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HACCP-based Cooperative Model for Smart Factory in South Korea

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Abstract

Smart Factory has already become an irresistible entity in manufacturing, which has led to a much wider scope of existing manufacturing innovations and the achievement of qualitative improvements. Unsurpassed progress has been made in the manufacturing sector through the combination of professional know-how and advanced IT, and HACCP has already thoroughly managed all steps from raw materials for agricultural and livestock products to processing, packaging and distribution before digitalization. Sanitary issues in each country have now been raised to the level of national security under the influence of COVID-19. Although HACCP is already well-managed by country, we have looked at this discussion and detailed technological transformation from a digital data perspective, as it is now possible to collect, store, record and report data to government offices more smartly in line with technological advances in smart factories. The intersection of smart factories and HACCPs is consistent in terms of data collection, storage and utilization. Furthermore, the addition of Blockchain technology to strictly prevent data forgery is more interesting. Although the use of Blockchain in general factories has been relatively insignificant, it is expected that the use of Blockchain technology will be expanded through smart HACCP, which forms the interface between smart factory technology and HACCP, and that agricultural, livestock and household factories will introduce more smart factories.

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1. Introduction

Here introduces the Structure The HACCP [1] consists of Hazard Analysis and Critical Control Points to identify and analyze potential factors for food, and the central management department is managed to ensure the prevention, elimination and safety of such hazards. Hazard Analysis refers to "predicting a hazard in advance and identifying the risk factors in advance." Critical Control Points imply "it is an essential item to manage." In other words, HACCP refers to a preventive food safety management system to prevent harm. The HACCP system refers to the systematic regulation for supplying safe and clean products to consumers by scientifically analyzing the situations in which biological, chemical and physical hazards may occur in the process of making food and blocking the conditions of occurrence of hazards in advance. In conclusion, HACCP is a scientific hygiene management system for ensuring the safety of food through autonomous, systematic and efficient management by determining the critical control points to focus on identifying and managing hazards that may occur at each stage of the final consumer's intake through manufacturing, processing, preservation, distribution, and cooking steps.

Manufacturing industries around the world, including the food industry, are making unprecedented innovations such as digital transformation through the remarkable development of ICT. In a food factory, strictly identifying the harmfulness or deterioration of food that is manufactured is no different from raising the quality control level in a smart factory [2] [3]. However, additional procedures include the physical and chemical environment that the managed item processes, and more thoroughly and strictly check, record, and report to the certificating authority, including the level of cleanliness of the worker. Although HACCP's demand for computerized transformation has continued, it is now an opportunity to significantly improve the quality control level of the smart HACCP or smart factory's food industry through the combination of smart factory and HACCP, as utilization technologies have developed to store, transmit and analyze data more easily. HACCP applications are divided into three types of food, livestock and feed, with the Ministry of Food and Drug Safety in charge of food and livestock products and the Ministry of Agriculture, Food and Rural Affairs in charge of animal feed. In South Korea, HACCP maintains and operates standards in accordance with national laws, and more trust and benefits are given when it receives certification marks. All places and conditions of contamination, refrigeration facilities and water quality standards, storage, delivery, inspection, disposal, and tracking of food products are included for companies that manufacture and process food.

2. Supply Chain Model in HACCP

In all manufacturing industries, supply chain models have a common basic process. After purchasing raw materials, manufacture, store them, and deliver them to reach consumers, follow the order of normal logistics and reverse logistics corresponding to returns. Unlike ordinary industrial products, items handled by HACCP start with securing plants and animal life as the main raw material and go through a manufacturing process to store, distribute, or return, but must be discarded without exception if defective goods occur or return is received in the middle for quality control purposes. This is also a key element of HACCP management. The Data flow diagram of a typical food supply chain has added Korean HACCP management points, as referenced in Feng Tian's work [7].

Since raw materials are living things, it would be good to get data on the process of purchasing seeds and growing them, buying or breeding young, and raising well. However, at HACCP, information on the country of origin will only be needed. In other words, the necessary conditions can be satisfied if information on harvest and slaughter is obtained, rather than the process of growing well. Through the raw production process, the raw material is stored through primary logistics, which is sensitive to the temperature and humidity of the raw material, so this becomes the second management element of HACCP. And it travels through logistics, which also requires good management of conditions for refrigeration or freezing.
Manufacturing is then carried out in the normal order at the manufacturing plant, such as general manufactured goods. However, it is important that a cleaning process similar to the inspection of the quality of raw materials can be added, and the processing, packaging, and storage of raw materials are the same after that. Data management points are added to determine the temperature, humidity and cleanliness of each process.

Fig. 1. Data Flow Diagram

Products that are stocked as finished products are delivered again and finally delivered to consumers and consumed. This is not much different from Distribution 1. The key is to maintain the refrigerated and frozen temperature of the delivery vehicle. Subsequently, the HACCP emphasizes the phase of disposal, which must be collected, discarded, stored and transmitted as data, because degraded products should not be eaten by humans. There are four main stages of organizing the Supply Chain Model in HACCP, of which the distribution of raw materials and finished products can be grouped in the same form, although in different order.

A) Raw Production
B) Distribution
C) Manufacturing
D) Disposal

The CCPs that collect key data at all levels can be summarized in a total of 10 steps and classified as T1 to T10 following the transmission to the Blockchain [4] to be mentioned in the next section. What is not covered here is the data for each plant and facility, which can be imported by applying IoT [5] technology. The order of movement of logistics and the flow of supply chains at each stage are defined here, and the data of sensors and installations, factories, or fixed equipment, are excluded and listed based on the flow of supplies. In addition, the types of data mentioned in Table 1 are arranged in Table 1 by linking each step with the transmission number by order.
The principle of smart HACCP is to use the data generated by each equipment as a standard for storing directly in the Blockchain. Only in exceptional cases does a person enter data.

| Application Basis | Management Area | Stage | Transactions |
|-------------------|-----------------|-------|--------------|
| Business Place    | C)              |       | T8, T9       |
| Hygiene Control   | B), C)          |       | T2, T3, T4, T5, T7, T8, T9 |
| Manufacturing Facility | B)          |       | T4, T5       |
| Food manufacturing and processing company | Refrigeration Facility | B), C) | T2, T3, T6, T7, T8, T9 |
| & group catering company | Water Standard | B)    | T4           |
|                   | Storage & Transport | C)    | T2, T3, T7, T8, T9 |
|                   | Inspection Management | A), B), C), D) | T1 ~ T10 |
|                   | Disposal & Tracking | D)    | T10          |

3. HACCP-based Cooperative Model for Smart Factory

3.1. Blockchain Architecture for HACCP

Blockchain can be seen as a distributed database [6]: The block and the chronological chain of each block store all the information of network activity because the block is added to the chain. A Blockchain, is a growing list of records, called blocks that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. Blockchain-based systems rely on miners to aggregate transactions into blocks and add them to the Blockchain. If the deal is reached, Identified as a sufficient number of nodes, it becomes a valid and permanent part of the database [7]. By design, a Section is resistant to modification of the data. It is "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way". For use as a distributed ledger, a Section is typically managed by a peer-to-peer network collectively adhering to a protocol for inter-node communication and validating new blocks. Once recorded, the data in any given block cannot be altered retroactively without alteration of all subsequent blocks, which requires consensus of the network majority. Although Section records are not unalterable, Sections may be considered secure by design and exemplify a distributed computing system with high Byzantine fault tolerance [8]. Decentralized consensus has therefore been claimed with a Section. Section technology is currently being used most often as a means for trading in crypto. Smart Contract is a kind of computer program operated by a Blockchain operated by all Consensus nodes, consisting of program code and storage files [9]. Anyone can make a contract by posting transactions on the Blockchain. The program code of the contract is fixed at the time of writing the contract and cannot be changed [9]. The advantage of the impossibility of forgery and tampering is expected to lead to more use as a surefire means of authentication in the future, one of which is the smart HACCP sector. Each block is connected as shown in Fig. 2. And when transactions accumulate persistence, it creates a new block and connects the block hash value to the previous block as a link. Blockchain is a distributed system without a central system, so anyone can create a block, but it does not create a block in any way. For block generation, a single block is completed when a hash of block value is required, and due to the one-way nature of the hash function, it is not possible to calculate the input value for the hash result. If we use a hash to check for falsification of data, and only have a private key using a hash, we can confirm that the data has not changed. A block is generated through a node and is sent from A to B to inform it, which is called a Transaction ID (TXID).
3.2. Application Scenario For Smart Factory

A) Raw Production

Raw production is an area of purchase from the manufacturer's point of view. In other words, if it is an extension of SCM [10] [11] planning and execution, and if its supply schedule and price were the main control criteria for general industrial products, Smart HACCP should also collect, store and manage quality and country of origin data more importantly (T1). At this stage, quality control should establish and implement standards for more thorough data collection. If general product quality is abnormal, efforts are made to minimize losses through disposal or rework. However, since there are various national benefits for food manufacturing plants to simultaneously implement and apply smart factories rather than separately certify each country has now been elevated to the level of national security under the influence of Covid-19. Although distribution can be divided into semi-finished and finished product status, it is the same that temperature and humidity that can be measured in refrigerators and freezers installed in vehicles (T3) that are stored and moved in warehouses (T2) should be collected, and data stored and managed. It is necessary to develop convenient applications for storing in the Blockchain.

B) Distribution

Although distribution can be divided into semi-finished and finished product status, it is the same that temperature and humidity that can be measured in refrigerators and freezers installed in vehicles (T3) that are stored and moved in warehouses (T2) should be collected, and data stored and managed. It is necessary to develop convenient applications for storing in the Blockchain.

C) Manufacturing

In order to complete HACCP certification, the process of collecting and storing data is important, but infrastructure using the Blockchain network must also be equipped to regularly send and report data to related agencies. To do so, wired and wireless communication infrastructure such as Ethernet and Wi-Fi in the factory must be basic, and a high-performance, uninterrupted communication system for constant communication, up to the temperature of the refrigerated frozen storage system in the vehicle in transit. South Korea is already leading the 5G network [12], and national preparations are under way. The need to store in a distributed network at the same time as a centralized factory information processing system causes inconvenience. It is recommended to use the smart HACCP method because this data must be recorded and reported separately to obtain HACCP certification.
D) Disposal

If general product quality is abnormal, efforts are made to minimize losses through disposal or rework. However, food must be disposed of when contaminated or deteriorated. Waste disposal management is strictly carried out because rework without dumping waste can cause serious health damage. To utilize a Blockchain that prohibits data tampering and disposal forgery is the most appropriate choice.

4. Conclusion

HACCP has already been implemented in several countries through thorough certification procedures under national food safety management regulations. With the recent technological advances in smart factories, it is desirable for food manufacturing plants to simultaneously implement and apply smart factories rather than separately certify HACCP. This is because they need to have the same form in terms of collecting, storing, and recording data. Unlike general products, however, there are many areas of data collection and difficulties in enhancing quality control in terms of coping with food hygiene. However, since there are various national benefits for food manufacturing companies that are certified as HACCP, it is clear that corporate profits and competitiveness will be greatly strengthened if they are properly equipped with that infrastructure and are officially certified. And if such companies increase, the health and security level of a country will be much improved. This paper introduced HACCP's certification procedures and the types and areas of data collected, and how to utilize the Blockchain as a way to enhance the security of data that SMART HACCP should pursue compared to the cycle of generating and using data in smart factories. It also outlined that 5G networks were also recommended as the infrastructure needed for the transport method to send the data to relevant certification bodies. As previously emphasized, the issue of hygiene in each country has now been elevated to the level of national security under the influence of Covid-19. Although HACCP is already an area that has been well supervised by country, it has become possible to collect data smarter, store, record, and report to government offices in line with the technological advances of smart factories, so we have looked at the discussion of this and detailed technological transformation from a digital data perspective.

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