenses, and enhance profitability, ultimately fostering growth and success within the industry. As time progresses, the attributes of manufacturing processes and operations undergo continual transformations. The requisite type and quantity of workforce fluctuate according to the specific attributes of the intended final product.

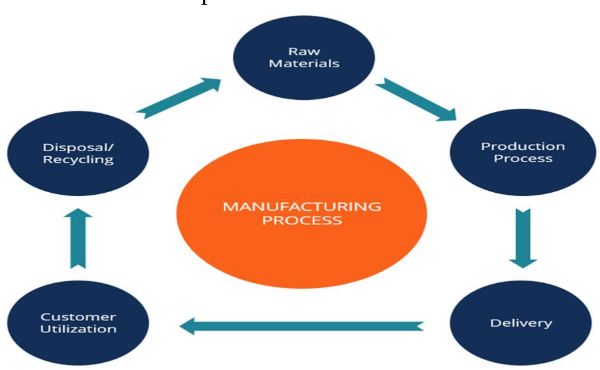

Fig 1: Manufacturing Process

II. BACKGROUND HISTORY OF MANUFACTURING

The origins of manufacturing trace back to the 19th-century Industrial Revolution, a time when raw materials underwent conversion into finished goods. This epoch denoted a pivotal transition from reliance on human labor to the adoption of machinery and chemical manufacturing techniques, effectively reshaping the industry landscape. Artisans, once the backbone of production, found themselves transformed into wage laborers amidst this technological upheaval. Prior to this shift, the market was predominantly characterized by handmade goods. The emergence and refinement of steam engines and other technological advancements ushered in an early modern industrial era, during which companies embraced machinery in their manufacturing processes. Computer-controlled systems and electronic equipment designed for precision play a crucial role in synchronizing operations, empowering companies to embrace advanced manufacturing processes. In the contemporary landscape, rapid technological advancements are driving efficiency within the manufacturing sector. Notably, product life cycles are shrinking while maintaining high quality standards. Additionally, the adaptability and responsiveness of technology are enhancing employee productivity.

A. *Manufacturing Exerts a Significant Influence on the Finance Capital.*

Historical evidence consistently highlights the strong correlation between manufacturing and economic growth. Economists offer two primary sets of explanations to elucidate manufacturing's role as the engine of economic growth. The initial explanation focuses on the distinctive attributes of manufacturing, while the second delves into how these characteristics impact returns and overall economic growth. In the former scenario, manufacturing offers wider avenues for intensification and capital accumulation. Furthermore, manufacturing capitalizes on economies of scale driven by technical indivisibilities and large-scale production. The increased learning opportunities inherent in manufacturing production also contribute to technological advancement. The impact of government capital expenditure on the manufacturing sector output in Nigeria.

Through empirical analysis, the study explores the relationship between government spending on infrastructure and equipment and the performance of the manufacturing industry. The findings contribute valuable insights into the effectiveness of government policies in stimulating growth within the manufacturing sector, offering implications for policymakers and stakeholders seeking to enhance economic development in Nigeria [1].

This study investigates the impact of financial leverage on the profitability of listed manufacturing firms in China. By examining financial data and employing statistical analysis, the research aims to determine how the level of debt financing affects the profitability metrics of manufacturing companies. The findings of this study shed light on the relationship between financial leverage and profitability, offering valuable insights for investors, policymakers, and stakeholders interested in the Chinese manufacturing sector. This research provides empirical evidence that can inform decision-making processes related to financial management strategies and investment decisions within the manufacturing industry in China [2].

Agencies utilize surveys of manufacturing companies to gauge metrics such as new orders, employment, and inventory levels.

III. LATEST TRENDS IN ADVANCED MANUFACTURING

A. *Servitization*

Servitization, a transformative business model, entails transitioning from merely selling products to providing comprehensive services. Particularly in the manufacturing sector, this shift encompasses offering post-sale services like maintenance, repairs, and upgrades to clientele. Embracing this model not only fosters deeper connections with customers but also cultivates enduring loyalty and establishes consistent revenue streams. Moreover, it empowers manufacturers to distinguish themselves from competitors by delivering value-added services that elevate the overall customer journey. Additionally, servitization facilitates a profound understanding of customer requirements and inclinations, thereby informing product innovation and bolstering overall customer satisfaction [3] [4].

B. *Reshoring*

Reshoring, a notable phenomenon, involves relocating manufacturing operations from overseas back to their domestic origin. This trend has surged in recent years owing to factors such as labor shortages, supply chain disruptions, geopolitical risks, and escalating labor costs in foreign locales. This strategic move can yield numerous advantages for manufacturing enterprises, encompassing diminished transportation expenses, enhanced quality control, and heightened operational flexibility. Furthermore, reshoring has the potential to spur job creation and bolster local economies [5] [6].

C. Extended Reality

Extended reality (XR), encompassing technologies that blend the physical and digital realms such as virtual reality (VR) and augmented reality (AR), offers significant advantages in enhancing employee training and education while bridging worker skills gaps. Through XR, manufacturers can develop immersive training simulations that facilitate the acquisition of new skills and procedures by employees within a controlled environment. Consequently, workers benefit from real-time information and guidance, leading to heightened productivity and reduced errors for companies. From a consumer perspective, XR has the potential to enrich the customer experience through virtual product demonstrations and visualizations. Furthermore, it aids manufacturers in crafting superior products for customers by enabling designers to visualize and test products in a virtual environment prior to mass production and market release [7] [8].

D. Digital Twins

In the realm of smart manufacturing, the concept of digital twins has garnered significant traction. These digital twins, acting as virtual replicas of physical objects or systems, are outfitted with sensors and linked to the internet, enabling them to gather data and furnish real-time performance insights. Within smart factories, digital twins play a pivotal role in monitoring and fine-tuning the performance of manufacturing processes, machinery, and equipment. The emergence and industrial applications of digital twins have revolutionized various sectors, including manufacturing, healthcare, and transportation. Digital twins, virtual replicas of physical assets or processes, enable real-time monitoring, predictive maintenance, and optimization of systems. They facilitate data-driven decision-making and enhance operational efficiency, reliability, and safety. With the advancement of IoT, AI, and cloud computing technologies, digital twins have become increasingly prevalent, offering unprecedented insights and opportunities for innovation. Incorporating digital twins into research can provide valuable insights into their implementation and impact across diverse industries, contributing to advancements in technology-driven solutions and enhancing overall productivity and performance [9][10][11]. Through the aggregation of sensor data from manufacturing equipment, digital twins excel in detecting anomalies, pinpointing potential issues, enhancing forecasting accuracy, and offering insights into optimizing production processes. Moreover, manufacturers leverage digital twins to simulate scenarios and trial configurations prior to implementation, thereby refining decision-making processes and minimizing risks.

E. Cobot

The adoption of collaborative robots in manufacturing is steadily increasing, propelled by advancements in robot technology that foster innovation across various aspects of the manufacturing landscape. Industrial cobots, renowned for their collaborative nature, are broadening the horizons of automation across a multitude of functions, encompassing maintenance, machine tending, material handling, quality control, material removal, and beyond. In many instances within manufacturing, the most effective applications of cobots involve collaboration with human workers. Here, robots undertake the monotonous, hazardous, and dirty tasks, while employees focus on critical, high-value functions that machines cannot replicate. Some of the key advantages of cobots in manufacturing include enhanced safety measures, increased production efficiency, mitigation of skills gaps and labor shortages, among others. Throughout the remainder of this piece, we will delve deeper into the functions, applications, and advantages of collaborative robots, offering insights into the potential benefits they may offer to your operations.

F. What are Collaborative Robots?

A cobot is a versatile piece of equipment engineered to replicate tasks that would typically be performed by human employees but are considered undesirable due to their repetitive, unpleasant, or hazardous nature—commonly known as the "three D's": dull, dirty, and dangerous jobs. Cobots typically feature an articulated arm capable of movement along a predefined number of axes or planes of motion, usually ranging from four to six or seven. At the end of this arm, various tooling can be interchanged to carry out different tasks, including gripping or placing objects, machining, welding, and more. What distinguishes cobots is their "collaborative" nature, enabling them to work safely alongside human workers in close proximity. This paper provides an overview of cobot programming for collaborative industrial tasks. It delves into the programming techniques and methodologies employed in configuring collaborative robots (cobots) to work alongside human workers in industrial settings. The research explores the advancements in cobot programming, including safety features, task allocation, motion planning, and human-robot interaction. By examining the current state-of-the-art in cobot programming, the paper offers valuable insights for researchers and practitioners interested in deploying cobots for collaborative manufacturing processes, thereby contributing to the ongoing development and adoption of cobot technology in industry[12].

In contrast to the traditional automation equipment of the past, which typically requires programming by a technician and is isolated from employees behind safety gates or fences, cobots offer a user-friendly alternative. They can typically be set up and operated by almost anyone, regardless of programming knowledge, and tasks can be easily configured and adjusted on the fly. Unlike legacy automation equipment, which poses a high risk of injury if an employee comes into contact with it, cobots are designed to operate alongside human workers, equipped with built-in sensors, failsafes, and a user-friendly operating interface. A framework for the integration of collaborative robots (CoBots) into advanced manufacturing systems. The framework aims to facilitate the seamless incorporation of CoBots into existing manufacturing processes, enabling enhanced efficiency, flexibility, and safety. By outlining key considerations such as task allocation, human-robot interaction, and system interoperability, the framework provides a structured approach for implementing CoBot technology in industrial settings. This framework serves as a valuable resource for researchers and practitioners seeking to leverage the benefits of collaborative robotics in advanced manufacturing applications, offering guidance for effective integration and utilization of CoBots to improve overall system performance and productivity [13].

G. What are cobots used for

Cobots possess a wide array of applications thanks to their versatility, facilitated by:

1) Extensive articulated motion capabilities
2) Interchangeable tooling options
3) Simple setup procedures
4) Capacity to operate in close proximity to employees

For decades, automation has addressed the challenge of completing repetitive tasks swiftly and efficiently. Cobots extend the capabilities of automation equipment to encompass a broader spectrum of tasks with enhanced efficiency, spanning areas such as machining, packaging, and maintenance. In the realm of maintenance, cobots can:

a) Assist in accessing hazardous or hard-to-reach areas for diagnostic purposes, repairs, or component replacement.
b) Monitor equipment by collecting and transmitting data, as well as issuing alerts for additional investigation when necessary.
c) Carrying out maintenance procedures automatically if equipment deviates from specifications or malfunctions, enabling technicians to optimize their time and priorities for increased efficiency.
d) Enhance return on investment (ROI) by increasing the efficiency and speed of maintenance procedures.

Cobots can additionally stabilize pieces during welding, perform machining operations, extract finished parts from molds, handle the placement of pieces into packaging, transport raw materials and finished products, prepare products for quality control inspections, and fulfill various other tasks. collaborative robot (cobot) control, addressing the need for efficient and adaptable control strategies in human-robot collaborative environments. The framework encompasses various aspects such as motion planning, task allocation, safety monitoring, and human-robot interaction. By providing a structured approach to cobot control, this framework facilitates the development of robust and flexible control systems that can seamlessly integrate with human workers and adapt to changing task requirements. Researchers can utilize this framework as a foundational reference for designing and implementing cobot control systems in diverse industrial and collaborative settings, thereby advancing the field of human-robot collaboration[14]. Cobots investigates the latest developments in cobot technology and examines the various industries where cobots are increasingly being deployed, such as manufacturing, healthcare, and agriculture. Additionally, the paper discusses the challenges associated with cobot implementation, including safety concerns, human-robot interaction, and scalability issues. By providing insights into the current state of cobot technology and its potential applications, this paper serves as a valuable reference for researchers and practitioners interested in incorporating cobots into their work environments[15].

H. Benefits of cobots

Cobots bring about a multitude of advantages in maintenance and various other domains, such as:

1) Enhanced human/robot efficiency: Collaboration between cobots and human workers boosts speed, precision, and effectiveness in any task, resulting in time and cost savings.
2) Accessibility for small and mid-sized manufacturers: With advancing technology, cobots are increasingly cost-effective, making them accessible to smaller and mid-sized manufacturers seeking to enhance their automation capabilities with more sophisticated and efficient solutions.
3) Swift return on investment (ROI): Cobots offer rapid ROI due to their straightforward setup, adaptable configuration, and applicability across a wide range of processes. Their ability to enhance speed, efficiency, and safety often leads to reduced resource expenditures, resulting in a positive ROI in a short timeframe.

4) Enhanced adaptability: Cobots provide flexible, seamless motion across multiple axes and can be swiftly reprogrammed for various tasks. Consequently, they extend their advantages across the entire facility, rather than being confined to a single area.
5) Enhanced safety: By undertaking hazardous and repetitive tasks, cobots can mitigate risks to human workers, thus improving overall workplace safety. This can lead to a reduction in repetitive stress injuries, resulting in benefits such as enhanced worker morale, increased uptime, and reduced costs.
6) Vast potential: Cobots can be effectively utilized in almost any conceivable application, spanning from maintenance and production to fulfillment operations and beyond.

IV. CONCLUSION

The survey findings shed light on the current trends dominating the global manufacturing landscape and underscore the pragmatic strategies adopted by industry players to remain competitive. The analysis reveals a significant shift towards digitalization, automation, sustainability, and customization as key drivers of innovation and efficiency in manufacturing. Manufacturers are increasingly leveraging advanced technologies and data-driven insights to optimize processes, reduce costs, and meet evolving consumer demands. Moreover, there is a growing emphasis on sustainability initiatives, such as eco-friendly production methods and circular economy practices, reflecting a broader commitment to environmental stewardship. Moving forward, it is imperative for manufacturers to continue embracing change, fostering innovation, and investing in talent development to stay ahead in the rapidly evolving marketplace. Collaboration, knowledge sharing, and strategic partnerships will be critical in driving sustainable growth and navigating the complexities of the global manufacturing industry.

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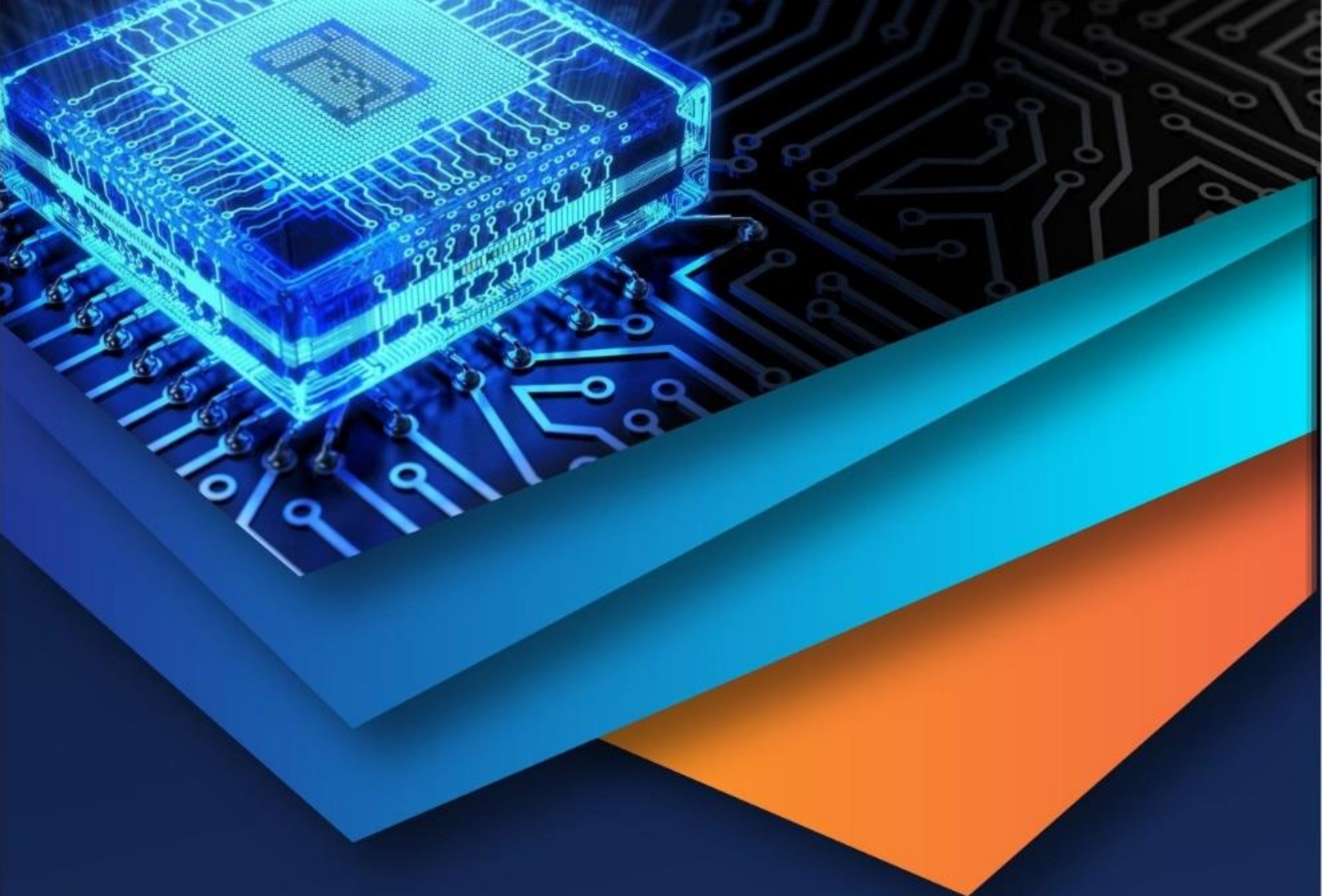

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