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A study on supply chain system of manufacturing steel industry

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Abstract- The manufacturing industry, the backbone of global economies, relies heavily on a sophisticated and well-orchestrated supply chain system. Far from a simple linear progression, today's manufacturing supply chains are complex, interconnected networks that encompass every stage from raw material acquisition to the delivery of finished goods to the end consumer. An efficient and resilient supply chain is not merely an operational necessity; it is a critical differentiator that determines a manufacturer's competitiveness, profitability, and ability to meet evolving customer demands in a dynamic global marketplace. A manufacturing supply chain involves a series of integrated activities that transform raw materials into sellable products. Planning involves forecasting demand, setting production goals, and developing strategies to align supply with anticipated market needs. Effective planning includes demand planning, supply planning, material requirements planning (MRP), and sales and operations planning. Procurement stage focuses on identifying, evaluating, and selecting suppliers for raw materials, components, and other necessary resources. Strong supplier relationships, contract negotiation, and quality assurance are crucial here. Production and Manufacturing is the heart of the supply chain, where raw materials are transformed into finished products through various processes. Efficient production schedules, quality control, and cost-effective manufacturing techniques are paramount. Logistics and Distribution component deals with the physical movement, storage, and delivery of goods. It includes inbound and outbound transportation management, fleet management, warehouse management, and inventory control, ensuring products reach customers in a timely and cost-effective manner.

I. INTRODUCTION

The significance of a robust supply chain in manufacturing cannot be overstated. Firstly, it directly impacts cost reduction. By optimizing the flow of goods, minimizing waste, and streamlining processes, manufacturers can significantly lower operational expenses, including inventory holding costs, logistics costs, and production overheads. Secondly, it drives enhanced efficiency and productivity. A well-managed supply chain ensures the availability of materials when needed, minimizes lead times, and optimizes resource utilization, leading to increased throughput and improved on-time delivery performance. (Kumar, 2020)

A strong supply chain fosters improved quality control. Close collaboration with suppliers ensures the quality of incoming raw materials, which translates to higher quality finished products and reduced returns. Crucially, an agile and responsive

supply chain enables manufacturers to adapt quickly to changes in market demand, consumer preferences, and unforeseen disruptions, thereby gaining a significant competitive advantage. In today's environmentally conscious world, supply chains also play a vital role in promoting sustainability by encouraging the use of eco-friendly materials, reducing waste, and optimizing transportation.

The manufacturing supply chain is undergoing a significant transformation driven by technological advancements and evolving market dynamics. Digitalization is at the forefront, with the increasing adoption of technologies like Artificial Intelligence (AI) and Machine Learning (ML) for demand forecasting, inventory optimization, and automated processes. Internet of Things (IoT) devices provide real-time visibility into inventory levels and asset tracking. Blockchain technology is gaining traction for enhanced transparency, security, and traceability across the chain.

Moreover, there is a growing emphasis on supply chain resilience and agility, with companies diversifying suppliers and implementing "near-shoring" or "re-shoring" strategies to mitigate risks. Sustainability will continue to be a dominant trend, pushing manufacturers to adopt circular economy principles and incorporate comprehensive Environmental, Social, and Governance (ESG) strategies. Finally, enhanced collaboration among all supply chain partners, facilitated by integrated platforms and data sharing, will be crucial for navigating future complexities. (Parthasarathy, 2022)

The supply chain system in the manufacturing industry is a vital and evolving entity. Its efficient management is not just about moving goods; it's about strategic planning, risk mitigation, fostering strong relationships, and embracing technological innovation. As the world becomes increasingly interconnected and unpredictable, the ability of manufacturing companies to build robust, agile, and sustainable supply chains will be the ultimate determinant of their long-term success and their contribution to a thriving global economy.

The demand for warehousing and logistics facilities is rapidly growing, with new developments in industrial cities to support the burgeoning industrial output and e- commerce growth. The Saudi logistics sector is increasingly adopting advanced technologies such as AI-driven route optimization, IoT-based tracking, and blockchain to enhance supply chain visibility, efficiency, and real-time monitoring.

Special Integrated Logistics Zones (SILZs) and Free Trade Zones (FTZs) are being established near key ports and airports, offering tax exemptions, simplified regulations, and cost-effective logistics solutions to attract foreign investment and optimize connectivity.

The primary demand for steel products in Saudi Arabia comes from its booming construction sector. Mega-projects like NEOM, The Line, and the expansion of urban centers drive a sustained need for various steel products, particularly rebar, hot-rolled steel plates, and structural steel. The petrochemical industry also requires specialized steel, such as stainless steel and pipeline steel, for its demanding applications. Steel manufacturers are focused on producing high-value steel products that meet international standards (e.g., ASTM, ISO) to reduce import dependence and unlock export opportunities.

Global and local market dynamics can lead to significant price fluctuations, impacting profitability, especially for newer mills. The steel and metal fabrication industries require a skilled workforce, and a shortage can lead to project delays. While there's a push for advanced technologies, initial investment costs and the need for skilled personnel can hinder adoption, particularly for smaller firms.

While the EAF model offers advantages, the industry is still working towards ambitious decarbonization goals, requiring significant investment in carbon capture, utilization, and storage (CCUS), electrification, and energy efficiency. The growing number of players in the

domestic market intensifies competition.(Siddiah, 2022)

II. LITERATURE REVIEW

Tariq et al. (2021): Returning (Reverse Logistics) often-overlooked aspect manages the return of products, whether due to defects, end-of-life, or recycling. An efficient returns process can enhance customer satisfaction and recover value.

Vethirajan et al. (2021): Customer service is to provide timely support, managing inquiries, resolving grievances, and gathering feedback are essential for maintaining customer loyalty and driving continuous improvement.

Sheriff et al. (2021): Managing SCM is not without its challenges. The manufacturing supply chain is constantly exposed to various risks and complexities. Geopolitical instability, natural disasters, pandemics, and unforeseen events can cause significant disruptions, leading to material shortages, production delays, and increased costs.

Bhoyar et al. (2020): Accurately predicting consumer demand in rapidly changing markets is a constant struggle, leading to either overstocking or stock outs. Fluctuations in raw material prices, labor costs, and transportation expenses can erode profit margins and necessitate constant cost control measures.

Siddiah et al. (2022): Fragmented supply chains with multiple stakeholders often suffer from a lack of real-time visibility into operations and insufficient collaboration, hindering efficient decision-making. Meeting increasing demands for ethical sourcing, reduced environmental impact, and adherence to evolving regulations adds layers of complexity.

As supply chains become more digitized, they become more vulnerable to cyberattacks, data breaches, and ransomware.

Supply chain system of manufacturing steel industry in Saudi Arabia

The steel industry in Saudi Arabia is a crucial component of the Kingdom's ambitious Vision 2030, aiming for economic diversification and reduced reliance on oil. Its supply chain system, while robust and undergoing significant modernization, presents a complex interplay of domestic capabilities and international dependencies.

Unlike some major steel-producing nations, Saudi Arabia has limited indigenous iron ore deposits. Consequently, the industry relies heavily on imported iron ore. This necessitates a strong global procurement strategy and exposes the supply chain to fluctuations in international commodity prices and geopolitical factors. To mitigate this, there's a growing emphasis on recycled scrap metal. Companies like Al Tuwairqi Holding and Rajhi Steel have invested in advanced scrap processing facilities, facilitating the efficient use of both local and imported scrap. The prevalence of Electric Arc Furnace (EAF) technology in Saudi Arabia's steel plants further supports this scrap-based production model, which is also more environmentally friendly than traditional blast furnaces due to its natural gas reliance.

Saudi Arabia's main steel production sites are concentrated in industrial cities like Jubail and Yanbu, as well as economic hubs such as Dammam, Jeddah and Riyadh. These locations offer strategic access to ports for imports and facilitate distribution to major construction projects. The manufacturing process largely utilizes modern electric arc furnaces (EAFs) and direct reduction iron (DRI) plants. A key competitive advantage for Saudi Arabia is its abundant natural gas reserves, which are used as a reducing agent in DRI plants instead of coking coal. This not only provides an economic benefit but also results in significantly lower CO2 emissions compared to traditional blast furnace methods, aligning with global sustainability goals. Major players in the Saudi steel industry include Saudi Iron & Steel Company (HADEED), Al Ittefaq Steel Products Co., and Rajhi Steel Industries Company Ltd.

The logistics and distribution network for steel in Saudi Arabia is undergoing significant transformation, driven by the National Industrial Development and Logistics Program (NIDLP) and Vision 2030. The Kingdom's strategic geographic location, with roughly 20% of global container trade passing through the Suez Canal, positions it as a potential global logistics hub.

Major ports like King Abdullah Port and Jeddah Islamic Port are undergoing continuous expansion to increase container capacity, facilitating smoother import of raw materials and export of finished products. A robust network of roads is essential for distributing steel products across the vast country, especially to major construction sites like NEOM, The Line, and other mega-projects. Rail infrastructure is also being developed to support bulk transport.

The steel industry in Saudi Arabia is a dynamic and strategically vital sector, undergoing significant transformation as the Kingdom pushes forward with its ambitious Vision 2030. Once heavily reliant on oil, Saudi Arabia is diversifying its economy, with the steel industry playing a crucial role in this shift by providing essential materials for a rapidly expanding infrastructure and industrial base.

Saudi Arabia has an annual crude steel production capacity of approximately 12 million tons (as of 2023), positioning itself as a significant regional player. The dominant entity in the Saudi steel industry is the Saudi Basic Industries Corporation (SABIC), through its subsidiary Saudi Iron and Steel Company (Hadeed), which is the largest steel producer in the Kingdom. Other major players include Al-Ittefaq Steel Products Company (ISPC) (the largest private steel producer), Rajhi Steel, Zamil Steel Holding Company, and Al Yamamah Steel Industries Co. These companies are actively involved in producing a range of steel products, including rebars, wire rods, structural steel, and various specialized steel items.

The Industry benefits from several structural advantages, most notably low energy costs due to the Kingdom's vast natural gas reserves, which significantly reduce production expenses. Additionally, there's a growing domestic market fueled by the immense construction and infrastructure projects under Vision 2030.

Saudi Vision 2030 is the primary catalyst for the growth and evolution of the steel industry. The ambitious national strategy aims to diversify the economy, reduce reliance on oil, and promote sustainable development across various sectors. The steel sector is central to this vision, driven by an unprecedented demand generated by mega-projects such as:

- **NEOM:** The futuristic $500 billion city, including "The Line" (a 170 km long linear city), a floating industrial complex, and a global trading hub.
- **Red Sea Project and Qiddiya City:** Large-scale tourism and entertainment destinations.
- **Expansion of holy sites and other urban developments:** Across cities like Riyadh, Jeddah, and Dammam.

These projects demand vast quantities of high-quality steel for construction, infrastructure, and the development of new industrial zones.

The government is also encouraging local manufacturing and reducing imports by investing in new steel plants, such as the integrated steel plate manufacturing complex in Ras al-Khair Industrial City, a joint venture between Saudi Aramco, China's Baoshan Iron & Steel Co. (Baosteel), and the Public Investment Fund (PIF). This facility, expected to be operational by 2026, aims to produce up to 1.5 million tons of steel plates annually and reduce CO2 emissions significantly.

Vision 2030 also emphasizes the adoption of advanced manufacturing technologies and the development of a skilled local workforce, further strengthening the industry's long- term prospects.

The future of the Saudi steel industry appears very promising. Steel demand is anticipated to grow at an average annual rate of 5-7% between 2024 and 2027, with exports also projected to increase. The ongoing mega-projects will continue to be the primary demand drivers, and the emphasis on local content and industrial diversification will ensure

continued investment in expanding production capacities and capabilities. The Kingdom's commitment to decarbonization will also lead to significant investments in cleaner technologies, positioning Saudi Arabia as a leader in sustainable steel production in the region.

The steel industry in Saudi Arabia is at the heart of the Kingdom's economic transformation. Driven by the ambitious goals of Vision 2030, it is set to witness sustained growth, increased domestic capacity, and a significant shift towards more sustainable and technologically advanced production methods, solidifying its role as a cornerstone of the Kingdom's industrial future.

III. CONCLUSION

The supply chain system of Saudi Arabia's steel manufacturing industry is dynamic and strategically aligned with the Kingdom's Vision 2030. It leverages modern production technologies, particularly the natural gas-based EAF model, and benefits from ongoing massive investments in logistics infrastructure. While challenges related to raw material dependency, market volatility, and talent acquisition persist, the strong domestic demand driven by mega-projects and the strategic push towards becoming a global logistics hub position the Saudi steel industry for continued growth and increased resilience in its supply chain. The focus on sustainability and technological innovation will be critical for its long-term success and competitiveness on the global stage.

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