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Smart Factory Promotion and Operation Analysis in the 4th Industrial Revolution Environment

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Abstract

Currently, the world is facing severe inflation due to Corona and the war in Ukraine, and it is causing a lot of difficulties for us. Companies are facing a lot of restrictions on their economic activities compared to the past due to supply chain problems and foreign exchange rates. In this situation, many countries have been implementing various smart factory promotion projects to secure competitiveness through productivity improvement in the manufacturing industry. In this study, the contents of smart factory promotion in major countries were reviewed, and problems raised about the implementation of smart factory in Korea, which are being implemented based on this, were described. It is most reasonable to judge the success of a smart factory by the achievement of the performance indicators presented at the time of the project. Therefore, based on the performance index of the business, which is a key factor in determining the success or failure of a smart factory, we investigated whether the company's smart factory promotion can be carried out successfully through examples

Keywords: *Smart factory, 4th industrial revolution, IoT, Information and communication technology.*

1. Introduction

In order to change the industrial environment and increase productivity around the world, companies are making their production processes smart. These factories are what we call smart factories. There are many reasons why the word smart factory appears rapidly in the manufacturing industry, but it can be mainly described in two ways. First, there is uncertainty about the business environment. The current corporate environment is shrinking at home and abroad. Due to the trade war between the US and China and the war between Russia and Ukraine, the global trade environment is in a very uncertain situation. Second, the background of the introduction of the smart factory is to expand or improve productivity in response to such uncertainty about the economy.

In a smart factory, all facilities and devices are connected through a network, so the entire process can be monitored and analyzed in real time. In a smart factory, Internet of Things (IoT) sensors and cameras are attached to various parts of the factory to collect data, store it on a platform, and analyze it. Based on the data

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analyzed in this way, it is described as controlling the overall process by understanding where the defective product occurred and which equipment shows abnormal signs. In summary, it can be said that it is a factory where the entire process of product production is automatically connected through wireless communication.

The meaning of the smart factory is very diverse, and the scope thereof is also very different. According to Maeil Economic Daily, a smart factory refers to an intelligent production factory that improves productivity, quality, and customer satisfaction by applying information and communication technology (ICT) combined with digital automation solutions to production processes such as design, development, manufacturing, distribution, and logistics [1]. The IT glossary describes an intelligent factory that can improve productivity, quality, and customer satisfaction by applying information and communication technology (ICT) to the entire production process, including design, development, manufacturing, distribution, and logistics [2].

Lastly, in the Smart Factory Promotion Team, which is supporting the smart factory business nationally, the smart factory integrates all production processes from product planning to sales with ICT (information and communication) technology, focusing on people who produce customized products with minimal cost and time. It is described as a state-of-the-art intelligent factory of [3].

2. Smart Factory

2.1 Smart Factory Overview

Smart factory includes all manufacturing-related processes from product development to mass production, market demand forecasting, parent company orders to finished product shipment, and vertically includes all areas such as field automation, control automation, and application systems. A smart factory can be divided into manufacturing stages. First, in the planning and design stage, by simulating the performance of a product before production in a virtual space, it has the meaning of shortening the production period and developing a customized product for consumer needs. Second, in the production stage, real-time information exchange between facilities, materials, and management systems has the meaning of producing a variety of products and improving energy and facility efficiency. Lastly, in the distribution and sales stages, real-time automatic order/ordering tailored to the production site dramatically reduces inventory costs and enables cooperation in all areas such as quality and logistics.

Various implementation methods are possible depending on the company that wants to introduce the smart factory, and it is classified into levels 1 to 5 according to the degree of use and capability of information and communication technology (ICT) [5]. Level 1 is a case in which the system is not applied, and is a level in which work is managed by using Excel or by hand. Level 2 is the basic level, where partial management systems (sales/materials/accounting, etc.) are being operated, and production performance information is automatically aggregated. Level 3 is the middle level 1, and there is a partial connection between management systems by field, and it means the level at which ICT-based automation is made. Level 4 is the middle level 2, meaning real-time interworking between management systems by field is possible, and automatic facility control through the management system is performed. Level 5 is an advanced level and refers to the level at which facilities, materials, and systems are connected through wired and wireless networks as an IoT and CPS-based intelligent factory operation system.

2.2 Smart Factory in Major Two Countries

Section 2.2 describes the direction and characteristics of smart factories in the Germany and United States, which are representative examples of smart factories. The smart factory is a representative example of Germany's Industry 4.0 and has the meaning of using an intelligent system to produce customized products and secure manufacturing competitiveness. It is a global success story that is first reviewed by the world, including Korea, to enhance productivity and competitiveness of the manufacturing industry [4]. As a representative manufacturing powerhouse, Germany is building a 21st century-style production system based on its excellent competitiveness in the automobile, machinery, and parts industries, which are its representative manufacturing industries. A typical example is the realization of a new multi-variety, small-volume production method to secure a production system that meets the needs of customers. Table 1 below shows the direction of the recent smart factory promotion in Germany.

Table 1. Main Characteristics of German Smart Factory Promotion

Propulsion entity	Government-led
Propulsion direction	• Diffusion to Continuous Process • Strengthening International Technical Cooperation • Smart Service Enforcement

Continuous process companies such as BASF in Germany and ThyssenKrupp in steel are also starting to introduce smart factories. The continuous process is not easy to convert because the entire plant is a huge system. Nevertheless, the reason German companies introduce smart factory technology is to increase productivity beyond the existing manufacturing innovation [9-12]. Another trend is to strengthen international technical cooperation. The government and private companies are promoting the two-way system, and at the government level, Industry 4.0 partners have been expanded to France, Italy, and Australia. In the industry, the Platform Industry 4.0 Association is strengthening cooperation with the American Industrial Internet Consortium. In addition, interest in smart services is increasing. Siemens, for example, is using remote maintenance services to enhance customer care for existing customers across all business areas.

In promoting smart factories, the U.S. is leading the private sector rather than the government. While the role of the government is weak in the United States, large corporations such as General Electric (GE) and Rockwell are leading the way. They formed the Industrial Internet Consortium (IIC) open to all industries around the world and are aiming for market-based standardization. Table 2 below summarizes and summarizes the major characteristics of the US smart factory promotion process.

Table 2. US smart factory promotion key characteristics

Propulsion entity	Privately led
Propulsion direction	• Market-based standardization based on IIC • Market expansion through platform and strengthen related technology capacity • Expansion of use cases through cooperation among companies • Combination of AI and AR/MR

American smart factory companies are building and strengthening platforms like ICT companies. The reason why we are focusing on strengthening the platform is that we can easily expand our power and strengthen our technological capabilities. GE's Predix has already become the most popular industrial platform. Rockwell is similarly creating related applications and platforms under the brand name of Factory Talk. In addition, US companies are expanding and accumulating use cases by collaborating with companies around the world through industry and Internet consortiums. The use case is a real use case, and it is a good benchmarking guide for general companies on how to introduce a smart factory. In addition, they are making use cases not only in manufacturing, but also in various industries such as agriculture, telecommunications, energy, healthcare, logistics, and railway. Eventually, American companies are focusing on pursuing business benefits that can be obtained immediately and creating new business models based on them. In addition, it is seeking to strengthen its capabilities and expand its power through platform preemption and active external links. Therefore, it is important to accumulate application results through external linkage. The use case can be said to be the result of the connection with the outside.

U.S. companies are also active in integrating the latest ICTs such as AI and augmented reality (AR) into smart factories. In particular, ICT companies such as IBM and Microsoft are leading this trend. IBM is using AI Watson for on-site big data analysis and improving machine vision capabilities. Microsoft has also developed a smart factory solution using Azure, an AI platform, and HoloLens, an AR technology.

3. Smart Factory Promotion Project Analysis

3.1 Smart Factory Operation Analysis

The smart factory promotion project in Korea has been promoted by the government under the name of ‘Manufacturing Industry Innovation 3.0’ or ‘Innovative Growth Leading Project’ since 2014. From 2014 to 2017, it was found that the companies that benefited from the government and large corporations' smart factory construction are seeing a fairly good effect. According to the data analyzed by the 4th Industrial Revolution Committee, these companies showed effects such as a 30% increase in productivity, a 45% decrease in the defect rate, and a 15% reduction in cost. Sales and operating profit also increased by 20% and 53%, respectively. The increase in production volume and the addition of new jobs such as smart factory control increased employment by 2.2 per company.

In the same analysis data, the 4th committee suggested that upgrading is necessary, saying that most of the companies' smart factory construction was at the basic stage. The basic stage is ‘a level at which digitalization of production information and management of product production history are possible’. The 4th committee analyzed that 76.4% of the companies that received support for building a smart factory for three years fell at this level, and the basic stage companies lack many aspects to be called a smart factory, and it can be seen that the level of computerization and automation corresponding to the previous period. The computerization and automation are not advanced at a high level, but at a basic level.

Based on the data of the 4th committee, it can be said that the project was overall successful in terms of performance. On the other hand, what is recognized as a problem at the business site is the operational aspect of the smart factory system. The main problems that appear in operating the smart factory system are as follows.

Table 3. Major Problems in Smart Factory Operation

Problem	Contents
Difficulty of operation	• Difficult to use 100% due to lack of skilled experts on smart factory system
Smart Factory Supplier Level	• System quality problems arising from differences in the level of smart factory suppliers (large companies, small and medium-sized enterprises)
Job anxiety	• Occurrence of job anxiety that may arise from system operation

The difficulties in operation and misunderstandings related to jobs mentioned above require various public relations efforts such as education for a correct understanding of smart factories. On the other hand, the level problem of smart factory suppliers is not something that can be solved with short-term efforts, and it seems that self-efforts to develop relevant capabilities within suppliers should be preceded.

Meanwhile, the results of the difficulties in using the smart factory system in 2017 surveyed by the National Statistical Office are shown in Table 4 below[13]. The main contents of the survey focusing on 88 manufacturing companies were the lack of expected business improvement effect, defects or instability of the built system, difficulty in improvement and maintenance required during the application process, difficulty in application because it did not fit well with the existing business system, and necessary. There were many and complicated tasks related to education and business improvement, lack of operation and management manpower, and passive participation due to lack of awareness of employees.

Table 4. Difficulties in operating the construction system (multiple responses)

Main Content	Ratio (%)
• Difficulty in improvement and maintenance required during the application process	45.4
• Many and complex related tasks	39.7
• Lack of expected work improvement effect	35.2
• Lack of operational and management personnel	31.8
• Defects and instability of the building system	28.4
• Difficult to apply because it does not fit well with the existing work system	21.6
• Passive participation due to lack of awareness of members	13.6

3.2 Business feasibility analysis based on performance indicators

The successful implementation of the smart factory project depends on whether the objectives of the evaluation index items described in the company's performance plan related to this project are achieved. The quantitative performance indicators presented in the business plan are very important because they are important factors that can determine the success or failure of a business. The performance indicators presented in the smart factory promotion project are largely composed of four areas: P(production), Q(quality), C(cost), and D(delivery), and each area consists of 4-6 detailed items. Therefore, each company can select and present the most appropriate one among these indicators. In this section, the success potential of this project is analyzed based on the performance index items of companies. First, Company A (pseudonym) introduced and operated a real-time information sharing (SCM) system, including the MES system, as a smart factory support project in 2015. Later, in 2018, through the production digitization project, the material warehousing system using QR codes was introduced. Table 5 below shows the quantitative goals suggested for the promotion of the MES system advancement project established in 2020. The ultimate goal of the upgrade project was to improve inventory management and quality defect management, which are the results of ‘Smart Factory Pre-Diagnosis Analysis Consulting’.

Table 5. Quantitative Goal of Company A

performance indicator	Now	Goal	Remarks
Production per hour (ea)	48.4	85.2	Recommend modification to be feasible
Reduction of defect rate (PPM)	20,128	11,756	Recommend modification to be feasible
Number of days in stock (day)	4.3	3.7	Goal is likely to be achieved
Delivery standard yield (%)	38	50	Recommend modification to be feasible

When the target values presented in the table above are compared with the current level, two performance indicators (production per hour, reduction of defect rate) appear to have low probability of achieving the target compared to the present, so it is necessary to recommend reasonable targets that are feasible seems to be. In addition, the content of the delivery date compliance rate indicator appears to be less likely to be realized. What should be improved in this area is that it is not desirable to present excessive target values to win a project, and efforts are needed to induce an achievable target to be set. Comparing with the current level, it seems necessary to implement a penalty (point reduction, etc.) for the presentation of a target level that is not feasible. If such companies carry out the business, it is highly likely that the expected business improvement effect among the contents shown in Table 4 will be insufficient. Another problem is that, although the goal of the upgrade project was to improve inventory management and poor quality management, it is rather an indicator that focuses on hourly output. Therefore, it seems that efforts such as efforts to reflect the goals of the project in the performance indicators are necessary.

On the other hand, Company B intends to introduce the MES system through this project, and set the target level to level 1. The current smart factory level is not applied to ICT. When comparing the contents of the current and target levels for the four performance indicators of Company B presented in Table 6, the target level can be said to be achievable at the current company level.

Table 6. Quantitative Goal of Company B

performance indicator	Now	Goal	Remarks
Production per hour (ea)	300	310	Goal is likely to be achieved
Finished product defect rate (%)	3	2	Goal is likely to be achieved
Inventory cost	200	180	Goal is likely to be achieved
Shorter delivery time	48	46	Goal is likely to be achieved

As a result, company A was selected for the smart factory promotion project because of the feasibility of the indicator, whereas company B was not selected because it was found that the feasibility of the indicator was not feasible.

Table 7. Comparison of Companies

	Company A	Company B
Indicator feasibility	Three indicators are not feasible.	All detailed indicators are feasible
Business Selection	No selection	Selection

4. Conclusion

Our society has passed the 3rd industrial revolution and is entering the age of the 4th industrial revolution. The 4th industrial revolution is basically being accomplished through convergence with ICT technology, which includes essential intelligence information, and requires new environmental changes in various manufacturing industries. In the meantime, beyond the meaning of factory automation, the manufacturing environment is facing a change to a smart factory. In the sense of the existing factory automation, the factory will gradually pursue smartization by applying intelligent information including artificial intelligence and Internet of Things technology.

In this study, based on the need for a smart factory, the change process of the smart factory was analyzed for various contents that occur in the smart factory operation process targeting domestic and foreign related companies. Focusing on Germany and the United States, which are playing a leading role in smart factory operation. In addition, the achievement of performance indicators in the process of smart factory promotion depends on whether the project is successful or not. As it is a key factor in determining whether the smart factory can be successfully promoted through some examples of companies, we examined whether the smart factory can be successfully promoted.

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