Development of integrated control system for smart factory in the injection molding process

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Abstract. In this study, we proposed integrated control system for automation of injection molding process required for construction of smart factory. The injection molding process consists of heating, tool close, injection, cooling, tool open, and take-out. Take-out robot controller, image processing module, and process data acquisition interface module are developed and assembled to integrated control system. By adoption of integrated control system, the injection molding process can be simplified and the cost for construction of smart factory can be inexpensive.

1. Introduction
Goods made from plastic are used in the various area of living and industry. Injection molding process is used for production of plastic goods [1]. The injection molding machine used for injection molding process consists of hopper for supplying the plastic chip, heater for heating, screw for transferring melted material, mold for shape as showed in Figure 1 and Figure 2. This injection molding process has been conducted by manual.

Figure 1. Configuration of the injection molding machine.

Figure 2. Injection molding has the process such as (a) tool close, (b) injection, (c) tool open, and (d) take-out.
Recently, the effort for saving of production cost by using the process improvement in the injection molding product, which can be achieved by adoption of smart factory, is increasing. Automation of production process, gathering of process data, and transfer to manufacturing execution system (MES) are required for the construction of smart factory [2]. Take-out robot, motion controller, mold monitoring device, and HMI HUB are used in the injection molding process to construct smart factory as showed in Figure 3. Process data generated in the injection molding process is transferred to MES via HMI HUB. By using the various peripheral devices such as dehumidifier, grinder, and refrigerator, the injection molding process is complex and cost for construction of smart factory is expensive.

**Figure 3.** Configuration for construction of smart factory in the injection molding process.

In this study, integrated control system, which consists of take-out robot controller, image processing module, mold monitoring device controller, and process data acquisition interface module, is proposed to simplify the injection molding process and to reduce the cost for construction of smart factory.

**2. Configuration of integrated control system**

Integrated control system having the function such as take-out robot controlling, camera image processing, mold monitoring device controlling, process data acquisition, and data transferring, consists of take-out robot controller, image processing module, mold monitoring device controller, and process data acquisition interface module as showed in Figure 4.
The process data generated by mold monitoring device, take-out robot, injection molding machine, and peripheral devices such as dehumidifier, grinder, and refrigerator are saved in the integrated control system and transferred to MES and process management and monitoring system.

3. Development of integrated control system

Integrated control system, which consists of take-out robot controller, image processing module, and process data acquisition interface module, is developed to simplify the injection molding process and to inexpensive the cost for construction of smart factory

3.1. Take-out robot controller

Take-out robot controller has functions such as 8-axis motor control, interpolation motion, point to point (PTP) motion, round motion. Figure 5 shows the developed take-out robot controller.

3.2. Image processing module

Image processing module consists of camera, illuminator, and image processing algorithm. The mold status image captured by camera is transferred to the microprocessor, which has the image processing algorithm, of integrated control system and processed to catch the defect of the mold status. Figure 6 shows the captured image and processed image by developed image processing module.
Figure 6. (a) Captured image and (b) processed image by developed image processing module.

3.3. Process data acquisition interface module
Process data acquisition interface module has 8 analog interfaces, 32 each digital input and output, and serial port. Figure 7 shows developed process data acquisition interface module.

Figure 7. Developed process data acquisition interface module.

4. Conclusions
In this study, integrated control system having the function such as take-out robot controlling, camera image processing, mold monitoring device controlling, process data acquisition, and data transferring is proposed. By adoption of integrated control system, the injection molding process can be simplified and the cost for construction of smart factory can be inexpensive.

5. References
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