RFID Configuration for Part Monitoring in Job Shop Production System

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***Abstract*—Job-shop production system produces several types of product at the same time. The work parts are transported among the stations following the routing according to the type of the product. Some of the stations are shared by different product. Consequently the production line has a set of complex process flows and material handling process become difficult. The setup time is required whenever type of product is change at a station which results with the increasing of waiting time and work-in-process inventory. This situation makes the monitoring of part flow is essential as the information for production management and control. This paper discusses the work part monitoring system in job-shop production line by using Radio Frequency Identification Device (RFID). The system was developed under Microsoft Visual Studio software and built using CSL High Level API Manual software for CSL CS-461 RFID. RFID chip was attached at each work part and antennas are installed at several locations in the production line. A set of experiment were conducted to investigate the effect of chip orientation at the work part to the reading performance of the antenna. The result shows that the system is able to detect the number and location of the work part. The information could be used to monitor the current waiting time and number of work-in-process in the production line.**

***Index Terms*—Job shop, production system, radion frequency identification device**

I. INTRODUCTION

Planning and control of job-shop production system is a challenge task. The products are typically complex, costumer orders are often special and repeat orders are never occur. Interruptions are always happen such as new order, setup time, change of supporting equipment and change of cycle time. The production manager should be able to review the current situation and take immediate decision to change the production scheduling accordingly.

In order to solve scheduling problems in job-shop production, dispatching rules have been used to prioritize the jobs that are waiting for processing in the machine queue. Dispatching rules can be classified in various ways. Among the techniques are shortest processing time, longest processing time first, most work remaining, first in first out, last in first out, the shortest setup time first and the shortest queue at the next operation. However, only four techniques were found mostly applied in job-shop scheduling, as follow [1], [2]:

- The Service in Random Order (SIRO): No priority is given to the waiting jobs. The next job is selected randomly.
- First In First Out (FIFO): The priority is given to the waiting jobs that arrive at the queue first. This rule is equivalent to the Earliest Release Date First (ERD). The objective is to minimize the variation in the waiting times of the operation.
- The Earliest Due Date First (EDD): The priority is given to the jobs with the earliest due date with the objective of minimizing the maximum lateness among the jobs waiting to be processed.
- Shortest Processing Time (SPT): The priority is given to the jobs with the shortest processing time. The objective is to minimize number of waiting parts.

The dispatching rules can be implemented successfully if the production management has a detail information regarding flow of products from the raw materials, parts, components, and work-in-processes (WIPs) to the end products. Decision maker requires real time information regarding status of raw material, availability of workstation, number of waiting part, waiting time, due date of completion and penalty cost of lateness. Radio Frequency Identification Device (RFID) has been used extensively to provide information regarding the status and location of part in production line. RFID is able to search for things without too much time and trouble, one can simply put radio transceiver tags on physical objects; the tags can then be used to find those objects [3].

A number of studies have explored the use of RFID to improve production performance. Shibata et al. [4] used RFID technology at production sites in order to visualize the processes in the production line in real time. Huang et al. [5] propose an RFID-based approach to improve the real time shop-floor information visibility and traceability

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at a walking-worker fixed-position flexible assembly line. This type of shop floor environment normally has limited spaces at work centers with high dynamics of material and worker flows and is suitable for a modest variety of products and production volumes. Their study demonstrates how RFID can facilitate and smoothen the production flow in such environments.

RFID have been also used in dynamic scheduling as it able to provide real time information that required by mathematical analysis of production rescheduling problems. Many studies Duwayri *et al.* [6], Li *et al.* [7] and Vieira *et al.* [8] propose different scheduling heuristics to tackle the challenges of changes or disruptions in dynamic rescheduling environments.

Chongwatpol and Sharda [9] evaluated how RFID can facilitate rescheduling tasks or update an existing plan when disruption situations or unexpected events occur in the shop-floor operations. Their study proposed a traceability-based information visibility model and investigating how an RFID-based scheduling rule can facilitate job-shop scheduling activities. They provided simulation study to compare the performance of job-shop production by using manual information and RFID technology.

However, all of these studies have not utilized information visibility through RFID to improve the existing rescheduling policy. In fact, they mostly focus on finding optimal schedules or improving scheduling decisions in dynamic manufacturing environment through the mathematical analysis of production scheduling problems or simulation study by assuming that all data is known with certainty by using RFID system. To our knowledge, no one of the study describe how to configure the RFID into the production line. Configuration of RFID is an important task since many aspects need to be considered such as location of the antennas, reading frequency, tag attachment, communication devices, computer setting and software development. Without a proper configuration, the system will face some serious problems such as incomplete information, delay of information time, undetected tags and overlapping of reading. This paper describes how to configure the RFID system in production line. It reports the result of the study to identify the proper location of antennas, to setting up the system components, to develop the software and to investigate the effect of tag orientation to the reading performance. The result will be useful in implementation of RFID system in the production line.

Configuration And Methods

The system was developed by using CSL CS-461 RFID components that consists of; reader, antenna, tag and personal computer. The reader is powered with the extremely high inventory rate, true dense reader mode and high tag velocity detection. The reader is able to connect and control four UHF antennas from its 4 TNC duplex antenna ports. The reader is connected to the computer via Ethernet LAN cable (RJ45 socket). Either static IP address or Dynamic Host Configuration Protocol (DHCP) can be used in the reader – computer configuration. Static IP address was used as it is more convenient compare DHCP, since it is not changed when the reader reboots. However, the user need to ensure there is no collision occurs with other network devices in the network. The complete setup of hardware components is shown in Fig. 1.

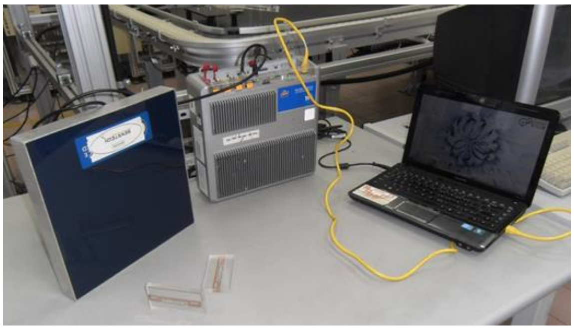


Figure 1. Setup of the hardware components of the RFID system

In multiple antenna installation, the most important concern is spatial coupling or isolation between antennas. When the antenna is mounted back to back, there is possibility that the back lobe of the antenna will be able to transmit enough of the energy to turn on a tag that are on the opposite side that should only be picked up by the opposite antenna. To avoid this inaccurate detection, a spacer metal plate can be put between the two back to back mounted antennas, or the antenna can be placed farther apart or a combination of the two methods can be applied.

In computer configuration, the protocol IP address needs to be changed. Under Internet Protocol Version 4 of the Control Panel, change the IP address to 100.100.100.2 and subnet mask to 255.255.255.0. Re-enter the IP address via Internet Explorer then the web-based administration page of the reader will be displayed on the web browser and ready to be used.

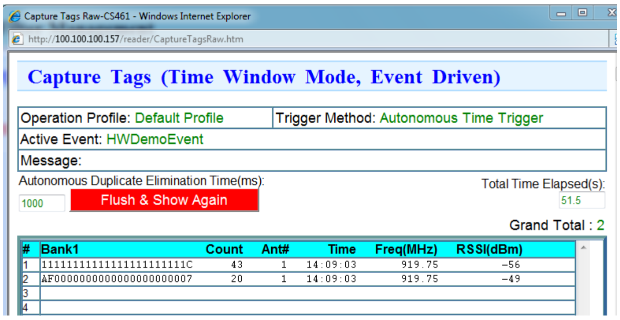


Figure 2. RFID tags are detected

RFID tags need to be placed close to the antenna in order to test the reading function. Activate the tag capture popup window of the administration page. If the connection of RFID hardware and computer configuration is successfully complete, the RFID tag will be detected as shown in Fig. 2.

The software was developed under Microsoft Visual Studio software and built using CSL High Level API Manual. Three windows were developed as the user interfaces; Write Tag (for changing the EPC of the tag), Kill Tag (for killing the tag ID and information), and

Read Tags (for tag detection). The Read Tags tab contents the main function of the whole software development. The software was built for measuring time detection of the tag and its location. The software could be further developed to calculate the waiting time and processing time in manufacturing workstation of the shop floor.

II. Result and Discussion

The developed RFID system was installed to the Flexible Manufacturing System (FMS) at The Laboratory of Computer Integrated Manufacturing System, International Islamic University Malaysia. The FMS consists of three processing stations (milling, turning and assembly), two storage racks and one close loop conveyor as part transport system. Three RFID antennas were located in the FMS as shown in Fig. 3. The location and position of the antennas were set to avoid overlapping detection.

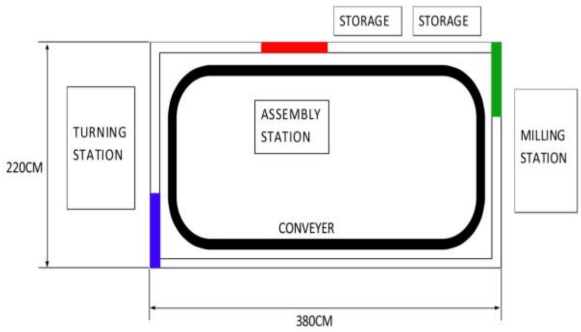


Figure 3. Layout of the FMS

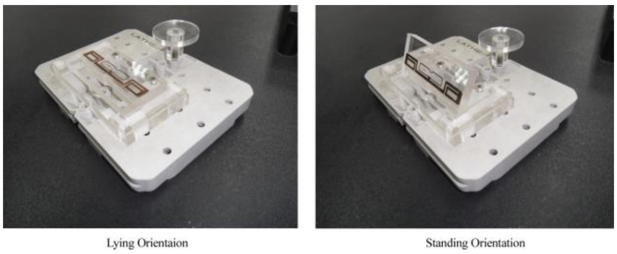


Figure 4. Two orientations of RFID tag on the work carrier

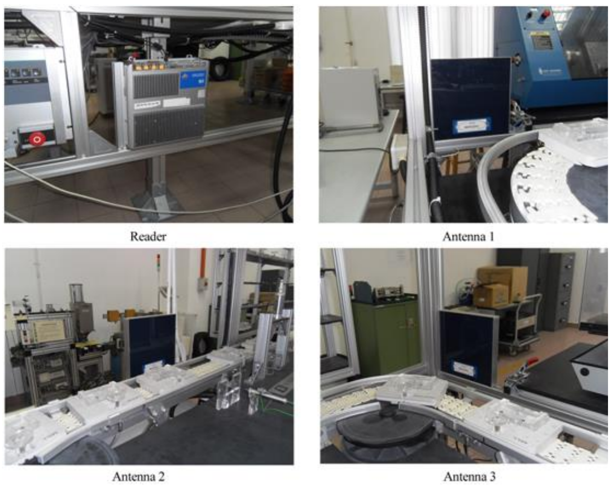
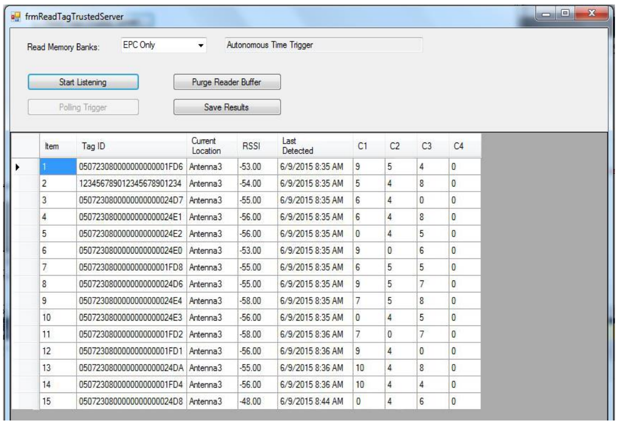


Figure 5. Movement of the RFOD tagds in the flexible manufacturing system



Item	Tag ID	Current Location	RSSI	Last Detected	C1	C2	C3	C4
1	050723080000000000001FD6	Antenna3	-53.00	6/9/2015 8:35 AM	9	5	4	0
2	123456789012345678901234	Antenna3	-54.00	6/9/2015 8:35 AM	5	4	8	0
3	0507230800000000000024D7	Antenna3	-55.00	6/9/2015 8:35 AM	6	4	0	0
4	0507230800000000000024E1	Antenna3	-56.00	6/9/2015 8:35 AM	6	4	8	0
5	0507230800000000000024E2	Antenna3	-56.00	6/9/2015 8:35 AM	0	4	5	0
6	0507230800000000000024E0	Antenna3	-53.00	6/9/2015 8:35 AM	9	0	6	0
7	050723080000000000001FD8	Antenna3	-55.00	6/9/2015 8:35 AM	6	5	5	0
8	0507230800000000000024D6	Antenna3	-55.00	6/9/2015 8:35 AM	9	5	7	0
9	0507230800000000000024E4	Antenna3	-58.00	6/9/2015 8:35 AM	7	5	8	0
10	0507230800000000000024E3	Antenna3	-56.00	6/9/2015 8:35 AM	0	4	5	0
11	050723080000000000001FD2	Antenna3	-58.00	6/9/2015 8:36 AM	7	0	7	0
12	050723080000000000001FD1	Antenna3	-56.00	6/9/2015 8:36 AM	9	4	0	0
13	0507230800000000000024DA	Antenna3	-55.00	6/9/2015 8:36 AM	10	4	8	0
14	050723080000000000001FD4	Antenna3	-56.00	6/9/2015 8:36 AM	10	4	4	0
15	0507230800000000000024D8	Antenna3	-48.00	6/9/2015 8:44 AM	0	4	6	0

Figure 6. The display of reading time

A set of experiments was conducted to detect the reading performance of the RFID system. The tag was attached to the standard part of the FMS that made of acrylic with the dimension of 80 mm x 50 mm x 10 mm. The part with tag was put on standard work carrier of the conveyor with two different orientations: laying and standing as shown in Fig. 4. Fifteen tags of each orientation are transported on the work carrier trough the conveyor of the FMS. All of the tags were transported through the reading area of the antennas as shown in Fig. 5.

All of the tags were successfully detected by the system. The detection time of each antenna are recoded and displayed as shown in Fig. 6. First column (Item) represents the tag number (1 to 15). Second column (Tag ID) represents the identification code of each tag.Columns C1, C2, and C3 represent the duration in seconds of detection time by respective antenna (C1 = Antenna1, C2 = Antenna 2, C3 = Antenna 3).

TABLE I. Mean and Standard Deviation of Time Detection

	Time Detection (seconds)					
	Antenna 1		Antenna 2		Antenna 3	
	L	S	L	S	L	S
Mean	5.60	9.37	3.73	7.33	5.40	10.47
SD	3.68	0.44	1.53	0.47	2.52	0.62

SD = Standard deviation
L = Lying position
S = Standing position

In order to get clear information regarding the reading performance, mean and standard deviation of the reading time were calculated for each antenna and orientation as shown in Table I. The result of shows that reading time of standing orientation is longer than lying orientation at all of the antennas. This means that standing orientation can be detected further than lying orientation. The result also shows that standard deviation of standing orientation is lower then lying orientation at all of the antennas. It means that standing orientation has better stability since its deviation of the reading is smaller compare to lying orientation.

III. Conclussion

The configuration of RFID system, including computer setup, software development and hardware installation has been discussed in detail. The experiment has been conducted to investigate the effect of tag orientation to reading performance. The result shows that standing orientation has better reading performance compare to lying orientation. The information will be useful when RFID is applied in real production line.

Acknowledgment

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- High speed milling of silicon carbide with diamond coated end mills (Advanced Materials Research Journal, vol. 576, pp. 535-538, 2012).
- Diamond coated end mills in machining silicon carbide (Advanced Materials Research Journal, vol. 576, pp. 531-534, 2012).

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