IoT-based Production Output Monitoring System for Plastic Packaging Manufacturing Process

Wong Yun Yee¹, Chew Chang Choon¹, Teo Chee Siong², Radzi Ambar¹ and Mohd Helmy Abd Wahab¹

¹Department of Electronic Engineering, Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.
²Chiga Light Industries Sdn. Bhd., PLO15, Kawasan Perindustrian Parit Raja, 86400 Parit Raja, Batu Pahat, Johor, Malaysia

E-mail: chewcc@uthm.edu.my

Abstract. This paper discusses about the development of an IoT-based production output monitoring system in the production line of Chiga Light Industries Sdn. Bhd. which is a plastic packaging manufacturing company. Although the existing company Enterprise Resource Planning (ERP) system provides a platform for production manager and officers to monitor as well as collect the length of plastic film produced on a printing machine, only the total amount of finished goods in kilograms (kg) is recorded. However, the total length of plastic produced, and time taken to finish one tubing are needed for machine analysis and production planning. Therefore, a length encoder is used to detect the length of plastic film produced and connected to a counter meter to display the present value of plastic produced as well as the setting value for one roll of plastic. Besides, an Arduino board is used to read data from the counter meter while an ESP8266-01 Wi-Fi module is used to send the data to ThingSpeak™ cloud for storing. ThingSpeak™ analysed and visualised the collected present and setting values of the counter meter on a private channel. The duration for uploading a data is set to one hour. From the developed monitoring system, production manager and officers could monitor machine performance, operators working performance and collect the length of plastic produced on a printing machine. Besides, the total length of plastic in a roll could also be detected to ensure customer requirement is achieved.

1 Introduction

Internet has been widely used in many areas such as transportation, healthcare, agriculture and manufacturing industry. It has become essential in our daily life that Internet of Things (IoT) had been developed. IoT is defined as a network of physical objects [1][2]. It enables the communication between machine and machine as well as machine and human which is widely used on industrial automation. With the application of IoT technologies, manufacturing industry able to increase productivity and data collection efficiency. Besides, it enhances the safety at working areas, reduce risks and minimize machine malfunction [3]. It leads to a “smart factory” because every machine is
under supervision and control. It also brings many advantages and convenience to the manufacturing industry. The manufacturing is “smarter” due to the communication between machines and peripheral devices improves the decision-making from humans to technical systems. Besides, the volume and variety of data generated by a networked economy provide the analytical possibilities for industrial processes optimization. Therefore, machine to machine (M2M) communications enabled by IoT optimize the industrial processes for reducing maintenance downtime, outages and energy consumption [3]. Several existing literatures provide the ideas on IoT application for industries. This includes Bluetooth embedded devices [4], machines controlled via website [5], IoT-enabled manufacturing execution system [6] and water level management system using IoT [7]. These literatures show that IoT has become an important tool in optimizing performance of industrial processes.

In this paper, an IoT based production output monitoring system is developed in the production line of Chiga Light Industries Sdn. Bhd., which is a plastic packaging manufacturing company. Although the existing company Enterprise Resource Planning (ERP) system provides a platform for production manager and officers to monitor as well as collect the length of plastic film produced on a printing machine, it had weaknesses too. From the ERP system, only the total amount of finished goods in kilograms (kg) is recorded. However, the total length of plastic produced, and time taken to finish one tubing are needed for machine analysis and production planning. Besides, the working performance of operators could not be monitored through the ERP system. Moreover, the length of plastic film produced affects the weight of tubing too. Hence, the setting value on the counter in the unit of meter is very important so that the finished goods achieving customer demands. Therefore, this work describes the propose IoT-based monitoring system including overall system design including hardware parts, monitoring system and actual implementation of the system on the plastic printing machine in Chiga Light Industries Sdn. Bhd. located in Batu Pahat, Johor, Malaysia.

The remainder of the paper is as follows; section 2 describes the methodology of the work including overall design of the system including hardware parts and monitoring system. Section 3 gives detail description of preliminary experimental setup and steps followed by experimental results and analysis. A brief conclusion is described in section 4.

2 Methodology

2.1 Design of the System

IoT-based production output monitoring system provides a platform to the production line in Chiga Light Industries Sdn Bhd to collect the length of the plastic film produced in a roll and monitor the working performance of operators.

Figure 1 shows the overall design of the system. As shown in the figure, a wheel type length encoder is used to detect the length of the plastic film produced by the plastic printing machine. Then, a counter is connected to the length encoder to count and display the length of the plastic film in the unit of meter. The present value of the plastic produced and the setting value which is the total length of plastic tubing are shown on the counter. A MAX485 module is used to enable the communication between the Arduino and the counter MAX485 is used as a RS485 to Transistor-Transistor Logic (TTL) converter. The setting and present values stored in the counter registers are polled and read by the Arduino. The Arduino is connected to an ESP8266 Wi-Fi module for sending two fields of data to the cloud of IoT platform called ThingSpeak™ via the internet. Thus, the user could view the data displayed on the ThingSpeak™ channel by using Personal Computer (PC) or smartphone. The length of the produced plastic film is displayed on a ThingSpeak™ channel in line graph. Therefore, the production manager could monitor the machine and operator performances without visiting the site through the developed system.
Figure 1. Overall System Diagram

2.2 Monitoring System

ThingSpeak™ is a free Internet-of-Things (IoT) analytic platform that allows the collected sensor data to be sent privately to the cloud followed by analyzing and visualizing the production output data for the monitoring system. With ThingSpeak™, an IoT based monitoring system is built without setting up servers or developing web software.

Since the platform is free, it could only create 4 channels with 8 fields each. Users of the free license could only send 3 million messages in a year. Besides, the message update is limited at minimum 15 seconds. Users could set the ThingSpeak™ channel in private or public view. Furthermore, API keys are provided in ThingSpeak™ to allow users to write or read data in a private channel. Write API key is used to write the ESP8266 data to ThingSpeak™ for analyzing and visualizing. In addition, the data could be exported into a CSV format with all the feeds in a file by choosing the desired time zone in the Data Import/Export page and clicking download. Channel feeds could also be cleared by pressing the “Clear Channel” button in the Channel Settings page resulting in the visualization of the data is cleared. The private ThingSpeak™ channel could be shared with other specific ThingSpeak™ users. Thus, only specified users could view the channel.

3 Results and Discussion

3.1 Experimental Setup and Steps

The counter and data processing unit which mainly consists of Arduino, MAX485 and ESP8266 Wifi module is kept in a plastic box and mounted beside the in-feed of the printing machine for validation as shown in figure 2(a). The interval for the prototype to display data via the counter is set to an hour. On the other hand, the length encoder is installed on a roller of the printing machine in-feed part as shown in figure 2(b). The validation is carried out for 2 days starting from 14th May 2019 to 16th May 2019 continuously. The prototype is tested for the hardware functionality and the consistency of uploading data on the ThingSpeak™ channel.
Figures 2(a) and (b) show the data collection for two days operation that are obtained from ThingSpeak™ channel representing the present (actual) value and setting (target) value on the counter meter respectively.

The validation process of the prototype started at 11:03 am on 14th May 2019 and ended at 12:35 pm on 16th May 2019. Figure 3(a) shows the data collected for the first 24-hour operation, where the setting value and present value are uploaded per hour consistently based on the company’s requirement. As shown in the figure, the first three hours data are not consistently uploaded due to the ESP-8266-01 Wi-Fi required some time to function properly. Since the setting value of the counter meter is set to 5000 meters, it remained constant throughout the testing. During the first three hours of operation, the present value increased as the printing machine operated. However, the present value remained constant after three hours. This is because the on-duty operator did not reset the counter meter as the present value reached the setting value. Therefore, the experiment only tested the consistency of the prototype uploading data on the ThingSpeak™. As a result, the data is successfully displayed once per hour with 11s delay on the field charts of the ThingSpeak™ channel for the first day of validation.

For the second day of the validation, the data collected are analyzed as shown in figure 3(b). As the operator did not reset the counter meter, the present and setting values on the meter are remained the same. As shown in the figure, the present value is overlapped with the setting value as they hold the same value. As a result, the two fields of value are uploaded with 11s delay consistently.

Based on these experimental results, that the plastic production output data were successfully measured by the length encoder and the data were sent to the cloud successfully and can be visualized via ThingSpeak™ platform. The collected data can also be used for further analyses in the future.
4 Conclusions
In this project, an IoT-based production output monitoring system is developed to collect the total length of plastic film produced on a printing machine in one day as well as the setting value for a plastic tubing at the production line in Chiga Light Industries Sdn Bhd. Data from encoder were successfully polled and processed by Arduino and visualized and analyzed on ThingSpeak™ cloud via Internet. Thus, the developed IoT-based monitoring system is able to collect the length of plastic film produced and time taken of producing one tubing of plastic film on a printing machine. With the collected data, the production manager could analyze and use it for further production planning. Besides, the operators working performance and machine performance could be monitored through the system.

Acknowledgements
The authors would like to thank the Research Management Center (RMC), UTHM and Malaysia Ministry of Higher Education for sponsoring the research under Tier 1 Research Grant (H161).

References
[1] Patel K and Patel S 2016 Int. J. Eng. Sci. Comput. 6 6122–31
[2] Wortmann F and Flüchter K 2015 Bus. Inf. Syst. Eng. 57 221–4
[3] Kamal Z, Mohammed A, Sayed E and Ahmed A 2017 World Sci. News 67 126–148
[4] Tandur D, Gandhi M, Kour H and Gore R 2018 IEEE Int. Conf. on Emerging Technologies and Factory Automation pp 1–4
[5] Ammour K 2018 15th Learning and Technology Conf. pp 120–8
[6] Zhang Y and Sun S 2013 10th IEEE International Conf. on Networking, Sensing and Control pp 486–90
[7] Siddula S S, Babu P and Jain P C 2018 3rd International Conf. on Internet of Things: Smart Innovation and Usages pp 1–5