Design of Product Monitoring System Using Internet of Things Technology for Smart Manufacturing

Marti Widya Sari¹, Herianto², IGB Budi Dharma³, A.E. Tontowi⁴
¹,²,³,⁴Mechanical and Industrial Engineering Department, Universitas Gadjah Mada Yogyakarta, Indonesia
²Informatics Department, Universitas PGRI Yogyakarta, Yogyakarta, Indonesia
³marti.widya.sari@mail.ugm.ac.id

Abstract. The application system in the industrial era 4.0 is currently growing rapidly. One of them is the implementation of smart manufacturing in the industrial sector. In smart manufacturing, production processes can be monitored automatically and real time, starting from material selection, then the production process to the planned product. In this study discussed the design of a monitoring system on smart manufacturing based on internet of things technology. Smart technology is implemented on material scans automatically based on color sensors, then from the material it will also be known that with these materials produce certain products and require any material. In addition, the system will also automatically detect through the initial material to find out which processes will be passed. The methods used include literature studies, system requirements analysis, system design and system testing. The results of this study are in the form of a hardware system design and display of production process monitoring system applications. In the system that is made also a notification is displayed if a bottle neck occurs in the production process.

1. Introduction

Information and communication technology is highly needed for modern manufacturing nowadays. The Forth Industrial Revolution (Industry 4.0) integrates all current technologies such as wireless network, sensors, Internet of Things (IoT), control and robotics, artificial intelligence and information management system to create a Cyber Physical System (CPS) and smart factories [1],[2]. Industry 4.0 refers to a number of automated systems equipped with automatic data exchange and manufacturing technology capabilities [3],[4],[5]. These systems exert a transformative effect on economic and social processes [5]. Recently, Industry 4.0 concepts have attracted considerable attention in advanced manufacturing countries as a means of streamlining production. The widespread application of CPS in manufacturing environments renders manufacturing systems increasingly smart for more effective production process [6][7]. To advance research on the implementation of Industry 4.0, this study discusses smart manufacturing system for Industry 4.0 [8], [9]. The IoT is considered to be a modern manufacturing concept under Industry 4.0 and has adopted recent advances, such as cutting-edge information technology (IT) infrastructure for data acquisition and sharing, which greatly influence the performance of a manufacturing system [10]. The real-time data collection and sharing are based on...
key technologies such as radio frequency identification (RFID) and wireless communication standards [11][12]. By using RFID technology, physical manufacturing flows such as the movements of materials and associated information flows such as the visibility and traceability of various manufacturing operations can be seamlessly integrated [3], [13],[14]. Several real-life cases of IoT-enabled manufacturing have been reported [15]. In addition to IoT-based manufacturing, it needs to be supported by flexible manufacturing for a more effective and efficient production process. Flexible manufacturing allows for the addition of hardware, software changes and production equipment functions [16], [17].

2. Manufacturing

2.1 Smart Manufacturing

Figure 1 presents a framework of Industry 4.0 smart manufacturing systems, including smart design, smart machining, smart monitoring, smart control, smart scheduling, and industrial applications, which are the focus of this work. The vertical axis shows issues in another dimension of Industry 4.0 ranging from sensor and actuator deployment to data collection, data analysis, and decision making [6],[18]. In Industry 4.0, data gathering and analysis are the main sources of the smartness of activities shown on the horizontal axis.

2.2 Smart Monitoring and Control

Monitoring is an important aspect in the operation, maintenance, and optimal scheduling of Industry 4.0 manufacturing systems [19]. The widespread deployment of various sensors has made smart monitoring possible [20],[21]. For example, data on various manufacturing objects, such as temperature, electricity consumption, vibrations, and speed, can be obtained in real time. Smart monitoring provides not only a graphical visualization of these data but also alerts when abnormality occurs in machines or tools. Internet of things are key technologies that enable smart monitoring in Industry 4.0 smart manufacturing systems [2], [4].

Production behavior and procedures can then be carried out automatically and effectively because of the well established structures and services. With the aid of data input mechanisms, the output resolutions are fed back to the parties involved in different ways [5], [18].
3. Research Method

Based on some of the studies above, there is still not much research that discusses the production process monitoring system in the smart manufacturing based internet of things technology, especially those using material selection at the beginning of the process and flexible manufacturing. In this research discussed about the design of a production process monitoring system in real time that can display activities on the production floor starting from material detection, work in process needs of each material, detection of bottleneck up to the final product. The research methods used include the following: literature study, system requirements analysis for hardware and software needed, system design and system testing. Literature studies are conducted to get complete information and knowledge about the theme of the research that will be conducted.

3.1 System Analysis

Before designing a monitoring system, a system requirements analysis was carried out, both hardware and software requirements. Hardware requirements include colour sensors, PIR sensors, RFID and RFID tags, Arduino Mega, ethernet shields, routers and Raspberry Pi mini PCs. The hardware system scheme is shown in the Figure 2 below. Colour sensors are used to detect initial material based on material colours. Colour sensors are used because the product will be made using material of a certain color. RFID is used to store material data to make it easier to detect during the production process. Routers are used to connect to the internet, because the monitoring system is built on internet of things. Then the Raspberry Pi mini PC is used to control the system as a whole, including the smart material detection process. Furthermore, for software systems using PHP for display on the web and databases to support the overall system data availability. The monitoring system is web-based because it can be implemented on a multi-platform or compatible basis for all operating systems so that it is more flexible. Then for storing the database using MySQL.
3.2 System Design

The design of a monitoring system is generally explained in the following Figure 3. In designing this monitoring system it starts with scanning the initial material through a sensing process. The sensor used in this system is a colour sensor, because the product to be made is related to the colour of the material. Then the material will pass Work in Process (WIP) 1 and 2 for the production process.

Between WIP 1 and WIP 2, several PIR sensors were installed to detect the bottle neck. A bottle neck can occur if there is a queue that exceeds the capacity between WIP 1 and WIP 2. The monitoring system also displays notification of bottle neck during the production process. Furthermore, the material that has been processed in WIP 1 and WIP 2 will enter the final stage, namely the product form. All production processes databases are stored in cloud computing based.

4. Results and Discussion

4.1 Results

The following picture is the result of designing a product monitoring system application on smart manufacturing. On the dashboard display of monitoring application, there is material data, in this case
there are 3 materials to support the product to be made. The process monitoring shows data on material that is running and being processed. Then in this system there is also information on the final product that will be produced. The results of the design of the monitoring system are shown in Figure 4 below.

![Figure 4. Display of monitoring system dashboard](image)

### 4.2 Discussion

In the system view, Figure 4 contains some information that can be used as an analysis material for the results of monitoring system testing. On the system display dashboard, on the top side, there is any material information provided and how many, the numbers will change according to the production process that requires available material. In this system three types of material are provided to make a product. Furthermore, on the middle side there is a column to display the status and notification of bottle neck during the production process. Status bottle neck will appear if there is damage or there is a queue in the production process between WIP 1 and WIP 2. The monitoring system also shows the target time needed for a production process from the beginning of material selection to the final product. On the right side there is Output Production data, which shows the number and types of products that have been produced.

### 5. Conclusion

The conclusion from the results of this study is that the system designed can be used to monitor the production process in smart manufacturing, from the material selection process, the production process to the final product. This monitoring system also displays information on the production process, bottle neck and WIP requirements for each product. Material selection in this system uses color sensors to make a particular product based on material colors. As a propose for further research can use image processing for material selection at the beginning of the production process, so that the material detection process can more details. Then, measurements can also be made and analysis of time allocation for the overall production process.

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