

Challenges and Innovations in Implementing Sustainable Supply Chain Smart Manufacturing in the Metal Recycling Industry

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Abstract: Recently, the State-owned Assets Supervision and Administration Commission of the State Council and the Ministry of Industry and Information Technology jointly launched the common chain action for integrating and developing the industrial chain of central enterprises (referred to as the common chain action). The government has actively taken measures to promote the modernization of industrial and supply chains, with digital intelligence empowerment becoming a key driving force. In this context, metal recycling companies face new challenges and opportunities in supply chain construction. This paper aims to deeply explore how digital intelligence empowerment affects the supply chain of recycled metal companies, as well as the difficulties faced and innovative solutions.

Keywords: Metal recycling companies; Supply chain smart manufacturing; Difficulties; Innovation

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1. Introduction

The advent of the digital age has completely changed how metal recycling companies manage their supply chains. Digital intelligence empowerment, as a key component of digital technology, plays a vital role in this transformation. This article will delve into the strategic importance of digital intelligence empowerment and supply chain construction for recycled metal companies, focusing on the advantages and specific application areas of digital intelligence empowerment in supply chain management.

2. Advantages of supply chain management empowered by digital intelligence

Supply chain management has undergone fundamental changes in the digital era, and digital intelligence has become the key to improving the competitiveness of metal recycling companies. Digital intelligence integrates modern technologies such as data analysis, artificial intelligence, and the Internet of Things (IoT), providing enterprises with new tools and perspectives. For metal recycling companies, this means real-time monitoring

and optimization of the supply chain, thereby improving production efficiency, reducing costs, and better meeting environmental protection and sustainability requirements. The advantage of digital intelligence lies in the visualization and real-time supply chain monitoring. Companies can use data analysis tools to present all aspects of the supply chain to managers, including raw material procurement, production processes, inventory management, and transportation ^[1]. This visualization not only helps to quickly identify problems and bottlenecks but also helps in making timely decisions to reduce potential risks.

Digital intelligence empowerment also provides companies with more accurate demand forecasts through data analysis, which is crucial to the supply chain planning of recycled metal companies. Enterprises can better understand market demand, optimize production and inventory levels, and avoid resource waste and backlogs, reducing costs, improving the company's production efficiency, and helping it better respond to market fluctuations. In addition, digital intelligence-enabled technology also allows the monitoring of equipment and production processes in real-time ^[2]. Through IoT, companies can connect sensors and devices to the Internet to achieve real-time data collection and sharing, which enables companies to understand the equipment status at any time, monitor production processes, detect potential problems promptly, and take measures to solve them.

3. The importance of intelligent manufacturing and supply chain construction

In this digital age, digital intelligence empowerment has become a strategic focus of the supply chain construction of metal recycling companies. Digital intelligence integrates advanced technologies such as data analysis, artificial intelligence, and the IoT, providing enterprises with opportunities to improve supply chain management. For metal recycling companies, the application of digital intelligence not only improves production efficiency but also helps control costs, improve sustainability, and gain competitive advantages in the market ^[3].

Improving sustainability is an important goal for metal recycling companies. Digital intelligence can help companies better manage the utilization of resources and energy, reduce waste, and reduce dependence on natural resources ^[4]. Through real-time monitoring and data analysis, companies can identify waste of energy and resources and take steps to reduce environmental impact ^[5], which helps improve corporate sustainability and comply with environmental regulations and social responsibility.

4. Applications of digital intelligence

Digital intelligence is widely used in the supply chain management of recycled metal companies. First, data analysis technology can monitor supply chains and forecast demand, helping companies adjust production and inventory levels to reduce resource waste. Businesses can analyze historical data and market trends to better predict demand and ensure production can meet market demand, helping avoid overproduction and inventory build-up, thereby reducing the wastage of resources and money.

IoT plays a key role in equipment monitoring and production processes. By connecting equipment and sensors to the Internet, companies can monitor equipment status and production progress in real time, thereby increasing equipment utilization, reducing the need for maintenance, and ensuring the smoothness of the production process. In addition, the IoT also enables remote monitoring, allowing enterprises to manage equipment remotely reducing labor and maintenance costs. Artificial intelligence technology is the core component of digital intelligence empowerment, which can automate decision-making and intelligent prediction ^[6]. In supply chain management, artificial intelligence can help companies optimize route planning, inventory management, and order processing. For example, intelligent forecasting can help companies better predict

demand, reduce inventory levels, and reduce operating costs ^[7]. Digital intelligence allows automated decision-making for certain procedures, such as selecting logistics routes, so as to improve efficiency.

5. Difficulties in supply chain construction and integrated development

There are several challenges in supply chain construction that need to be adequately addressed to ensure the efficiency and sustainability of the supply chain. The following is a more substantial breakdown of the difficulties in supply chain construction.

5.1. Data security and privacy protection

Data security and privacy issues in digital supply chains are particularly critical. Collecting and processing large-scale data requires enterprises to take strict measures to protect data while ensuring data compliance. Strict data security and privacy protection policies should be developed to ensure that the employees comply with relevant laws and regulations. These policies should clearly define data access rights and data usage rules to minimize the risk of data breaches. Advanced encryption technology should be utilized to protect sensitive data and ensure that data is not easily stolen during transmission and storage. Encryption technology can help ensure the confidentiality of data, making it difficult to decrypt even if the data is leaked. Data security training should be carried out regularly to improve employees' awareness of data security and reduce internal threats. Employee education is key because insiders can be potential data security risks. A monitoring and response mechanism should be established to promptly detect and respond to data leakage. This mechanism should include including monitoring data access logs, implementing intrusion detection systems, and establishing emergency response plans.

5.2. Technology integration and interoperability

A supply chain involves multiple links, including procurement, production, logistics, and warehousing, and it requires the integration of different systems. Technology integration and interoperability are a challenge, and companies need to ensure that systems can effectively connect and share data to enable collaborative decision-making. Solutions to this problem include selecting software and hardware supporting open standards to ensure system interoperability. Open standards help interconnect different systems and avoid the problems of closed systems. Middleware and Application Programming Interfaces (APIs) should be employed to help data transfer and interaction between different systems. Middleware and APIs are key connectivity tools that ensure seamless data transfer and interaction. A cross-departmental collaboration team should be established for the planning and implementation of technology integration projects. Cross-departmental collaboration is key to solving technology integration issues to ensure that the interests of all parties are balanced. System integration testing should be conducted to ensure that various systems can work together smoothly. System integration testing helps identify and resolve technology integration issues to ensure the smooth operation of the supply chain.

5.3. Talent training

A digital supply chain requires talents that are familiar with different technologies. Metal recycling companies should recruit and train employees to enhance their professional capabilities in data analysis, artificial intelligence, and the IoT. It takes time and resources to achieve this and companies will have to ensure that their staff are adaptable and willing to change. The solution to this problem includes recruiting professionals with digital intelligence skills, including data analysts, and artificial intelligence engineers. Recruitment can help businesses acquire the necessary skills immediately. Internal training programs should be provided to enhance

the employees' technical and digital skills. Internship projects and research can be initiated in collaboration with universities and research institutions to acquire the latest technical knowledge. Partnering with universities can help businesses stay abreast of the latest technologies and trends. An employee development plan should be established to encourage employees to improve their capabilities. Employee development programs can encourage employees to actively participate in training and self-improvement.

5.4. Investment and costs

Digital transformation requires a large amount of capital investment, including hardware, software, and talent training. Metal recycling companies need to strike a careful balance between investment and returns in order to make informed decisions on when and how to implement digital intelligence. Addressing this includes developing a clear digital transformation strategy, including a budget and investment plan. A clear strategy helps ensure that investments are used effectively. Companies should also look out for potential investment sources such as government subsidies, venture capital, and loans. Diversifying investment sources helps reduce financial risk. A cost-benefit analysis should be conducted to determine which digital technologies are most profitable for the business ^[8]. The investment strategies employed should be consistent with the company's long-term development goals to ensure the sustainability of the investment, and over-investment should be avoided ^[9].

6. Innovative measures to build an industrial system

Overcoming difficulties in supply chain construction requires innovative solutions and specific measures. These innovative solutions can help metal recycling companies better cope with challenges, achieve digital transformation, and improve the supply chain's competitiveness. Below is a more substantial breakdown of the innovative solution.

6.1. Specific applications of blockchain technology

Blockchain technology can be used to ensure transparency and traceability in supply chains. Metal recycling companies can use blockchain to record the origin, production process, and transportation of raw materials, thereby increasing the credibility and sustainability of the supply chain. Specific applications include establishing a distributed ledger system to ensure that data in the supply chain is not tampered with. The distributed ledger system records every step of transactions and activities to ensure the authenticity of the data. Smart contracts should be used to enforce contract terms and reduce human error automatically. Smart contracts can automatically execute contracts and eliminate uncertainty in contract performance. The blockchain data should be shared with supply chain partners for collaborative decision-making and problem-solving. The sharing of blockchain data can promote cooperation and collaborative work.

6.2. Applications of cloud computing and edge computing

Cloud and edge computing can process large-scale data and enable real-time analysis. Metal recycling companies can use cloud computing to store and process data while leveraging edge computing for real-time monitoring and decision-making. Practical applications include establishing a cloud computing platform for storing and analyzing supply chain data. Cloud computing platforms can expand an enterprise's computing and storage capabilities to meet growing data demands. Edge devices should be utilized to monitor production processes and sensor data. Edge devices can collect and process real-time data, reduce transmission delays, and enable real-time data analysis as well as automated alarms and responses. Real-time data analysis helps identify

problems and opportunities on time, and automated alerts and responses improve the flexibility of the supply.

6.3. Specific implementation of cooperation and alliance

Collaborations and alliances can facilitate collaboration and knowledge sharing in the supply chain. Recycled metals companies can collaborate with supply chain partners to solve problems and drive innovation jointly. Including launching joint research and development projects to solve common problems in the supply chain. Joint R&D projects can focus on solving common supply chain challenges and improving efficiency. Establish a knowledge-sharing platform for sharing best practices and domain knowledge. Knowledge-sharing platforms can facilitate information transfer and learning. Ensure the sustainability and success of collaborative work through clear contracts and goals. Clarity in contracts and goals can help maintain alliances and achieve shared goals.

6.4. Employee education and training programs

Education and training programs can improve employees' digital skills. Metal recycling companies can provide training courses and educational partnerships to ensure employees have the necessary knowledge and skills.

- (1) Designing training programs covering data analysis, artificial intelligence, and the IoT
Training programs should cover the various skills required for digital supply chains, including data analytics, artificial intelligence, and the IoT.
- (2) Collaborating with universities and research institutions to provide internship projects and practical cases
Cooperation with universities and research institutions helps employees gain practical experience and the latest technical knowledge. The effectiveness of the training program should be evaluated regularly so that improvement measures can be taken.

6.5. Close collaboration with government and research institutions

Partnerships are crucial for metal recycling companies to establish a sustainable smart supply chain. Partnerships provide valuable guidance for companies to formulate future development strategies and enable companies to participate in important technological research to ensure that the industry's competitiveness continues to improve. Working with the government means companies can better understand and comply with regulations, and the government can also provide support, such as financial incentives and policy guidance, to encourage companies to adopt sustainable smart manufacturing practices. Collaboration with research institutes allows companies to participate in important technological research and innovation. Through cooperation with universities, scientific research institutes, and technological innovation enterprises, enterprises can obtain the latest industry trends and technical knowledge to better respond to changes and take advantage of new opportunities. This kind of collaboration also allows companies to actively participate in R&D projects, explore new technologies, improve production efficiency, and promote innovation in smart manufacturing in the supply chain. In summary, close collaboration with governments and research institutions provides broad opportunities and support for metal recycling companies, helping to ensure that supply chains can achieve high efficiency, low cost, environmental protection, and sustainability requirements, ultimately promoting industrial modernization and laying a solid foundation for the future development of enterprises, enabling them to gain competitive advantages in the digital age.

The metal recycling industry faces challenges and innovation opportunities in implementing smart manufacturing for supply chains. Challenges include data security and privacy protection, technology integration and interoperability, talent development, and investment and cost. By applying blockchain

technology, cloud, and edge computing, establishing collaborations and alliances, and developing effective education and training programs, metal recycling companies can innovatively solve these challenges and achieve the goal of smart manufacturing for sustainable supply chains.

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Shen Q, Wang J, Dong W, 2018, Key Technologies and Development Trends of Intelligent Manufacturing. *Chinese Engineering Science*, 20(7): 8–16.
- [2] Ma C, Zhang X, 2018, Intelligent Manufacturing Technology and its Application in Manufacturing. *Mechanical Design and Manufacturing*, 11: 160–162.
- [3] Wang G, Wang W, 2019, Application and Development Trends of Industrial Internet of Things in Intelligent Manufacturing. *Journal of Instrumentation*, 40(6): 24–33.
- [4] Wang Y, Guo X, Wu Q, 2018, Research and Application of Cloud Manufacturing Technology. *Mechanical Design and Manufacturing*, 7: 184–186.
- [5] Ma K, Zhang Y, Wang X, 2017, A Review of Intelligent Manufacturing Research Based on Big Data. *Computer Integrated Manufacturing Systems*, 23(6): 1291–1301.
- [6] Tian H, Chen Z, Li D, 2018, Key Technologies of Intelligent Manufacturing from the Perspective of Internet + Intelligent Manufacturing. *Computer Application Research*, 35(12): 3321–3326.
- [7] Wang D, Chen T, 2017, Development and Application of Intelligent Manufacturing Technology in the Context of Industry 4.0. *Modern Manufacturing Engineering*, 11: 13–15.
- [8] Glaum M, Orlikowski WJ, De Vaujany FX, 2019, Blockchain and the Reimagining of Management. *Journal of Management Studies*, 56(5): 911–914.
- [9] Wan J, Tang S, Shu Z, et al., 2016, Smart City: An Event-Driven Architecture. *IEEE Communications Magazine*, 54(9): 44–49.

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