IJIE

http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Time Monitoring System for Assembly Line Operators Using RFID

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DOI: https://doi.org/10.30880/ijie.2023.15.03.027
Received 21 June 2023; Accepted 17 July 2023; Available online 2 October 2023

Abstract: This project discussed monitoring system in an assembly line to monitor and track the performance of the operators in industries. Industry is an important workplace around the world including research and development, design, process, production, quality assurance and so on. A large number of jobs involve humans, and there are also parts that require humans to work using machines, especially operational workers or operators. There are many systems developed in the industry that involve the operator, some of them are to monitor the machining process, and some are to monitor and control the machine. Assembly line operator performance is a critical aspect that severely affects the overall production performance in any production nature. Non-productive time contributes to inequality in task distribution that often results in bottleneck points on a production line. Therefore, the non-productive time is considered as a waste of resources that has a relative impact on the production yield of an industry. In this project, Radio Frequency Identification (RFID) is used on the production line as a monitoring system so that it can help organizations to increase the performance of the working environment among all the employees as well as to achieve better production yield by reducing the non-productive time of assembly line operator.

Keywords: Time monitoring system, RFID, MIT App Inventor

1. Introduction

The Economic Census in 2019 shows that the manufacturing sector in Mexico in 2018 is the most important with the total gross production with the generation of national income reaching 48.2%. Nevertheless, SMEs dedicated to manufacturing lack the training, techniques, tools, quality management systems, culture of innovation and technological development that allow them to maintain the quantity and quality of demand required by transnationals. [1]. Optimization of the performance of assembly line operators is an important aspect that severely affects the overall performance of production in any production. Unproductive time leads to inequality in task distribution that often results in production line bottlenecks. Therefore, the non-productive time is considered a resource loss that has a relative impact on the industry output yield.

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Companies recognize that employee engagement is essential to ensure successful performance and quality improvement. The success of the organization in terms of performance success and quality improvement depends on employee performance and continuous improvement in employee performance. This can be seen through a well-planned performance management strategy because it can guarantee continuous quality improvement in the organization.

Employee monitoring systems consist of various types. There are systems developed to enable continuous monitoring for various activities including worker positions [2], and awkward work postures [3]. In the study, employers can find out when employees walk through the door, when they approach the workstation and when they leave for a break or after work hours are over. All data will be saved automatically and can be used to calculate the total working hours. This system allows companies to determine the number of efficient working hours without additional working hours that may be manually added to the punch card, thus helping employers to provide reasonable salary.

In this project, a monitoring system using Radio Frequency Identification (RFID) to monitor non-productive time of operators at their workstations will be developed. The system is expected to help organizations to increase the performance of the working environment among all the employee of the organization. A smart ID with an embedded RFID tag will be provided to everyone. When the operator enters and leaves the assembly line, the RFID reader will be put at the door, which acts as the door access to know the exact time when they are slacking in their working time.

RFID system usually consists of a base station, reader, coupling devices and terminal, which is a function to identify and process by using radio waves [4]. The information will be stored contactless in one or more deported items such as transponders, tags, badges, electronic tokens or smart cards. Different designation of fixed and deported items depends on the applications, contexts and their hardware and software resources. The fixed items are connected to middleware data processing serves and databases for analysis, archiving and traceability.

The unique characteristic of RFID constitutes its broad adoption in various application such as transport tracking system, document identification, real-time industrial monitoring and library management system. The system of RFID serves in identifying objects, transaction and places [5-7]. RFID use takes many forms in many usage scenarios. The most common methods for distinguishing between passive and active RFID are to assess the label, whether it is a passive or active system, and whether the frequency range is usable [8]. The RFID can be used to track and identify objects. It can also operate for years without batteries because it only needs a dedicated RFID reader for the exchange of information and power [9].

The frequency range of RFID can divide into three different frequencies, such as low frequency (LF), high frequency (HF), and ultra-high frequency (UHF) [10]. The LF class of tags operates within the range of 30kHz - 300kHz [6]. This frequency mainly operates at 125kHz. Based on this frequency range, the read range for the reader have short-range usually can reach up to several centimeters. The factor that makes this LF technology widely used and fit for implanting into animal and access control is that at this frequency RF waves are allowed to transmit through the liquid as well as metals reach up a few millimeters thick.

The next frequency range is known as HF or High Frequency. This frequency operates from the distance of 3MHz-30MHz. It primarily operates at a reading of 13.56MHz. The communication range of these tags can reach up to only 1 meter. At this frequency, the read range is depending on the applications and commonly used in the electronic payment system, public transportation and authorized access [11-12]. One of the benefits for this system is that it works comparatively well around liquids and metal. The last frequency range operates in a range of 850MHz-960MHz. This frequency range is mainly known as Ultra High Frequency or UHF. UHF RFID tags is a form of a silicon chip and an antenna paired into an object. At this frequency, the read range can reach up to 6 meters. The latest technology in UHF RFID shows that it can also be used to detect structural damage [13] and can also function as a temperature sensor tag in the textile industry [14].

Generally, RFID has two types of transponders known as passive and active transponders. Passive RFID systems are powered by the electromagnetic field energy that is transmitted from the reading device known as the RFID reader. It means that this system of RFID uses tags with no requirement of an internal power supply. Passive RFID tags are tiny, and it requires a lower price per tag make these passive RFID systems economical for many industries. Compared to passive RFID, active RFID systems use battery-powered, which means they have their power supply. Active RFID tags will continuously broadcast their signal. It enables them to transmit at higher levels of power and thus be read or written at a greater distance (up to and above 100 meters).

RFID systems have been commonly used in many different application areas, such as product record, manufacturing process management, control of inventory, container tracking and ID badges and access control. There are also RFID applications used to record student attendance [15-16], parking systems that can automatically detect empty parking spaces to save time [17-18], faster toll or parking payment systems [19-20], personal tracking system [2] and so on. In the future, RFID technology is expected to be used widely for various applications that simplify and speed up daily business.

2. Materials and Methods

The principles of non-production time monitoring systems depend on sensing the time in and time out of a person and how long the person is not in the workstation. The system helps line leader or manager to monitor the presence of the operator during working hour. The main materials used are RFID, buzzer, Arduino UNO and ESP8266 NodeMCU. RFID is the abbreviation for Radio Frequency Identification. RFID is one of the most of the series of wi-fi eras that gaining faster and widely adopted in our nowadays society due to its compact, versatile and user-friendly. This unique characteristic constitutes its broad adoption in various application such as transport tracking system, document identification, real-time industrial monitoring and library management system.

The DC buzzer used in this project because it is easy to use since these buzzer work across a large range of voltages, from 1.5V to 15V. This ability to operate over a wide range of voltage makes it suitable for use with a variety of different board. These buzzers can produce audio signal by simply powering it using DC power supply to the buzzer terminal. Since these DC buzzers is a small yet efficient component, it is widely used component in most electronic applications.

Arduino is an open-source platform used for building electronics projects. This Arduino is working as a controller in this project. The hardware consists of a basic open-source hardware board based around an Atmel AVR 8-bit microcontroller or an Atmel ARM 32-bit. The software consists of a standard programming language compiler and a bootloader that executes on the microcontroller.

Meanwhile, NodeMCU is an open-source of IoT platform developed for ESP8266 wifi chip which integrates a 32-bit microcontroller in a small package that includes a standard digital peripheral interface, antenna switches, power amplifier, low noise and power management module. Since NodeMCU is an open-source platform, its hardware design is free to edit, modify and build. Besides that, this module is a low-cost wifi chip that easies to find in the market.

A block diagram is used to represent the system layout and structure that involved in the project. The block diagram for this project is shown in Fig. 1. The first block is RFID card. RFID cards are scanned by RFID reader to assign the ID of the worker to the cards. These cards refer to the smart ID of the worker that already created on the system in Arduino Uno. Everyone will be provided with a smart ID with embedded RFID tag. The ID of the worker includes the information such as exact time when the operator enters or exit the assembly line and total non-productive time of the worker per day. The next block is power supply, it will give supply to the NodeMCU module. This system is using smart phone as a user's controller. Cloud means the connection to the internet which is MIT App Inventor and Node MCU module are connected with. While supply connected, NodeMCU will start receiving the data from RFID reader. NodeMCU are transmit the signal using Internet of Things, which is send the data to the MIT App Inventor and the MIT App Inventor will send the information to the smart phone. The smart phone can be monitored by the supervisor or line leader to monitor the performance of the operators during working hour.

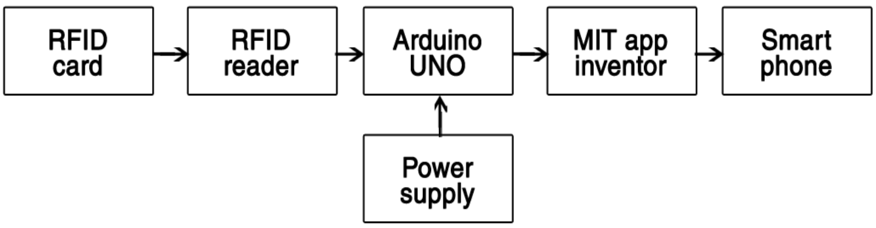

Fig. 1 - Block diagram of the working time monitoring process

Fig. 2 illustrates the system operation of the project. The whole system will have a power supply to make sure the system function continuously. When the system has been turning on, the main controller, Nodemcu, RFID and DC buzzer will be activated. The Arduino UNO used as the main controller in the project is a brain of the system that control the whole system process. When the system has been turning on, it will wait the signal from the RFID reader for worker tag in from the audio signal from DC buzzer. The LED change to GREEN for working time and the system will record the working time of the day of the worker.

When the worker tag out, the LED change from GREEN to RED for resting time and the system start count the resting time of the worker. When the worker tag in, the DC buzzer will sound and the LED change from RED to GREEN for working time and the system will stop count the resting time of the worker. The system will repeat to monitor the non-productive time of the worker in the assembly line operator. Then, the system will stop operation.

3. Results and Discussion

The results and discussion section present the hardware and software testing and simulation. The hardware needs to be tested to ensure that the system is well functioning. After developing the hardware and completing the programming for the monitoring system, the system will undergo a testing phase to ensure that the system is working properly.

Fig. 3 shows the output results at serial monitor of Arduino IDE for non-productive time monitoring system. When RFID tag has been scanned, a buzzer will be triggered and make a sound, and the Nodemcu will read the tag and send the information to the Arduino IDE to produce an output.

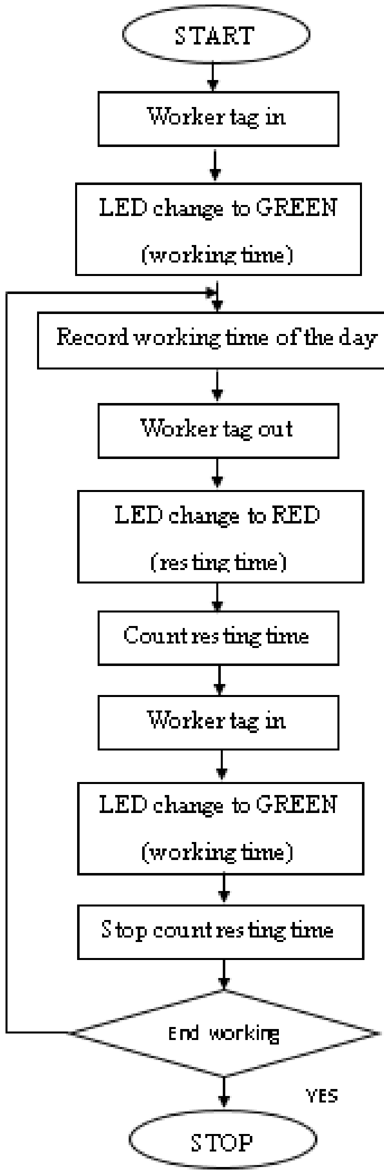

Fig. 2 - Flowchart of the monitoring system

```
23:46:35.877 -> UID TAG:
23:46:35.896 ->  F9 EC 55 99
23:46:35.896 -> message :
23:46:35.896 -> ACCESS GRANTED
23:46:48.005 -> setting /message failed:
23:46:52.349 -> UID TAG:
23:46:52.385 ->  F9 EC 55 99
23:46:52.385 -> message :
23:46:52.385 -> ACCESS CLOSED
23:47:03.838 -> setting /message failed:
```

Fig. 3 - The output result at the serial monitor of Arduino IDE

Fig. 4 shows the hardware setup of the system and Fig. 5 shows the initial condition for the time monitoring system when a tag is scanned in. The LED which represents the operator in the assembly line will turn GREEN colour and the status will display “WORKING”. The time is displaying 00:00 because this system only monitors the non-productive time of the operator which means it will start counting when the operator is not in the workstation.

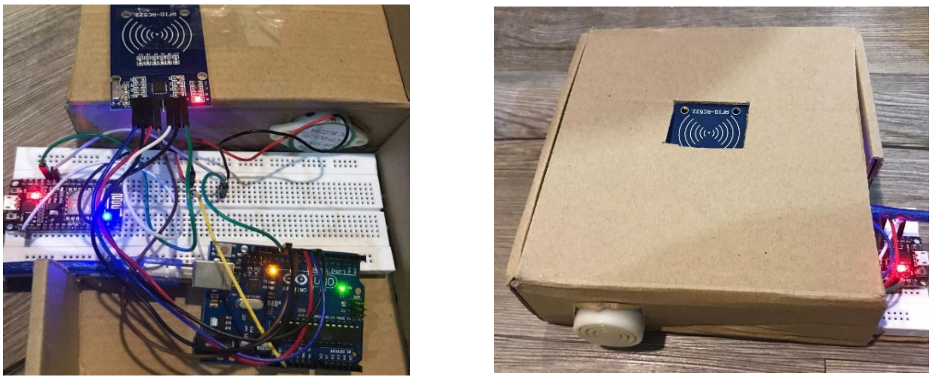

Fig. 4 - Hardware setup (a) inner view; (b) outer view

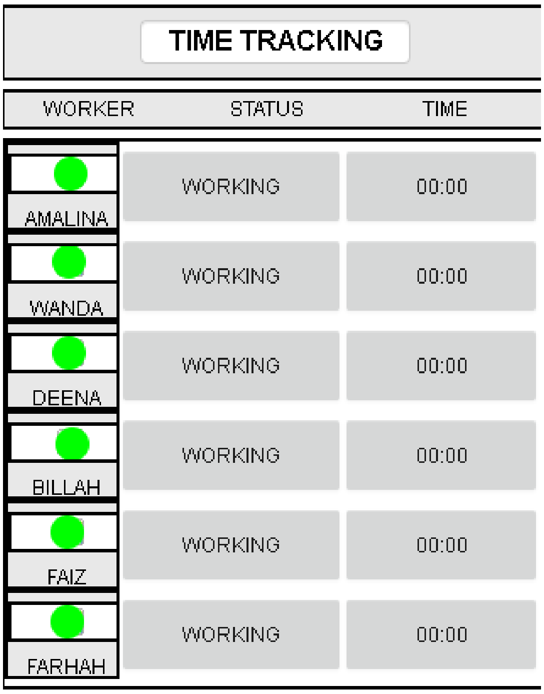

Fig. 5 - Condition when the tag is scan in

When the tag is scanned out, the time monitoring system will display the result as in Fig. 6. The LED is changing from GREEN to RED colour to represent the operator is not in the workstation. The status will be changed to “TRIGGERED” conditions to tells the supervisor or line leader of being aware and monitoring the time. The time will start counting as soon as the operator scanned out their tags. The time will stop counting when the tags scanned in again and continued counting from the previous period when the operator scanned out the tags for the next scanning process. To make the project successful, we have to consider two main factors which play an important role in the system. The first factor is the configuration of hardware which plays mostly in tag scanning and data collecting the information of the operator. The components used in this system are Arduino Uno, ESP8266 Nodemcu, MFRC522 RFID and DC Buzzer. Each of these components has their own roles that needed to designed neatly and the connections must be made correctly.

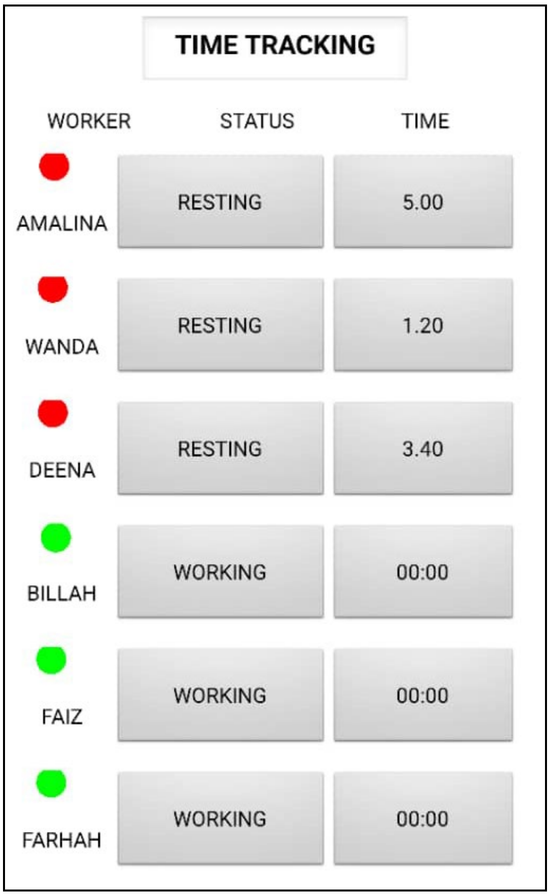

Fig. 6 - Condition when the tag is scan out

In this project, the RFID tag is used as the external hardware which has its unique ID. The unique ID of the tags represents the operator in the assembly line. The physical size of the tag is small makes the scanning process of the tag to the module is much easier. The operator has to make sure they bring along their tags when they want to enter or exit the assembly line because time tracking can only start counting their time when they start scanning out their tags. Otherwise, it considers the operator is still in their workstation.

The second part of this project includes the database which acts to collect and display all data obtained. It is necessary to have the database in this project in order to read the data. Nodemcu is used in this system so that the transferring process of the data could be maintained in high efficiency as it has an internet connection. It allows to program the ESP8266 Nodemcu with the simple or powerful program with Arduino IDE. The features of App Inventor used to make the database is possible to happen. The DC buzzer will produce audio signal when the scanning process happened.

The App Inventor shows how the time monitoring display when the operator scans in or scan out their tags to the module. When the scanning process happened, the LED will be changing from RED to GREEN or GREEN to RED. Then, the time monitoring will start counting when the operator scans out the tag and counting for how long the operator is not in the assembly line and the status will display triggered.

Based on the result obtained, the system helps supervisor or line leader to monitor the presence of the operator in the workstation during working hour. Moreover, they also can find out what time the operator is out from the workstation and how long the operator has been out.

When the operator scans in their tags at the RFID module, buzzer will produce a beep sound as a warning alert for the supervisor or line leader that the operator are in the workstation. The time will stop counting and the LED will light up GREEN colour and the status of the operator changed to WORKING.

When the operator scans out their tags, it considers the operator is not in the workstation. The LED will turn a RED colour and the time will start counting as the operator out from the assembly line. The status of the operator also changed to RESTING. This App Inventor will display the presence of the operator in the workstation and helps the supervisor or line leader to monitor their performance.

4. Conclusion

The main objective of this project is to identify a suitable apparatus to be used as a resting time monitoring system for production line operator performance. Research through some sensors is done to make sure the sensor that has been chosen is suitable for the monitoring system purpose. The sensor that will be selected must be able to work in the read range of 1cm or less since it will be installed at the door access so that the operator can scan the tags provided with the RFID module. The monitoring system design on production line will be able to help the supervisor or line leader to monitor the performance of the operator during their working hour. Without this time monitoring system, supervisor or line leader cannot track the location of the operator if they are slacking in their working hour. In order to minimize the non-productive time of production line operator, a solution is formulated by employing the IoT platform in industries. Therefore, the objectives have been achieved but this project can increase the specification of the system by using active UHF RFID that can read long range distance of tags detection.

Acknowledgement

This research was supported by Ministry of Higher Education (MOHE) through Fundamental Research Grant Scheme (FRGS/1/2022/TK07/UTHM/02/3).

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