THE APPLICATION OF RADIO FREQUENCY IDENTIFICATION (RFID) IN SPEEDING UP THE FLOW OF MATERIALS IN AN INDUSTRIAL MANUFACTURING PROCESS

B.N. GATSHENI AND F. AGHDASI

ABSTRACT:

RFID can work in conjunction with sensors in material handling especially on a conveyor belt. A dozen different graded tagged products can be picked up by the RFID system in real-time and transported to respective chutes into automatic guided vehicles (AGV) for transportation to specific storage locations. The development of this system is now at an advanced stage. Our predictions to date show that the application of RFID in material handling in a manufacturing environment can assist in the fast flow of components throughout the assembly line beyond what available systems can do.

Key words: RFID Application, Automated Manufacturing, Automated Material Handling

1. INTRODUCTION

The improvement in the speed of flow of material in an industrial manufacturing process is critical for the global economic competitiveness of the South African economy. This competitiveness can be achieved through automating all the facets in material handling. In the process both quantity and quality must be ensured.

In this paper material shall also refer to components. In a manufacturing plant components are usually moved from one assembly line to the other by a conveyor belt. Different finished products are graded in terms of size, quality and weight among other measurements.

1.1 The current material handling system

The current material handling system designed at the School of Electrical and Computer Systems Engineering of the Central University of Technology, Free State, consists of a conveyor belt, a digital camera, a robot and chutes in which different components exit the conveyor belt into respective automatic guided vehicles (AGV) for transportation and then storage. These components are different in terms of quality and weight and are taken from one basket onto the conveyor belt. The latter and former are graded using a load cell and image analysis respectively. The weakness with the former measurement is that it was designed to discriminate components that have very distinct colours. This parameter might fail where colours are very close to each other or when discriminating components that have the same colour but different quality.

The spacing between the components on the conveyor belt is 250mm and this large spacing slows the delivery (flow) of the components to their respective destinations**.** Additionally, the slow response of the chute-image analysis system results in next in-line components piling up or falling into a wrong chute.

Radio frequency identification [12, 13] will assist in speeding up the flow of material in the manufacturing industry.

2. The Radio Frequency Identification (RFID) System:

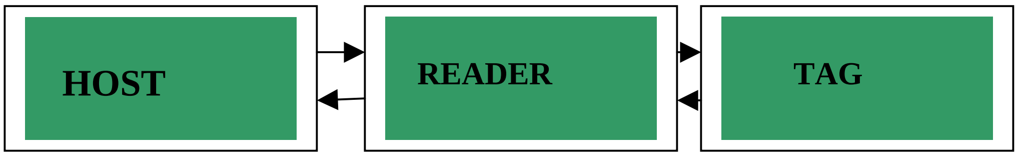

Figure 1: This is the block diagram of the RFID system. The reader acts as an interface between the host and the tag.

The RFID consists of a host, a reader and a tag (transponder). There is the master-slave relationship in Figure 1. The objective is for the host to get information from the tag. The Host constantly sends a command to the reader to collect information (identification and data) from any tag that is within the vicinity (also called the interrogation zone) of a reader. Any tag that enters the area in which the reader has an influence (interrogation zone) is activated by the reader, hence communication starts between them. A tag emits a unique identifier and also data.

RFID started in 1960 [12, 13] and was first proposed by Stockman [2].

There are two types of tags, the active and the passive tag. The active tag has a large read/write memory (EEPROM capacity of 128kb i.e. 500 times that of passive tags) and processing capabilities [4]. The high-end tag is controlled by a microprocessor respectively. What makes this tag active is the onboard battery that it uses to transmit data to the reader, consequently these tags although expensive, have greater ranges (250mm, about 6 times that for passive tags).
The passive tag (no onboard battery) is powered by radio waves from the reader; consequently these tags are cheap and smaller in size. These advantages are at the expense of the small read/write range, small storage capacity and limited processing capability and cannot read through metal surface due to their limited power.

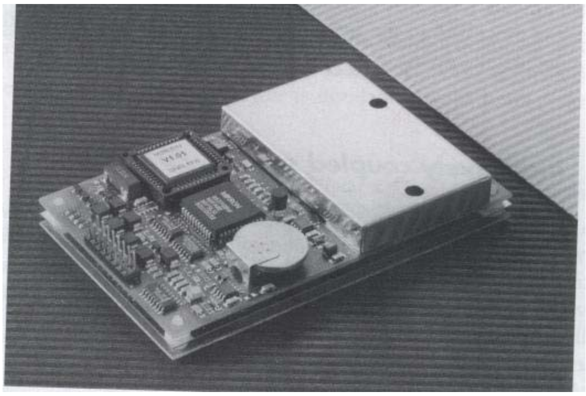

Figure 2: This is the RFID Reader.
Figure 3: This is the RFID Tag also called a transponder.

A reader is a transceiver made up of a radio frequency (RF) module and a control unit. The host initiates all reader and tag activities. The reader activates the tag, structures the communication sequence with the tag and then transfers data between the host computer and a tag. We will use the peripheral readers (attached to the host via RS 232 interfaces). Unlike barcodes readers can handle several labels in parallel. RFID tags can carry 96 bits of information compared with 19 bits for bar code technology. Unlike barcodes, RFID tag is independent of line of sight. We are building intelligence into the system so we can be certain at various points in the distribution system that components are sent to the correct location in real time.

Large-scale commercial use of RFID was in electronic toll collection on US highways [3]. RFID is used for tracking ship containers [20], in logistics [18], electrical article surveillance (EAS) in retail stores and tagging people, animal identification [22] and waste management [21].

2.1 Anti-collision

The reader can process many tags in its interrogation zone (IZ) simultaneously. In our task, the simultaneous reading of several tags in the radio frequency (RF field) is critical to speeding up the flow of materials. In addition the total time to identify all the tags is a key to ensuring that the robot arm has enough time to adjust to dimensions of each component as it comes along the conveyor belt. However, messages from tags can collide and cancel out each other at the reader and when this happens collision is said to have occurred.

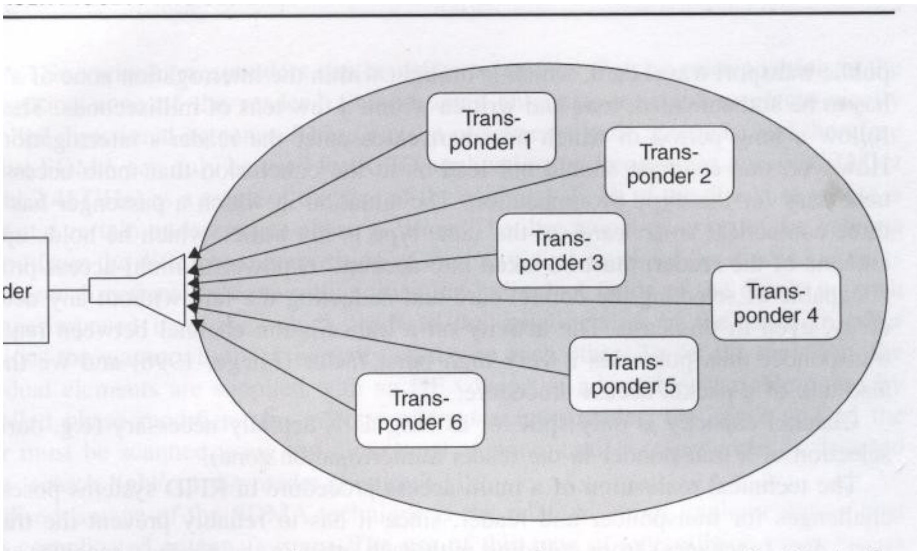

Figure 2: On the extreme left is the reader. The oval grey shape on the right is the interrogation zone of the reader. Inside the oval grey shape, in white are the tags in the IZ of the reader.

Multi-access protocols that comprise space division multiple access (SDMA), frequency domain multiple access (FDMA), time domain multiple access (TDMA) and code division multiple access (CDMA) are used in the detection and addressing of multiple tags in the interrogation zone (IZ). A more reliable and robust collision resolution protocol [15] is chosen to assist the RFID interface arbitration in ensuring that only one tag transmits its UID and data at a time.

RFID systems operate in the Industry, Scientific and Medical frequency (ISM) bands and they comprise low, high or ultra high frequency bands. 13.56MHz is used in inventories and goods on a conveyor belt among other places [6] and this frequency has been chosen for this project.

3. The proposed material handling system

In the proposed material handling system, there are 2 approaches that comprise the **RFID – Chute System** and the **RFID – Robot System**. The chute and the robot are linked to the host. The manufactured components come onto the conveyor belt already graded for quality and then labeled. In this project we have replaced some of the sensors with RFID as the former lacks the ability of storing information on a component. In addition, the latter is also capable of performing in real time. A tag on a component carries information on the quality, customer information, the chute in which it is to exit the conveyor belt and the width of the component. The component information read by a reader from the tag is compared to that in the host.

3.1 The RFID – Chute System

In this system, the Reader reads the information from the tag as the latter enters the interrogation one of the reader on the conveyor belt. The reader sends the information to the host. This information (includes the chute in which the component has to

exit the conveyor belt) is then transferred to a database where it is accessed by the chute which in turn effects appropriate action to ensure the component exits the conveyor belt through the correct chute.
It is required to ensure that different components A and B closely following each other will not exit through the same chute. This is achieved by having a threshold built into the chute system such that when a component is 0.75 of chute, the chute opens and then shuts before a closely following different component gets to the 0.75 mark.

3.1.1 The RFID – Robot System

The robot has to lift the component from the conveyor belt and put it in a relevant chute. Currently a robot uses sensors. Sensors lack the capacity to store the different dimensions information from the component. Sensors can be blocked by dirt and as a result can give false information. The robot is linked up with information contained in the tags through the database in the host. A signal is then sent to the Robot to exercise appropriate action to ensure the component exits the conveyor belt through the correct chute.

Currently the robot is programmed such that it can traverse to a specific component height. If a bigger component is brought it, the robot has to be reprogrammed and this is a handicap. The functioning of the robot is being modified such that a grip on different component sizes does not require reprogramming the robot. We also want to assist the robot to hold, lift and place components from the conveyor belt to the correct automated guided vehicle (AGV). We want to replace sensors with a system that can store information for the robot hand.

3.1.2 The spacing between components

We are maximizing the flow of components by having less than 2mm spacing between the components on a conveyor belt from the current 250mm spacing. The host continuously polls the conveyor belt using the reader. Tags might enter the IZ of the reader almost at the same time. We need to ensure that the component at the front is served first, otherwise if a component that is second from front of even more might push those in front resulting in a pile and hence some components might end up falling into wrong chutes. Multi-access protocol is used to ensure that there is no collision and that the tag in front is served first (tag nearest to the reader). The range for the reader is such that it ends somewhere on the conveyor belt to ensure that it does not read into the basket where all tags are taken from onto the conveyor belt.

3.2 System Development

System development included the hardware and software development.

3.2.1 Hardware development

The PIC 16F628 currently developing the hardware systems using the PIC 16F628 which will later be replaced with MiFare (chip) hardware (cutting edge) as the latter is more versatile. We are working on the layers of communication protocols so that these units (reader and tag) can communicate effectively.

MiFare's EEPROM has 16 independent sectors (memory locations). Each sector has its own access key. As a consequence, only a reader with the access key of that sector can access it. In terms of application in material handling, sixteen different components can be allocated to different sectors. However, there will have to be a corresponding number of RFID readers. Since all the 16 readers' interrogation zones converge on the conveyor belt, there will be overlap of these IZs. We are working on resolution protocols (one tag - many RFID readers) in order to resolve the problem.

3.2.2 Software development

A system that matches output from the reader to the host's database has been developed. Java has been used to enable the reader to interact with the MySQL database of components on the host computer. JDBC was used to rope in the MySQL database with the Java in the reader. This system matches information from the tag attached to a component with that contained in the database of all manufactured components.

3.2.3 Experimentation

20 components in one basket constituting 5 different groups in terms of quality, size and weight were put on the conveyor belt in a random order. In each group all the 4 components were similar. There was no spacing between the components on the conveyor belt. The reading from each component was sent to the host.

4. RESULTS

The hardware is still being developed. The software (using java and JDBC) for the reader has been partially completed. The database has been created using MySQL.

5. CONCLUSIONS

A system that improves material handling has been proposed. The application of RFID in material handling in an industrial manufacturing process can potentially improve the competitiveness of the manufacturing industries and hence the global economic competitiveness of the South African economy. Our predictions to date show that the application of RFID in material handling in a manufacturing environment can assist in the fast flow of components throughout the assembly line beyond what available systems can do.

6. FURTHER WORK

In terms of further work, we want to use tags that incorporate sensors and actuators and that are orientation independent. We shall endeavor to equip AGV with RFID so that it can deliver components to appropriate stacks.

7. ACKNOWLEDGEMENTS

We would like to thank the CUT Innovation Fund for sponsoring this research. We would also like to thank members of the RFID Research Activity at the CUT who gave constructive criticism on this work.

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