RFID BASED INSPECTION SYSTEM FOR ASSEMBLY OPERATION

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Abstract

This paper is called RFID based for Inspection System for assembly operation. The Radio Frequency Identification Method (RFID) system is used in developing an inspection system to inspect the assembly product by defining the correct amount and right components that have been assembled. The system consists of the RFID system driven by PC, conveyor and external devices such as indicator lamp, press button, and buzzer that driven by a programmable logic controller (PLC). The RFID system will read the data of tags that have been attached to the parts of product when the product passes through the RFID reader. The data will be read by the Visual Basic (VB) interfacing software on PC and will be compared with the saved standard data. The product is considered accepted if the data is matching with the standard data while the product will be considered reject if there are unequal numbers of parts or wrong component being assembled. The warning system that consists of indicator lamp and buzzer will be activated when the product is rejected. Performance analysis of the read range of the reader and relationship between selected materials of parts is conducted to estimate the effectiveness of integration of RFID into the inspection system.

Keywords:** **RFID Inspection System, product assembly, RF field characterization

I. INTRODUCTION

Inspection system is an important process in manufacturing practice. In order to ensure that the product produced is in standard quality and conform to the specification of customer requirement. Effective and efficient quality management based inspection systems are needed to complete the customer order with the standard quality requirement [1]. Currently, the automatic inspection system uses machine vision system to inspect a product [2]. However, vision system is largely used as a medium of inspection to inspect the defect of the product. Vision system does not have the capability to inspect in term ensuring that the correct amount of component is assembled and it does not have the algorithm to ensure that the right components are assembled at the right slot. This is where RFID mechanism will play its role. Otherwise, the manual system by using manpower is just another easy option to inspect the product. For example, in real case situation, there is a problem in PC assembly operation in which there are many different combinations of configuration taking place although it may use the same cases, with no differences in outer dimensions [7]. This is where RFID application can be introduced in order to ensure that the correct amount of part is being assembled to the central processing unit (CPU) of the PC and to ensure that the right component is being assembled at the right slot of the CPU [9]. In addition, Barcode system is an alternative for this purpose, but, in PC assembly, barcode reading still require either an operator moving the part under the bar code reader or the operator himself needs to scan the part. Therefore the drawback of bar code system is it involves manpower to operate it. Furthermore the disadvantage of barcode system is, it has low level of ruggedness or durability [8]. The bar code can easily malfunction if it is over exposed to water. In other words, bar code system is not a full fool-proof method. True mistake-proofing can only be achieved with devices that are deeply embedded within the production process and require no additional labor [3]. In developing an effective automatic inspection system, Radio Frequency Identification (RFID) system has been selected to integrate with the inspection system especially for assembly product. RFID is one of the cutting edge technologies around and it brings an impact into our lifestyle. RFID technology works in such a way that the RFID tag or marker is attached to an individual item and it act as a product identifier. The number is encrypted within each RFID chip and the use of a scanning device then activates the particles within the RFID chip to enable it to read the code by using electromagnetic waves [4].

II. EXPERIMENTAL METHOD

A. Installation of RFID system

The RFID inspection system consists of OMRON RFID system 13.56MHz/ HF V720 series, and conveyor system. The RFID system connected to the PC by RS-232 cable to interface the RFID controller is shown in Fig.1.

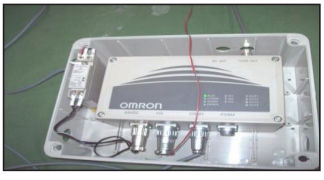

Fig.1. RFID Controller

The reader shown in Fig.2 is connected to the RFID controller using antenna cable (V720-A41).

Fig. 2. RFID Scanner

Output 1 on the I/O connector is connected to the input of SIEMENS SIMATIC S7-200 PLC that drives the conveyor system. An external device shown in Fig. 3 is connected to the same PLC that drives the conveyor system. The complete layout is shown in Fig. 4.

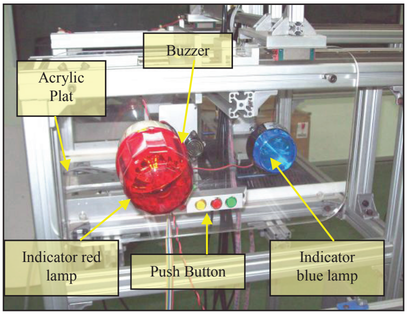

Fig. 3. External devices of the system

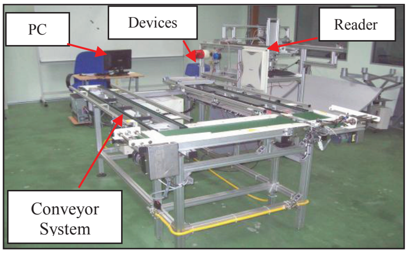

Fig. 4. Complete layout of RFID Inspection System

B. Visual Basic Interfacing Software

The process in developing the Visual Basic (VB) interfacing software consists of five steps. Step 1 is to analyze the design by defining the problem, step 2 is to design by planning the solution to the problem, step 3 is to choose the interface by selecting the objects (ex. Click button, list box, text box etc.), step 4 is coding process by translating the algorithm into a programming language, and finally step 5 is testing and debugging and to rectify errors in the program. The completed programming that has been developed has an ability to integrate with the RFID system and able to monitor the reading data at the display screen on the list box no.1 label as "no. of boxes". In this case, the operator can figure out the data of parts assembled. The standard data of parts assembled is read by RFID system by clicking start button and save it to the command list box no.2 labeled as "save data" box. Hence, by clicking the "save data" button, the operation will proceed to another product and read the data of it parts assembled. Data gathered will be compared with the data of standard parts by clicking the "check button". If the data of parts assemblies that have been read match with the data of the standard part assembled, then the product will be accepted and pass the inspection process. On the other hand, if the data is not matched, the part assembled will be rejected in such a way that the warning red light will blink, the warning buzzer will be activated and the conveyor itself will automatically stop. This condition is set up to indicate to the operator that there is a rejected part in the assembly line. The software also has the ability to send an output command to RFID controller if the situation of product is rejected. The command that has been sent to the RFID controller will activate the output no.1 of the controller. The graphical view of the complete software is shown in Fig. 5.

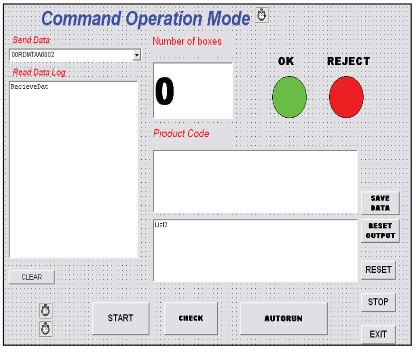

Fig. 5. Graphical User Interface (GUI) of the system

C. Wiring and Programming of PLC

The system requires a PLC wiring as an interface to run the conveyor and external devices. The output no.1 of the RFID controller and push button will be connected to the input of PLC with the external power 24VDC. A red and blue indicator lamp and also buzzer are connected to the output port of PLC. PLC is programmed using the Step 7-Micro/Win software by integrating the connection with the ladder logic diagram. The program must follow the requirement of the project that is to activate the blue indicator lamp when the start push button (green) is pressed. An active output no.1 of RFID controller will activate the red indicator lamp and buzzer while the conveyor is deactivated to avoid transferring a rejected product to the next station. The function of stop button (red) is to deactivate the red indicator lamp and the buzzer while the reset push button (yellow) is to deactivate all the output of an external device. Table 1 and Fig. 6 show the list of input and output of the system for the wiring purposes and the PLC wiring diagram.

Table 1:List Of Input Output Of The System

Input Components	Output Components
Push Start Button (Green)	Indicator lamp 24V (Blue)
Push Stop Button (Red)	Warning lamp 24V (Red)
Push Rest Button (Yellow)	Buzzer 24V
RFID Controller I/O port for Output1 (24V External Power Source)	Conveyor System

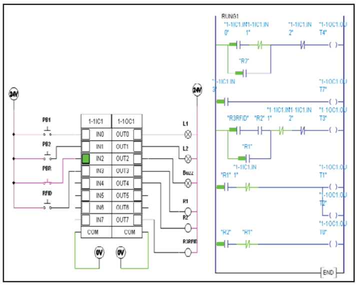

Fig 6 PLC wiring diagram

D. The system's flow

The flow process of the inspection system is shown in Fig. 7. It starts with the assembly operation and then the conveyor system will start simultaneously. The product assembly will be transferred pass through the RFID reader via the conveyor. The reader will read the data and compare the data with the standard data. The product that have fulfilled the specification of the standard part will pass the inspection operation by RFID and it will be transferred to the next station and finally it will be collected by operator or robot as the accepted finish product. On the other hand, the rejected product is indicated by the red lamp indicator and buzzer will be activated in parallel as well as the conveyor will stop the pallet from transferring to the next station. The operator will be alerted by the signal from the red indicator lamp and from the noise buzzer. The operator will pick that particular product for rework activities. After that the same cycle will continuously run from one station to another. The process is repeated until the product passes the inspection system.

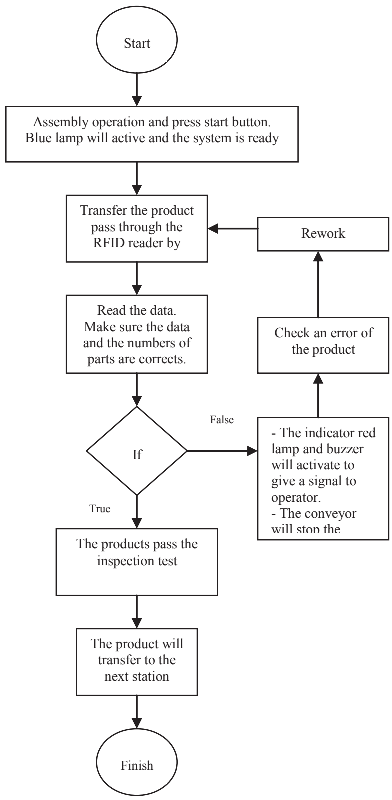

Fig. 7. The overall flow process of the system

III. RESULT AND DISCUSSION

A. Inspection and Testing

The prototype of part assembly is used to test the inspection system whether the system is functioning effectively to read the data of part assembled, to display the data, to compare the data with the standard data and to send a signal to indicate to the operator whether the product is accepted or rejected. The part assembly of product is developed based on the design that has been created as shown in Fig. 8 and Fig. 9.

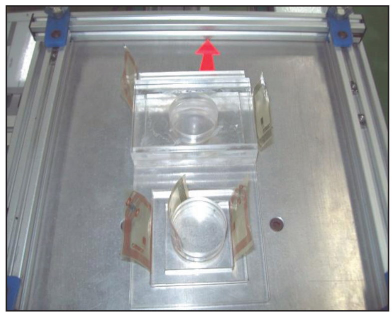

Fig. 8. Product Assembly

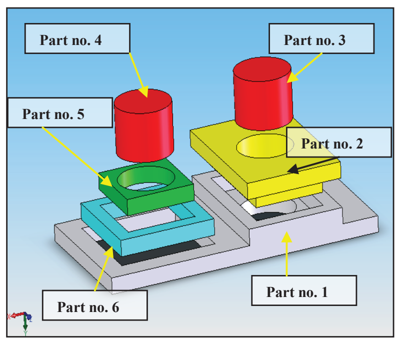

Fig. 9. Exploded View of Product Assembly

For this test, the standard part is firstly read by the reader and then the data is saved. After that, any finish product will pass through the reader for inspection purposes. This can be done by clicking the “autorun” button at the graphical user interface. The reader of will read the data of parts assembled automatically and make a comparison between the current data with the standard data. There are four phases of experiments needed to be conducted in order to test the effectiveness of the system. First experiment is to test the correct amount and the right parts assembled that can give an accepted result as shown in Fig. 10.

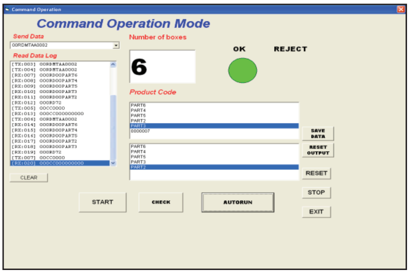

Fig. 10. Result to show that the inspection is "OK"

Second experiment is to test the amount of part being assembled whether the amount of components being assembled is correct or not. In other words, to test whether the amount of parts assembled is matched with the standard or not. The result is shown in Fig. 11.

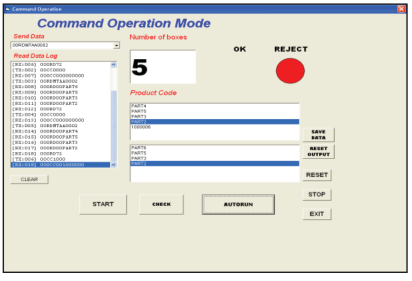

Fig. 11 Result to show that the inspection is "reject"

Third and forth experiments are to test, whether the system are capable or not to show a "reject" indicator when the amount of the parts and the components are not matched with the standard .This can simply be done by taking out one of the parts and replace one of the standard part with a non-standard part. The result is shown in Fig. 12.

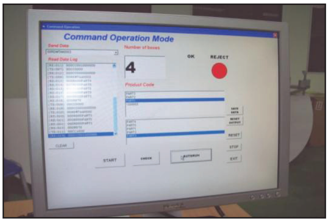

Fig. 12 Result for third and forth experiment

B. Reader read point and RF field characterization

The procedure for analysis is by measuring the maximum read range in the middle, left/right, and top/bottom of the reader by reducing the distance between tag and antenna until the reader display the data of tag. When the data inside the tag is being traced by the software interface, it simply means that the reader can read the tag from that particular distance. It also reflects and indicates that the particular distance is the maximum distance the scanner can read the tag. The environment factor and the orientation factor are also taken into consideration to find the barrier of antenna read range. The frequency of data is taken fifteen times to find the maximum distance. The graph is constructed as shown in Fig. 13.

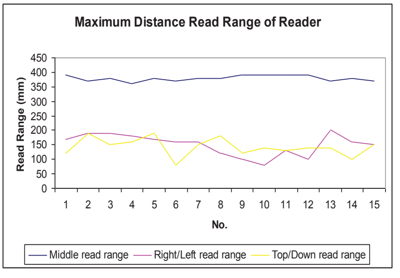

Fig. 13 Result shows the maximum distance of the scanner can read

From the recorded data, it can be concluded that the reader has its own geometry pattern in term of the read range. Fig. 15 shows the geometry shape of read range by the reader. The read range of data is referred to the orientation of tag based on the experiment result recorded from Fig. 14.

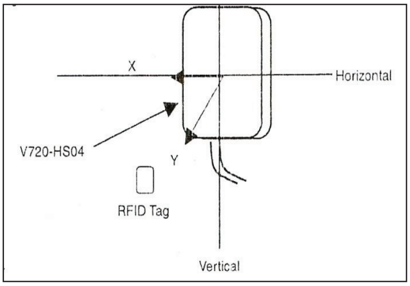

Fig. 14 The orientation of the tag

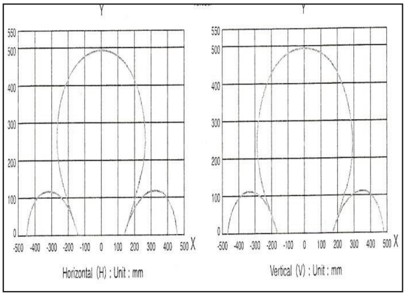

Fig. 15 Geometry shape read range of the scanner

The RF field that is radiated from the antenna has the property to control the Radio Frequency (RF) field. As a result, the geometry of the antenna has a significant effect on the visibility of RFID tags when presented to the antenna. The polarization is defined as the direction of the RF field relative to the earth. Knowing the direction of polarization is important because the transmission of energy between two linear polarized antennas is optimal when both antennas have the same polarization direction. The environment can affect the RF field radiated by the antenna as well. Therefore, great care has to be taken if an antenna is mounted near metal surfaces. It is recommended to plot the RF field characterization in order to map the signal coverage in the area where the tags are expected to be in the field of view of the antenna. RF field characterization is defined as the mapping RF field emitted by an antenna which defines the read pints. On RFID system, the reader's power settings, the gain, the RF field pattern of the antenna, and the environment define size and shape of RF field. The RF field can be changed because of metals around the read point and orientation of the physical antenna. Field characterization is a way to optimize the visibility of tags when presented to the antenna or read point within the RF field. Optimizing RF field is an iterative process requiring the proper orientation and canting of the antenna. Among other settings, the RF engineer should adjust the power settings to provide the proper RF field shape and size. One aspect to keep in mind is that by adjusting the power settings the read between the tag and the antenna changes. The minimal amount of power to achieve acceptable read rates is the preferred setting. This is done to avoid generating co-channel interference to the other readers and tags in the facility.

IV. CONCLUSION

The main objectives of this project is to design and develop the inspection system based on RFID technology to ensure that the correct amount of parts and the right parts are assembled to the product are successfully achieved.

The findings are as follows:-

(a) OMRON RFID reader V720-HS can have a maximum reading distance of 500mm vertically and horizontally.

(b) RFID application can be interrupted with the presence of metal. It is because the presence of metal will interfere the wavelength signal of the radio frequency. As a result, the RFID scanner will not be able to read the tag that is in contact with metal.

(c) Environment factor and the orientation of the scanner also need to take into consideration as it may affect the capability of the RFID scanner. In noisy environment, the scanner needs to be near to the tag in order to read the data from the tag.

(d) The effectiveness percentage of correct or wrong identification of the system is 99 percent provided that it is within the range of the reading distance of the reader.

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