Incorporating Radio Frequency Identification into The Production Line for Work Flow Improvement

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***Abstract* - Radio Frequency Identification (RFID) technology can be used in many different applications. There are numerous instances of RFID being used in everyday life. For instance, anyone who works in a secure office, goes to university, drives a car with an immobiliser or parks in a secure car park. Other scenarios include the tracking of animals in the farming industry when cattle and sheep need to be identified by the farmer. Another instance where RFID can be used is in the manufacturing industry. Tags can be attached to items that are moving through the factory on conveyer belts or being moved around by staff on trucks or forklifts. This paper documents a "real life" manufacturing facility, assess its current work flow process, evaluate them against industries best practices and seek to integrate RFID to help stream line work flow. After assessment, the RFID solution will be implemented to tackle the highlighted areas. This will be achieved by understanding the client's current situation, industrial best practices and how RFID technology can be implemented now and modified in the future to continue to maximize efficiency. The expected outcome of the research is that RFID can contribute to modern work flow systems, however all systems will be inevitably based on a software database, and it will be how the RFID technology is used to create additional database entries and manipulate or link existing data that will see its true value.**

Keywords – RFID; Lean manufacturing; Location Determination; RFID tracking.

I. INTRODUCTION

It is often said in the automation industry that to control, you must first measure. RFID is a non contact, long distance, water proof, high temperature resistant, data storage, automatic identification system. These attributes make RFID the ideal solution for tracking and measuring the flow of physical items throughout a plant. The RFID system comprises of an integrated collection of components, the tag, the reader, the reader antenna, a controller, a sensor, actuator and annunciator (optional), host and software system and communication infrastructure [1]. These qualities allow RFID to play an important role in allowing the physical flow of equipment throughout a plant to be linked to, or create an information flow that is real-time. This type of information used in the correct way can allow for a transparent plant wide view of how the plant runs, enabling users to see and predict bottlenecks and backlogs. In acquiring this data, the plant is then in a position to allow for data interrogation in order to optimize plant or process activities. Lean Manufacturing is a process of data interrogation in order to eliminate any Non Value Adding Tasks (NVAT) thus improving efficiency [2].

All manufacturing facilities must possess and adhere to their own manufacturing systems. These systems are the foundation on which any industrial accreditations are built, they define the work flow process and are therefore critical to all aspects of how the company operates. The tools the systems are built on usually refer to electronic tools, such as software packages and written documents manually created, maintained and archived. A vast majority of these systems operating today have been developed onsite by skilled employees knowing their own responsibility and therefore produced a tool that delivers what his or her department needs to. These tools have been developed in a similar fashion, as quality controls or accreditation standards increase or the business changes. It is therefore accepted that a vast majority of these tools certainly serve their purpose, but are not as efficient or as transparent as they could be.

In today's global manufacturing environment the western world is at a disadvantage because of , high labour costs, high land rates, stringent environmental rules and regulations. These factors make it difficult for manufacturing facilities to compete with its neighbouring Asian counterpart. It is no surprise then that our manufacturing industry is in a consolidation period and looking to maximizing efficiency by increasing utilization of their current assets. This is clearly reflected in industrial management buzzwords. These buzz words are encapsulated by two ideas, Lean manufacturing and Total Cost of Ownership. Lean Manufacturing was a system originally developed by Toyota and defines wastefulness as any activity that is non value adding. It was claimed by implementing lean manufacturing, you can use less of everything compared to mass production- half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. In addition, it requires keeping less

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than half of the needed inventory on site, results in a lot fewer defects, and produces a greater and ever-growing variety of products. In short, it is called lean because it uses less, or the minimum of everything required to produce a product or perform a service [1].

All this can be achieved by reducing NVAT's at every stage in the system. Total cost of ownership analysis then looks at the total cost of the system for its life time. These costs include but are not limited to, cost of installation, preventative maintenance, corrective maintenance, operational costs, repair costs and end of life costs and expand the buyer's thought process beyond the initial purchase cost [3]. For manufacturing facilities to address the problem areas they must first find them. The solution requires gathering more data, gathering the data quicker, making the data more transparent and easy to access, increase communication ability and increase tractability. In comparing RFID technology to the traditional barcode system to provide the technology for the solution it has many advantages including but not limited to, short scan times, anti pollution and durable, flexible data, penetrability through other materials, usable user data and better security [4]. Given these advantages it is easy to see why the technology has been adopted in a wide range of industries such as logistic, Health care, toll systems, retail, security and identification to name a few. This project will look to integrating RFID into the current manufacturing work flow system to expose these advantages thus reducing waste and the TCO.

The "real life" facility is NuPrint Technologies LTD, a local manufacturing company who manufacture labels. NuPrint management have highlighted that there is an opportunity to reduce waste in two key production stages. These stages are known as Pre-prep and Production. Pre-prep, as the name suggests prepares the equipment before use in production, and maintains it after the job is complete. The equipment is in the form of plates and rollers. The plates must be wrapped around the roller and aligned. Production fit the plates to automated printing machines and produces the required label. The pre-prep process is not as straight forward as it may seem. This is due to a multiple of variables including, damaged or weakened plates, plates being difficult to align, prioritisation of batch jobs, sourcing and reserving common plates to multiple jobs as well as keeping in touch with Operation control and Production to continually evaluate the job status. The aim of this project was to integrate an RFID solution into a Manufacturing Execution System (MES). It is hoped that the RFID solution will allow the MES to view the process in greater detail in terms of job and equipment location in real time. The real time MES will provide a transparent view of the process to Pre-prep, Production and Operation Control. This electronic view will allow each department to have up to date process information with no need to ask the other department, thus greatly reducing the requirement for personnel interaction. Personnel interaction is a major fluctuating unknown, which can be very wasteful. The real time view will also build a history database of the information gathered, as well as having the ability to hold any additional notes the operators may want to add.

II. RELATED WORK

The Department of Industrial Engineering, Tsinghua University, Beijing, set up a micro plant as to best simulate a real plant situation. RFID technology was used to support the MES to automate the tracking of materials, Work in Progress (WIP), fixed and mobile resources. They designed and implemented the solution to target three key areas. These were Data Collection and Document Control, Labor Management and Production Control and Performance Analysis. Data Collection and Documentation Control is a continuous task throughout the manufacturing process, but are of particular advantage in the job scheduling and inventory control. The best example of this advantage comes at the beginning of the manufacturing system, after a customer places an order, an operator scans the RFID labeled inventory stock, this real time scan, allows the MES to decide if the required inventory is available to complete the customer request. If it is, the job is sent to the sorting centre for packaging before being sent to the assembly line. However, if the required inventory is not available the MES system automatically generates a Purchase Order (PO) and produces it for review before emailing it to the supplier.

Labor Management and Production Control in this solution were encapsulated by visibility. Two billboards where utilised, one for the assembly line operator which updated them on the current job information and segment procedure. After the job is completed the operator interfaced with the MES system and indicated if it was finished or scrapped, triggering a job status change. The second billboard allowed management visibility of the production schedule being completed, including the current status of jobs. Performance Analysis is achieved as a byproduct of the previous two implementations. The system now is data rich, and is used to target Key Performance Indicator (KPI) matrices such as work station load and production efficiency. Any target change made can now be evaluated on tangible numeric data that is non intrusive [5].

RFID MES system can be flexible and responsive to continuous, changing customer requirements [6]. Huang et al. [6] outlines an RFID MES implementation in JAC, an automotive production company based in china. JAC manufacture a full line of brand vehicles including trucks, Special Reconnaissance Vehicle's (SRV's) and

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Mechanically Propelled Vehicle's (MPV's). JAC already had an MES system using traditional data acquisition methods such as manual input and barcodes. However, they believed the gap between physical flow of product and information flow in the MES was too great to properly monitor and manage the production system. The additional data acquisition obtained by attaching RFID tags to tools, materials, personnel and equipment ensured the MES turned into a Real Time MES (RT-MES). The enhanced RT-MES decreased SRV cycle time from 5 days to 4 days, increased production efficiency by 20% and increased the MES data accuracy rate to 99.9%. It is important to look at what the technology has in store for the future. One key area for future development is combined logistical tracking with RFID & GPS [7]. The advantage here is the ability to link both business process info and geographical locations, this specifically targets the time consumed for sales, customer service, operation and warehouse staff to locate specific cargo in transit and provide the customer with the most accurate data in a time frame that is acceptable [8]. This data could also be shared between manufacturers, logistics and purchasers on the web so that better planning and scheduling can be done for incoming inventory.

III. RFID System Design

The design of this solution is to implement RFID in a manufacturing environment, to aid in the stream lining of production work flow. The incorporation of RFID itself may not achieve this, but using RFID as a data gathering tool to enrich databases with real-time information can target important areas to the business. The RFID system used was a Promag PCR-340 Dual-Frequency Stationary tag reader. The tags used were a combination of Gen2 Class1 Labels. These areas of the business include real time information which will highlight work flow bottlenecks. Monitoring this information during and after an operational fix has been implemented to reduce the bottleneck which will allow management to evaluate the fix and continue to improve it or move on to the next high priority bottleneck. In addition, operational procedures are stream lined whereby operatives must complete the previous task before moving on to the next stage.

Management Information System Integration

During the design of this solution, the client (Nuprint) bought an "off the shelf" Manufacturing Information System (MIS) called Tharsten [9][1]. Tharsten's MIS was implemented to control the production area and gathers a lot of critical information via user interfaces regarding the running of the printing presses. It was clear that if we could extract already gathered information from the Tharsten system we could greatly improve the richness of data in the Access database and therefore achieve better results. In light of this, Figure 1 shows a more detailed architectural overview of how data is gathered and shared between both systems. Data transfer is broken down into two types, same system communications and sub system communication. Same system communications is the server interacting with its own type of client to enable database entries, this takes place on both the Access side and the Tharsten side and is inherent in the systems and therefore relatively straight forward. What is not as usual is the passing of data between the systems, i.e. sub system communications. The Tharsten system is an SQL based server and after some research and testing it was decided that the sub system communications could be reliably delivered via an Open Database Connectivity (ODBC) link, note during discussions with Tharsten technical engineers it was clear that to maintain the Tharsten system integrity and support we could only read data from their system with no function of writing data to their system.

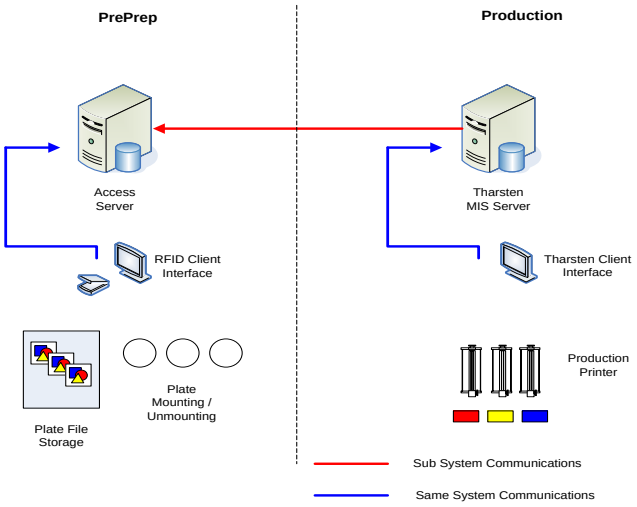

Figure 1 : System Communications

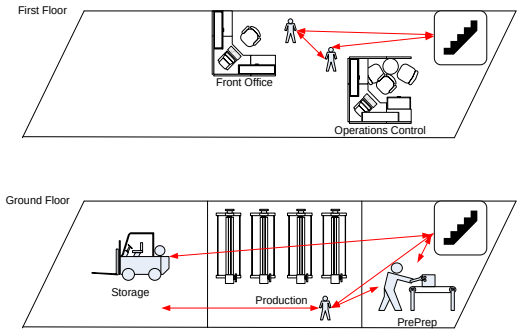

Figure 2 : Nuprint Facility Layout

[1] http://www.tharstern.com

Figure 2 shows how the facility is laid out and the typical personnel movement required to get a label batch produced from start to finish. After initial analysis, it was clear from the personnel movement that there are areas of concern i.e. the work flow is not fluid and there is a lot of required points of contact for each department to allow them to complete their individual tasks. This gives ground for a detailed analysis of both physical and data flow for a complete label batch production. It is clear that the area of greatest concern in the system is the communications between pre-prep and the production area. Given financial waste outlined earlier, it is clear there is an opportunity to introduce a system that will aim to tackle this area of high waste. It was decided that the specification is to incorporate an RFID system to operate as follows:

- Scan in Pre-prep to locate plate file and log time and confirm job is mounted ready for production and log time
- Scan at Production to identify and acknowledge receipt thus logging time beginning job production and indicate job completion and log time
- Scan in Pre-Prep to confirm receipt of plates and log time and to confirm plates have been cleaned, restored and log time

The incorporation of RFID should enable production control to establish the overall job status. These include the time taken to mount job, time spent in transit/waiting from pre-prep to the press, time spent on press and backlog of plates to be cleaned by pre-prep. The system should increase communication between production and pre-prep i.e. it should enable pre-prep to see the press status i.e. when the previous job has been scanned in by the printer to anticipate when a new job should be prepared. It should also allow pre-prep to see when the printing has finished and when the used plates/cylinders should be collected and production to check on the status of their next job. The system will provide traceability and accountability. It will enable JIT production with pre-prep preparing the next job only when the previous one has been scanned / received by the press. This will prevent wasted time caused by pre-prep mounting jobs too early in advance and potentially having to dismount them for an urgent job.

System Operation

After consultation with Nuprint and considering the new benefits the Tharsten system would have on the RFID system, the system operation was designed and a clear vision of how the final solution should interact with the operations team. It was clear that they required two main interfaces, one, to maintain their plate file database allowing the RFID labels to take over the old labelling system of Plate File numbers.

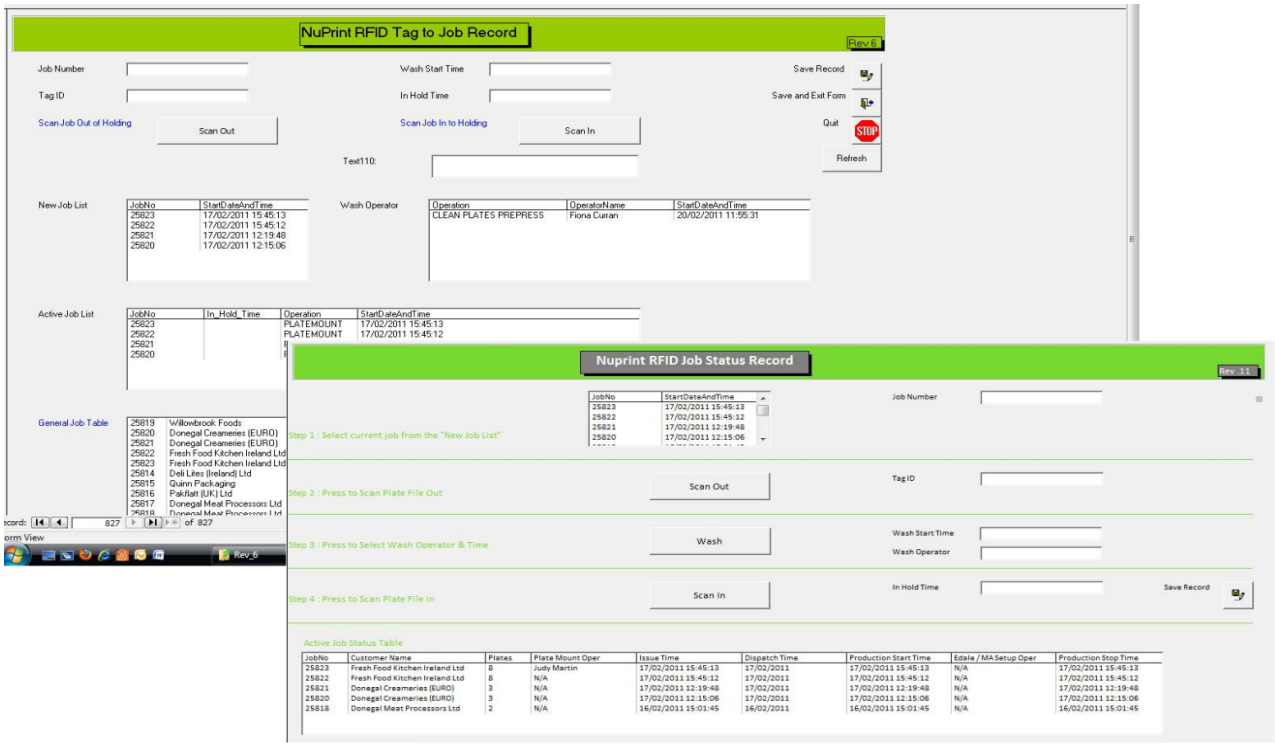

Figure 3 : User Friendly form design

The second interface is to allow production information to be inputted for the beginning and end of a job cycle in the Preprep area. These interfaces must be unambiguous, and simple to use. They must not increase the work load of operations and whether gathering information from Tharsten, RFID or Access appears to be one coherent system. The Nuprint RFID Plate File Record section is available to operations to associate RFID labels with the Plate File details. These details include, number of plates, Customer, supplier reference, number of colours, die size and product code.

The interface allows all relevant information to be shown with a simple scan button to associate a label with the plate file details. This interface will be used heavily on system implementation as Nuprint has approximately 350 current plate files, after this initial use the interface will only be used when a new job has been created for a customer or the RFID tag needs updating for an existing plate file. The Nuprint RFID Plate File Record section is the main operative interface. The interface is broken down into three main sections. Section one shows the operative interactions broken down into four main steps. Step one is for the operative to select an appropriate job, the choice available must only be jobs dispatched from Tharsten not yet picked up by Access, i.e. new jobs. Step two is to scan the plate file out of holding, there should be logical checks done in the background that ensures the correct plate file has been removed from holding by the operative, if the wrong one has been removed the operative should be prompted and not allowed to continue. Step three is to associate a plate cleaning operative and time with the plates after production has taken place. Step four is the scanning of the plate file back into hold and thus completing the job cycle. All steps must be clear and concise as to the operative actions. Figure 3 shows how the form was developed from early revisions to ensure user friendliness and additional work was kept to a minimum. This is the main form and subform which allows the worker in charge of preparing the plates to associate plates with tags and to also start a new job. Here a worker in the preprint area will locate a folder and select the scan out button. This will now start the clock for the time the folder is out of the preprint area. Once a job is finished and the cleaning down process begins, the worker will select the 'wash' button. This will now start the timer for the time taken to wash. This time will be complete when the worker selects the 'scan in' button which will allow them to replace the folder in the cabinet. This completes the process but most importantly, will time each of the stages allowing reports to be generated in real-time. The solution required multiple queries to provide operations and management with quality data to help improve work flow. The outputs of which provide dispatched jobs not yet picked up by operations, active jobs currently being manufactured, number of plates required per job, dates and times of specific actions, operator responsible for specific actions and the accumulative meters a plate has produced and sub divided into the specific jobs.

IV. RFID SYSTEM EVALUATION

It is important to evaluate how this project actually delivers on the key target areas outlined at the start. Analysis during the baseline showed the area of greatest waste in the communications between areas, take place between the Preprep and Production. The time now spent on overall communications is reduced from 37.1 min to 10.22 a reduction in 26.88 minutes per job, which represents a 72.4% reduction This data must now be equated to financial savings. The dispersion of the total saving 26.88 minutes is broken down into 19.03min for Production and 7.85 min for Preprep. Assuming that Nuprint run 1.5 batches a day these times increase to 28.6 min for production and 11.8 for Preprep. Taking a Preprep operative value at £30.00 per hour, the waste can be calculated as:

Financial Waste = (Saved Time (min) / 60) x 30
= (11.80 / 60) x 30 **= £ 5.90 per day**

Taking a Production operative value at £120.00 per hour, the waste can be calculated as:

Financial Waste = (Saved Time (min) / 60) x 120
= (28.60 / 60) x 120 **= £ 57.20 per day**

This equates to a total of **£ 63.10** of financial saving per day. As well as the everyday savings there is also non regular occurrences highlighted during base lining that the system tackles these types of individual issues are as follows:

Individual Issues: A typical example of an individual issue was, during a period when the pre-prep operator was off ill the pre-prep operators duties fell on the production operators. However, the process of washing the plates is an undesired task coupled with the limited time the production operator had, it was decided the plates would be left unwashed in a pile and not cleaned or filed away. The consequence of this was that when an urgent job came through, a delay was incurred in locating the plates. When the plates were located a further delay was incurred because they had to be washed and mounted. Once the plates were placed on the machine and the job ‘setup’ ready for ‘signoff’, it transpired that two were damaged as they had been situated at the bottom of the pile and were subsequently compressed. This necessitated the re-purchase of two £70 plates at a £10 delivery cost. The operations control was also faced with the dilemma of cleaning down

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the machine to run a job while the replacement plates were being manufactured and delivered or to hold off on the wash-up / setup and run the job the next day. This expense was in addition to delaying delivery of the labels. The result of this bad relationship was an escapade wasting £100's and damaged reputation with a customer. After site consultation this likelihood and financial waste was evaluated at £250 per month, i.e. approximately **£12.5 per day**.

To summarize, the system is saving approximately £63.10 + £12.50 = **£75.60 per day**. This saving is substantial when equated to yearly savings of **£18,144.00** calculated at 5 day week, 4 weeks per month and 12 months per year. Not only is the saving justification enough but throughout this project it has become clear that Nuprint's ability to introduce and work with RFID technology is of utmost importance. RFID is becoming a technology that more and more label purchasers are requesting to fulfill their own manufacturing processes. Having this technology already in Nuprint's portfolio allows them to be proactive in selling the technology in the market place and not be driven to it by customers who could go elsewhere in this competitive market space.

V. CONCLUSION AND FUTURE WORKS

This project initially assessed a manufacturing plants work flow processes and evaluated them against industry best practices. RFID was identified as a technology which could help stream line the flow of work on the factory floor. It was clear initially that there were NVAT in NuPrint's system. However obvious this waste is to anyone that analyses the system, it was of utmost importance to numerically evaluate this waste. This numerical evaluation base line, in terms of finance and time, will firstly keep focus on the project aims throughout the period of the project, and secondly allow for proper evaluation and justification for the end install. Ultimately, the system provides a mass amount of information to the system and allows proper analysis of how the system operates and how it can be modified to enhance KPI's. This information input not only provides great transparency between departments but allows management to oversee the complete process, and answer questions such as whether any jobs that went for production are not returned to storage, the length it normally takes for job A to be completed, and whether areas such as pre-prep hold up production or vice-versa? The main aim was to provide a solution that reduces waste in NuPrint. The key here was not just the RFID technology but rather the data manipulation in the MES which must be capable of providing transparent accurate, easy to access data to all departments. It was found that this system will save approximately £63.10 + £12.50 = **£75.60 per day**. This saving is substantial when equated to yearly savings of **£18,144.00** calculated at 5 day week, 4 weeks per month and 12 months per year. Throughout this project it became clear that Nuprint's ability to introduce and work with RFID technology is of utmost importance. RFID is becoming a technology that more and more label purchasers are requesting to fulfill their own manufacturing processes. Having this technology already in Nuprint's portfolio allows them to be proactive in selling the technology in the market place and not be driven to it by customers who could go elsewhere in this competitive market space.

The next step in the system is to incorporate live twitter alerts and emails to customers once labels are finished. This allows Nuprint's customers to be more informed of each relevant job on the factory floor.

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