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APPLICATION OF CORE TECHNOLOGIES FOR SMART MANUFACTURING: A CASE STUDY OF COST BENEFIT ANALYSIS BASED ON MODELING AND SIMULATION FOR SUSTAINABILITY

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ABSTRACT

Recently, corporations around the world have been making numerous efforts to innovate manufacturing due to intensified competition. These innovations in manufacturing can be characterized as “smart” manufacturing technology, and include Cyber Physical System(CPS), Internet of Things(IoT), big data, and cloud computing as applications of diverse information technologies. This study introduces research that has focused on Material Flow Cost Accounting(MFCA) in consideration of sustainability, targeting vehicle recycling factories, using an Modeling and Simulation(M&S) technique, which is one of the core elements of actualizing CPS among the core technologies in smart factory manufacturing. Specifically, this study describes the process from entering necessary data for a simulation to model creation to MFCA analysis, and verifies the applicability of the system using test examples.

1 INTRODUCTION

Through their research on the industry, the National Institute Standards and Technology in the United States has evaluated sustainability to be a major element of smart manufacturing (NIST 2014); in Korea, on the other hand, eight technologies have been designated as necessary for a smart factory, namely Cyber Physical System(CPS), Internet of Things(IoT), 3D Printing, big data, cloud computing, sensor, smart energy and hologram, and attempts to innovate the industry based on these technologies are ongoing (Ministries 2015). In particular, the importance of Modeling and Simulation(M&S) related research is once again being emphasized, as it has been frequently applied to analyses of existing production lines and mentioned as the major element of actualizing CPS (Kang et al. 2016).

This study conducts a cost benefit analysis based on a CPS model to simultaneously analyse the recycling ratio and energy usage in vehicle recycling factories. After defining the flows of recycling material and waste material that are disassembled in each process, a cost benefit analysis is conducted for each process in consideration of the energy usage and recycling ratio.

2 A CPS MODEL FOR MFCA AND COST BENEFIT ANALYSIS ON SUSTAINABILITY

For a cost-benefit analysis based on CPS considering sustainability, simulation should be performed through a real-time data link between a physical model corresponding to an actual factory and a cyber model. The information of the physical model is obtained through the legacy system and the IoT sensor installed in the facility. Physical model information obtained from legacy and IoT sensors is transmitted to the CPS server. When the information of the physical model is transmitted to the CPS server, the CPS server generates the cyber model based on the information transmitted. The CPS model is divided into two parts: one for the discrete event simulation model and one for the MFCA/cost benefit analysis. The simulation model is linked with the physical model in real time. The simulation can improve the accuracy of analysis through real-time data interworking with the physical model. When the simulation is performed, throughput, the operation ratio, energy consumption, lubricant consumption of the facility, and so on are derived as the results. The MFCA analysis is conducted using the throughput, operation ratio for each process, energy consumption, and disassembled part for each process from the simulation. The parts in each process are categorized into positive material (reuse product, recycle material, incinerate waste) and negative material (restricted material, landfill) to calculate the energy used to disassemble the part. Positive materials are assumed as material cost (benefit), whereas negative materials are assumed as waste cost (cost), energy as energy cost (cost) to get the value for the final process. After the results of the MFCA analysis are derived, a cost benefit analysis is performed based on the results.

3 CASE STUDY

To verify the findings of this study, the model for example simulations is defined and analyzed based on the information of vehicle recycling factories. We installed the IoT sensors to obtain energy usage information of the facility. In addition, we obtained facility information and production information from Legacy system. Using these two pieces of information, we created the CPS model. Of the processing information, the material information in the pre-processing and exterior disassembly processes was used in the example model. Using the as-is model based on the current data, an analysis was conducted on how the values in two processes are changed when doors are disassembled in the exterior disassembly process rather than in pre-processing. With the change in the door disassembly process, the working time and waste processing capacity were changed. Consequently, energy usage in pre-processing was changed from 53.4kwh to 38.5kwh, and in the external disassembly process was changed from 35.4kwh to 46.3kwh. In terms of the result of the cost benefit analysis, the pre-processing was changed from 1,243,898 won to 116,314 won and the external disassembly process was changed from 303,918 won to 1,571,601 won. An improvement of 140,099 won was anticipated based on line change.

4 RESULTS

This study conducted CPS model for MFCA analysis and a cost benefit analysis on sustainability targeting the vehicle recycling process in consideration of sustainability using the modeling and simulation methodology. Necessary system structure was defined to carry out the CPS model based on the relation with the physical model and cyber model, and the result obtained from the simulation was analyzed using the methods of MFCA and a cost benefit analysis. Based on the information on the parts to be disassembled in each process and energy consumption throughout the general vehicle recycling process, cost and benefit could be clearly estimated. Using the results of the study, the values for many alternatives could be estimated and the alternative with the highest value could be selected during decision-making.

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