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A framework of a smart injection molding system based on real-time data

Hwaseop Lee[a], Kwangyeol Ryu[a]*, Youngju Cho[b]

[a]*Department of Industrial Engineering, Pusan National University, usandaehak-ro 63beon-gil, Geumjeong-gu, Busan 608-735, South Korea*
[b] *Manufacturing System R&D Team, Korea Institute of Industrial Technology, 55 Danggok 3-gil, Ipjang-myeon, Cheonan-si, Chungcheongnam-do 331-825, South Korea*

Abstract

The manufacturing industry has been facing several challenges, including sustainability, performance and quality of production. Manufacturers attempt to enhance the competitiveness of companies by implementing CPS (Cyber-Physical Systems) through the convergence of IoT(Internet of Things) and ICT(Information & Communication Technology) in the manufacturing process level. However, a CPS platform (or Smart factory in other words) or a framework is composed of different types of data acquisition/handling method, decision making rules and functions depending on the characteristic of the manufacturing company. In this paper, we propose a smart injection molding system framework based on real-time manufacturing data considering the characteristics of injection molding processes, modules that compose the framework, and their detailed functions. This paper is expected to be used as a guideline to increase the market competitiveness of injection molding industry and support the construction of a smart factory in preparation of Industire 4.0.

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Keywords: CPS(Cyber-Physical Systems), IcT(Information & Communication Technology), IoT(Internet of Things), Injection molding, Smart factory

* Corresponding author. Tel.: (+82-51)510-2473; fax: (+82-51)510-7603.
E-mail address: kyryu@pusan.ac.kr

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1. Introduction

In order to increasing the competitiveness while reducing production costs, manufacturing companies are trying to increase their flexibility in processes or innovate their production methods. To achieve that, manufacturing companies introduce new technologies or innovate traditional production methods by integrating technologies that have not been widely applied.

Industire 4.0 and Smart factory are now very important issue in the manufacturing industry and academia as well. Industrie 4.0, or the fourth industrial revolution, exchanges information of objects (machine, workers, etc.) through the network technologies (Cloud, Wireless network) and Internet and Communication Technology (ICT) based on IoT (Internet of Things) and builds a CPS (Cyber-Physical System) to make decision-making self-centeredly by using AI (Artificial Intelligence) Technologies [1]. The new concept of production system in which CPS is built is call Smart Factory or CPPS (Cyber-Physical Production System). Important factors accelerating the introduction of Industry 4.0 include the lack of skilled workers, know-how or knowledge leakage, and population aging. Therefore, the establishment of a smart factory is expected to be a breakthrough for reviving traditional manufacturing industries (Molding, Casting, Welding, Plastic forming process, etc.) [2].

Injection molding is a manufacturing process for producing plastics parts by injecting material into a mold. A wide variety of products are manufactured using injection molding, which vary greatly in their size, complexity and application. Injection molding process has two most common problems of all. The first problem is the derivation of optimal process parameters for initial injection molding machine setting considering various process variables in order to implement effective manufacturing after product design. In order to derive the optimal process variables, there is a process of continuously adjusting the process parameters in a trial-error manner which causes considerable loss. The second problem is the difficulty to change the value of initial process parameter during injection molding process, especially when defects occur during manufacturing. Currently, there is not yet method for quality improvement of this dilemma, and it is challenging to response to the occurrence of equipment failure and sudden production problems.

In this research, we present a framework of real-time data based smart production system for increasing the manufacturing flexibility and propose the detailed functions and technical requirements for constituting the framework. This study is expected to facilitate establishment of smart factories for injection mold, and to suggest a guideline for manufacturing innovation toward the fourth industrial revolution.

2. Literature research

In this section, we conducted literature survey on the framework of smart factory and the process variable setting for injection molding process optimization for smart factory of injection molding system. The following section 2.1 discusses smart factory design principles and a framework of a new concept manufacturing system, which mainly focuses on Smart factory, Industry 4.0, Industrie 4.0, and Manufacturing system framework. Section 2.2 examines studies related to process variables optimization of injection molding machine, prediction of injection molding, and control the parameters of injection molding

2.1. Smart factory

Smart Factory is a manufacturing system of hyper-connected environments through CPS using IoT. However, it is suggested by various organizations and researchers in various forms of framework. The essential elements for building a Smart Factory defined in Industry 4.0 are interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity [3].

Interoperability means that the objects in the Smart Factory (workers, facilities, products, etc.) must be able to communicate with each other through IoT technology, open network and semantic transformation method. *Virtualization* refers to a method of predicting process problems by establishing a virtual factory by connecting virtual factory models or simulation models with shop floor in real-time. *Decentralization* is a distributed environment in which computers are embedded in a facility and their objectives are set and decisions are made by themselves. *Real-time capability* refers to the ability to acquire and analyze real-time data on equipment, quality,