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Design of the Production Line Based on RFID through 3D Modeling

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Abstract**—**Radio-frequency identification has entered as a beneficial means with conforming GS1 standards to provide the best solutions in the manufacturing area. It competes with other automated identification technologies e.g. barcodes and smart cards with regard to high speed scanning, reliability and accuracy as well. The purpose of this study is to improve production line's performance by implementing RFID system in the manufacturing area on the basis of radio-frequency identification (RFID) system by 3D modeling in the program Cinema 4D R13 which provides obvious graphical scenes for users to portray their applications. Finally, with regard to improving system performance, it shows how RFID appears as a well-suited technology in a comparison of the barcode scanner to handle different kinds of raw materials in the production line base on logical process.

Keywords**—**Radio Frequency Identification, Manufacturing and Production Lines, 3D modeling

I. Introduction

CURRENTLY, radio-frequency identification (RFID) has been playing an increasingly important role in the manufacturing, industry, supply chain, etc. It is a complicated system and consists of wide variety of jobs; for instance, identifying each object to be distinguished where it is located, and even it may provide the best solution for inventory control of stuff in warehouse management [1]. Meanwhile, it is a kind of competent automated technology that has the ability to retrieve and store information in the database.

RFID system can be used in various classes with variety of applications. As a case in point, the sorts of tags and readers, which are capable to track objects in the supply chain [2], are different from the ones used in emergency medicine [3]. One of the most substantial RFID system features in industry and manufacturing places is to recognize error messages which may occur during processing. Stepwise, all objects are identified and traced by the integrator. Therefore, with RFID reader software, status of each object can be displayed. A typical RFID system is comprised of readers, tags, antenna, and application software. Tags attached to target objects have an internal memory where all information about the object can be stored. An RFID reader corresponds with tags by radio frequency (RF) signals via antenna and subsequently, application software is needed to monitor the data [4].

Types of tags are categorized into three segments as follows [5]:

1) A passive tag uses from an integrator's radio wave as a source of energy to make a communication with an interrogator. The range of frequency, in which it has to be detected, is finite. Passive tags can be found cheaper, smaller, and lighter than other types of tags.
2) An active tag, which has an internal battery as a power source, communicates with the reader via RFID gate. Active tags are larger and more expensive and can be detected at wider distances than other types of tags.
3) A semi passive tag does not require receiving energy from interrogator or reader, so it can be woken up by battery to power on-board circuitry. Semi passive tags may act similar to sensor tags since the battery is used to power the sensor. Ordinarily, in diversity of applications, semi passive tags have more functionality as compared with passive tags owing to having more power.

This research attempts to illustrate the role of radio-frequency identification as a key solution in the manufacturing, and how RFID can be notably applied to the production line. At first, related works in manufacturing area is going to be carried out, and then the case study, which has been simulated by the Cinema 4D R13 software, will be reflected. Finally, it will be revealed how the total number of products would be increased by RFID application in a comparison of the barcode scanner where diverse types of materials are going to be produced.

II. Related Works

Different applications of RFID have been discussed by the last decade. The novel passive RFID tag was investigated in the oil drill pipe aiming that they can predict the lifetime of pipe and manage inventory control [6]. In a discrete manufacturing system, RFID system was applied in production control in order to enhance the quality and management level of production efficiency. An RFID detects the product during the producing stages and information can be updated in the database. Therefore, manager can check the status of product in real time [7]. A new Kanban management system in Lean manufacturing based on RFID was proposed to enhance Just-In-Time production mode [8]. The benefit of RFID technology in the emerging wireless internet manufacturing area was pointed out [9]. Applications of RFID in assembly line have been reported and the role of RFID for vehicle production was highlighted [10]. Through these applications, RFID advantages were demonstrated in the production line and warehouse management through 3D modeling and a specific model for warehousing operations was proposed [5]. The concept of agile management based on RFID system was taken into account in a manufacturing area to track and monitor assembly equipment [1].

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In a random mix manufacturing, the role of RFID for welding operations performance by a robotic assembly cell was discussed [11].

III. Integration of RFID System in the Production Line

Now, the significant role of radio-frequency identification is investigated, whether it can be a beneficial solution in the production area. First of all, with regard to having prosperous implementation, equipment has to be installed with the RFID system. This section is going to elaborate all the sequent works.

The motive why the case study was preferred to be simulated is to implant the whole equipment manufacturer in the convenient virtual environment. In other words, pertinent outline is designed in the software while optimum outcomes were achieved, then the actual building is going to be prepared. At first, this study was modeled and simulated in the Cinema 4D R13 which provides obvious graphical scenes for users to portray their applications. One of the dominant advantages of this program is to use dynamic systems, so it may be applied to dynamic motors, forces, connectors, etc., for particular systems such as a conveyor used for transportation.

In this case (see Fig. 1), three stations including three robot arms and machines, whose 3D model is depicted in Fig. 1, were designed that each station performs the discrete job.

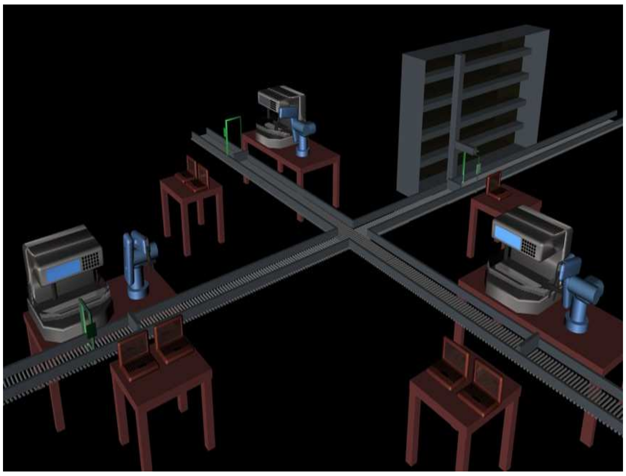

Fig. 1 3D model of production line based on RFID system

An automated storage and retrieval system (ASRS) is also obtained to remove raw diverse materials and leave them on the pallets transported on the conveyor. Moreover, it associates with a computer for treatment and recognizes which material has to be placed respectively. At the front of each station, a local computer (asset master), which is connected to a robot and machine, were located. Furthermore, three RFID gates are deliberated beside places that each of them has an antenna which can correspond with the reader. They detect the number of either inputs or outputs of parts to or from locations and send the data to the reader to communicate with related controller in each station.

In the assumed scenario, three sorts of raw materials, which are named by A, B, and C, are going to be machined by three different machines. Specific tags are labeled on each part. In addition, tags are introduced to the RFID system until parts can be carried to the appropriate place. As an illustration, since part A passed across the first gate, it is identified by the reader and sent to the station No.1. There are three distinct routs that parts A taken to the station No.1, parts B conveyed to the second station, and the last parts (C) transported to the station No.3.

At the beginning, when the system starts running, all pallets manually put and traverse to the ASRS location where a part A (first type) is loaded. Then, the RFID gate detects the status of current tag and sends it to the first station. The robot picks the part and places it on the machine. Operation time is limited to 35 time units in this place. The repetition process has been taken place since the maximum three parts are in this route and then, RFID system calls the part B (second type) from the ASRS and it is taken to the second station as long as four parts just remain in this route. Part B is fixed on the second machine by the related robot. The current machine performs processing in 25 time units. Meanwhile, it verifies the first line. If the number of parts became less than three, the first part would be taken from ASRS and sent to the first station again. After those lines were completed, the last type (part C) is distinguished from the ASRS and traveled to the third station. The related robot acts and puts it on the third machine which does processing in 10 time units. Through this procedure, RFID system checks the number of products on lines 1 and 2 again. If the parts become less than specific capacity, RFID commands the ASRS to put parts A or B on the conveyor in order to arrive at stations 1 or 2. Fig. 2 elaborates the entire production line proceeding.

Before removing parts from ASRS, the first RFID gate (as an entrance gate) identifies objects with regard to be dispatched to appropriate places. Other gates also display the number of parts leaving in each station. The logical process has been programmed for the reader to determine which route and part can be distinguished. Fig. 3 shows the flow chart of this method between RFID system and ASRS. It explains variety of stages of the process accomplished by the RFID system. As can be seen three logical processes were defined to the system, and the first two of them control the number of inputs and outputs and command to the ASRS to pick the suitable type of raw material in terms of preventing conflict in the routes. Due to the limited capacity of conveyor and operation time of machining process, the maximum number of parts staying to arrive at stations No. 1 and 2 are finite.

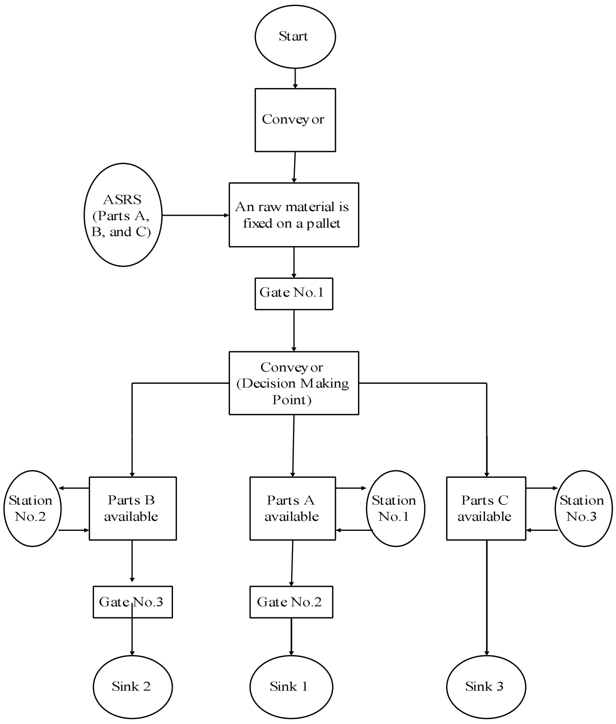

Fig. 2 Description of production line proceeding

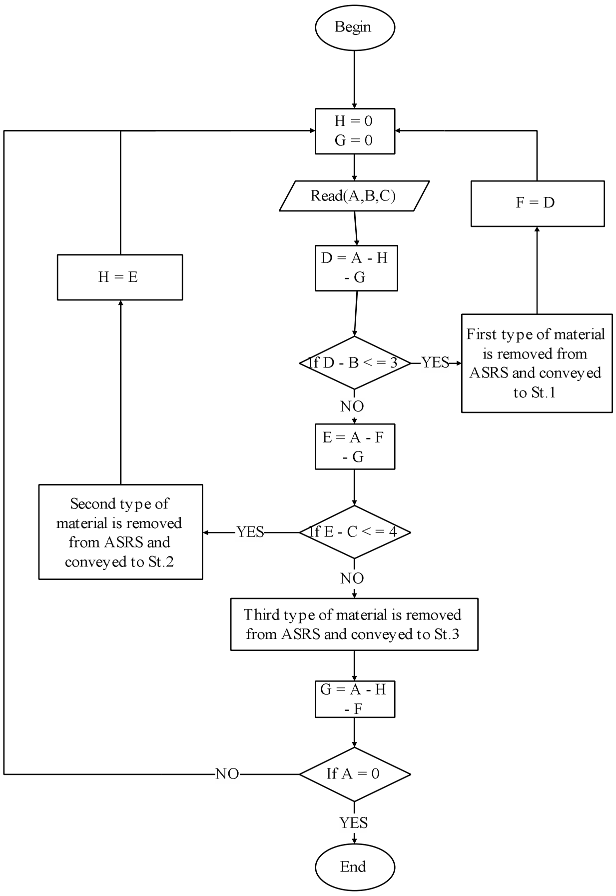

Fig. 3 Flowchart of programming for the RFID system

TABLE I
FEASIBLE ALGORITHM OF THE RFID SYSTEM

Steps	Description
1	Start
2	Variables of H and G represent the number of parts which pass in stations 2 and 1. Initial values are zero.
3	Read inputs from gate No.1 stored to A, and outputs from gates No.2 and 3 stored in B and C variables.
4	D checks The number of parts. Since they are collected by St.1, D will be equal to F. In this step, first type of materials (type A) are conveyed to St.1.
5	If there are less or equal than three parts between gates No.1 and 2, first kind of product will already be removed from ASRS and taken to St.1.
6	Else E checks the number of part (type B). When they come to St. 2, E will be equal to H.
7	If four parts or less than this number detects by gates No.1 and 3, other second type of materials are taken from ASRS to St.2.
8	Else the last type of materials (type C) is conveyed to get the third station.
9	G shows parts coming to the last station.
10	If A identifies that any part has not passed across the first RFID gate the program will be stopped.
11	Else it returns to third step.
12	End

Table I presents the feasible algorithm which the RFID system conforms and explains all steps in Fig. 3. It also displays all of the parameters introduced to the RFID system. In addition, it demonstrates how logical process is programmed in this study.

IV. DISCUSSION

In this section, authors' aim to compare the assumed case study without installing RFID technology when the logical process is denied. A barcode scanner, which can identify ID number of parts, is fixed before the decision making point on the conveyor. After the first variety of raw material (type A) is assembled on the pallet, it is read by the barcode reader and taken to the first station (for 16 parts). When they are completed, part B is ordered from ASRS and detected by the scanner in order to be sent to the second station (for 19 parts).

Similarly, this procedure goes in the same vein for the part C, whereas it is carried to the third station (for 25 parts).

Two cases were compared by the Cinema 4D software. In addition, all numerical scales (per time units) concluded in 636 time units are shown in Table II.

TABLE II
COMPARISON OF RFID AND BARCODE IN THE PRODUCTION LINE (IN 636 TIME UNIT)

Sources	Throughput sum		Service time	
	RFID	Barcode	RFID	Barcode
ASRS	60	36	4	4
M 1	16	16	35	35
M 2	19	8	25	25
M 3	25	-	10	10

Sources are included all machines and the ASRS. The throughput sum index means the total number of parts leaving in each source, and the Service time index explains the operation time units for each part to leave a source. Both situations simulated in the same service time. From the view point of total number of parts machining, RFID ameliorated the assumed system performance by managing higher parts. Thus, the ASRS robot can prepare 60 parts on the conveyor and Machines 2 and 3 perform machining for greater number of parts.

V. CONCLUSION

RFID has come as a useful technology in industrial automation. It is capable of having functionalities such as part detection, accuracy, and reliability to allow manufacturers or companies to increase their efficiency in terms of improving system performance. The present study has investigated an application driven in the manufacturing area based on RFID system through 3D modeling. Furthermore, it has explained how the logical process is defined to handle different sorts of materials by means of RFID technology in the production line as compared with the barcode scanner. This method is applicable to be implemented for any small and medium-sized manufacturing shop floors.

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