Smart Shop Floor – A Case Study on RFID Enabled Metal Tube Manufacturing Process

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Abstract :

RFID is one of the most fundamental technologies that enable wireless data transmission. Recently RFID finds greater usage in automating the Industries. RFID system promises a Pervasive environment by linking an optimal world of IT Systems and the real world of products. For typical work in progress monitoring system, handling issues like tracking orders, operation, stock and data is tedious. Initiatives are now well within the reach for introducing RFID technologies to manufacturing process. This paper demonstrates a case study in monitoring the work- in -progress on a material in a metal tube manufacturing unit.

Keywords: RFID, work-In-Progress, HF RFID reader.

1. Introduction

Radio Frequency Identification (RFID) is a generic technology concept that refers to the use of radio waves to identify objects. RFID system essentially consists of three parts: the RFID tag, the RFID reader and a backend information system. The applications can be extended for wide area network as shown in Fig 1.

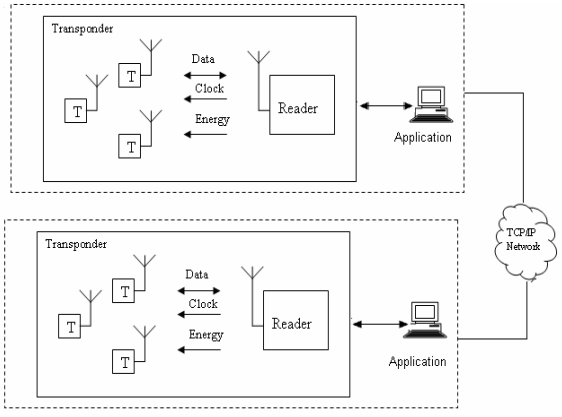

Fig1. Schematic of an RFID system

The RFID tag is that can store and transmit data to a reader in a contactless manner using radio waves. Tags can be classified into [1] Passive, Active, Semi-active, Read Only(RO), Write Once Read Many (WORM) and Read Write(RW) Tags. RFID reader also called an interrogator is a device that can read from and write data to RFID tags.

The existing smart card applications in the areas of payment systems like Public Transport, Ticketing and passes like ID cards and Company pass are getting replaced with contactless RFID technology. As in [2] the major applications of RFID are Public Transport, Access control, Animal Identification, Container applications, Sports events, Industrial Automation and Medical applications. Giant Enterprises such as Wal-Mart, the U.S. Department of Defense and the metro group has taken initiatives in launching RFID system. First Health Moore Regional Hospital in Pinehurst deployed [3] RFID system. Tobacco Institute of Japan (TIOJ) is working with the Japan Federation of Tobacco Retail associations and the Japan Vending Machine manufacturers Association [4], for implementing RFID age-verification system. Also in [5], a first aid is made for first aid kits. Thus there is a growth in RFID real time implementation.

As a Production Activity Control, a shop floor of a manufacturing unit is expected to have priority control, capacity control, order release, Work In Progress, stock control and data collection. The continually changing market environment needs an effective control of the production processes. The targets are fixed for production and the IT system has to be organized for the requirements of present and future. Besides the general deficiencies, there are many problems due to information flow. These problems include [6] static reports, lack of logging etc., To overcome such issues this work proposes a solution using RFID for shop floor.

The rest of the paper is organized into four major sections. In section 2, the background or the motive is explored. Section 3 reviews the working principle of RFID system and existing work-in-progress infrastructure. Section 4 elaborates the proposed system for automating the shop floor. Section 5 demonstrates the prototype obtained out of a specific case study. Finally the paper concludes at section 6 by highlighting the flexibility of the solution.

2. Background

Monitoring the part flows in a manufacturing system, time-wise and location-wise is very critical for productivity, cost, quality, inventory and speed. The need of bridging the gap between the physical flow of components/products and

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the corresponding information flow in conventional manufacturing systems is addressed in [7].A generic manufacturing monitoring and analysis system which allows rapid development of real-time manufacturing automation solution using RFID is proposed in [8], in a graphical modeling environment.

Middleware requirement, for the constraints imposed by passive RFID technology, has been analyzed in [9]. Also the required middleware, particularly when we work for Industry automation must have interoperable features with any existing ERP system modules. To prevent disconnection of application to the central database, a parallel execution of local & remote server model is suggested in [10] for their check-in, check-out parking lot application. For efficient data management model an algorithm of compression has been proposed in [11].

As a part of other Industrial automation solutions, RFID based Warehouse Management Information system was proposed in [12]. The same system was analyzed and concluded such that RFID is an indispensable technical tool and measure to improve management level of logistics and supply chain. Another interesting application with multi-case study is done on process steps & Critical Success Factor for pharmaceutical process in [13].

In general any shopfloor of a metal tube manufacturing unit involves many processes. Some of these processes will also be repeated periodically. When operator is handling any process, he requires a set of input. Also he has to authenticate the correctness of the sequence of process. Finally the process gets complete by generating a report with multiple parameters. With these areas the issues of an existing system are

(1) Lot of paper work
(2) Process sequence maintenance by using a route card technique
(3) Data logging issue.

Besides these, there will be general issues of tracking time (operator punctuality, job completion) and tracking the material (where the material is, major rejection stage) which are critical in a manufacturing unit. As an effort of addressing the above problem the paper proposes a case study report.

3. Review of RFID principle

The RFID system consists of a reader, tag and the host system. The reader and tag communicate through a RF signal link. Fig 2 shows components of a reader and the tag. The reader is the central nervous system of the entire RFID hardware system, establishing communication with the tag and the host system. The reader may be fixed (or table model) or handheld which is relatively costlier. The RFID tag is a device that can store and transmit data to a reader in a contactless manner using radio waves. RFID tags could be passive, active or semi-active (or semi passive). A passive tag has no on board power source and hence they have a limited range. They are also cheaper compared to an active or semi – active tag. The tag may also be a read only (RO), write once, read many (WORM) and Read – Write (RW) types. Both active and passive tags can be RO, or WORM or RW types.

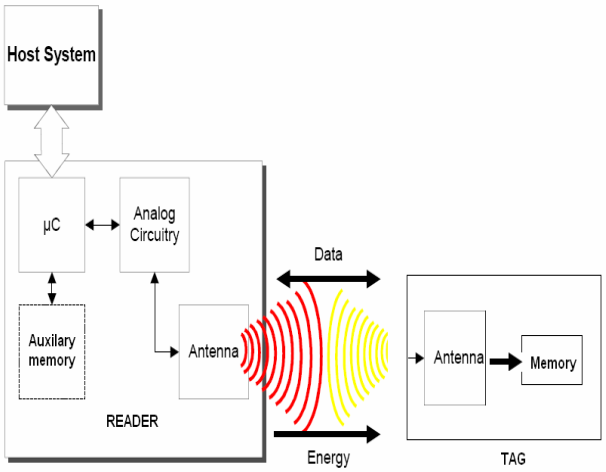


Fig 2 Overview of RFID system

The RFID reader operates at the following frequencies, low frequency (125 KHz), high frequency (13.56 MHz), Ultra High Frequency (868 and 915MHz) and microwave frequency's (either 2.45 GHz or 5.8 GHz). A typical LF RFID system operates at 125 KHz or 134.2 KHz. These RFID system have low data transfer rates from the tag to the reader and specially good if the operating environment contains metals liquids, dist, snow operating environment contains metals, liquids, dist, snow or mule. But the read range is low and need larger antennas refueling in higher cost tags further the tag memory capacity is also limited. However, they are least susceptible to performance degradation from metals and liquids. 13.56 MHz is the typical frequency of use for HF RFID system. Compared to LF, HF tags are less expensive than LF tags. They also offer a fair performance in the presence of metals and liquids, HF RFIDS are currently the most widely available systems. The RFID system operating in these frequency ranges have the fastest data transfer rate between the tag and the reader. They are mostly meant for long range operation. Since active tags are needed, they are costly and they perform poorly in the presence of metals and liquids.

Introduction of RFID technologies and its application to the manufacturing process such initiatives are now well within reach. The existing infrastructure set up involves various components as shown in Fig 3.

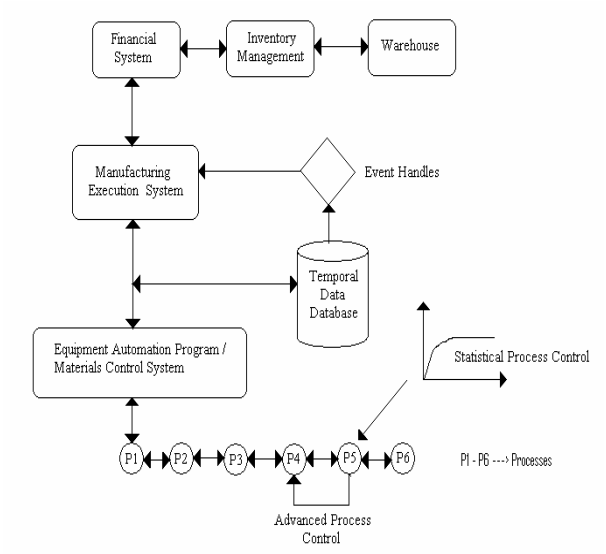


Fig 3. Components of Existing Shop Floor Infrastructure

RFID for WIP provides many benefits. Following are some of the ROIs with the RFID solutions:

i) Data is captured online and at real time
ii) A step-by-step electronic sign off confirmation at every process.
iii) Real time progress analysis and planning
iv) Line balancing can be done to get maximum efficiency and productivity.
v) Facilitates drivel of operator and operation efficiency and supervisory control.
vi) Tracking of work order completion status SKU (Stock keeping Unit) wise against deadlines.

4. Proposed System

In a tube manufacturing unit the starting material is rectangular mild steel sheet. The tubes formed from metal sheets are taken through various processes which are predefined at the time of process design in the process planning department. To make sure that the tubes for a particular job order are taken through various planned process steps, a route card system is followed. At each stage the operator after completing the operation on the batch of tubes, makes an entry in the route card. This serves as a check point for the operator at the subsequent stage. In addition to the route card, various reports are also generated at each process step where the operator makes an entry in a particular format for each job order handled by him on that day.

The existing route card system and the generation of process reports at each stage are not satisfactory because the operation involves a lot of paper work and the data in the process reports are manually filled by the operators. A schematic of this existing set up is shown in fig 5.

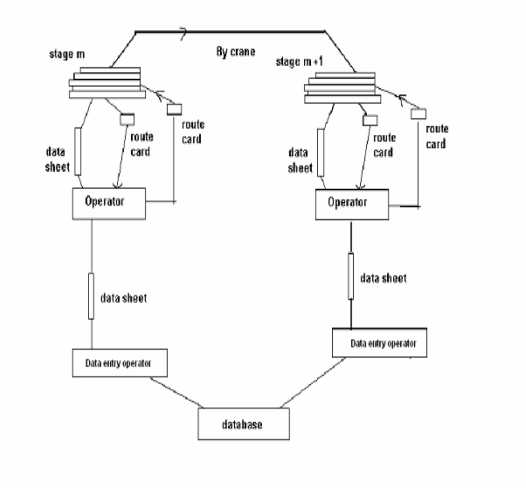


Fig 4 Existing Shop floor infrastructure

All these paper work and data entry operation can be eliminated by introducing the Radio Frequency Identification technique and introduction of personal computers to electronically generate the various reports and make it available at the data center. A schematic of this arrangement is shown in fig 6.

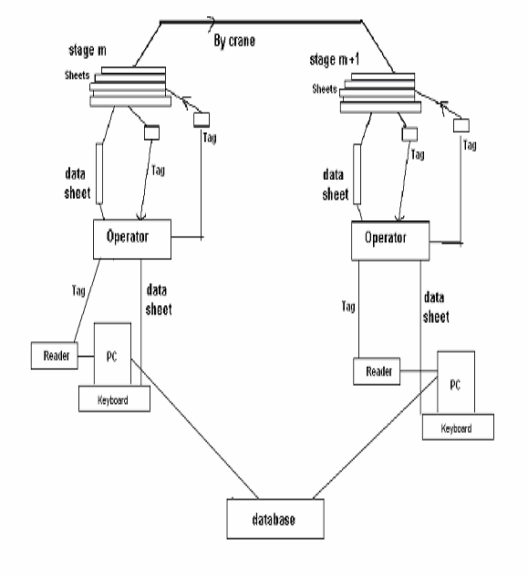


Fig 6: RFID based Shop floor infrastructure

The system architecture will consist of two setups. One will be the edge system within the

operational area. The edge system will consist of RFID readers, passive tags, host computer associated with the reader, RFID software, middleware, network switch. The other set up will be in the data center with a core network switch / data center router, Enterprise RFID information integrated with the existing ERP System by the development of IT middleware. The schematic for the system architecture is shown in fig 7.

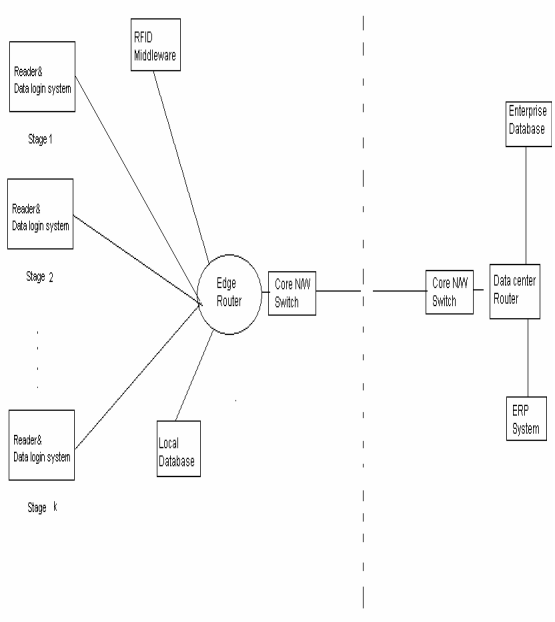


Fig 7 RFID system based architecture

5. Results:

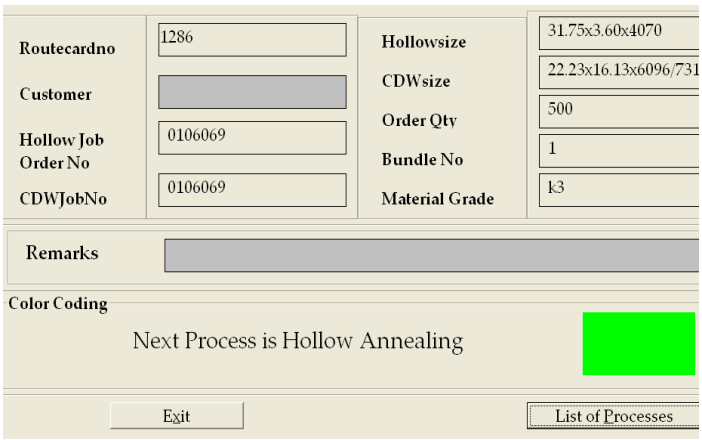
It is clear that the choice of 13.56 MHz RFID system is the most suitable, taking into account the range, tag memory capacity and cost. Since the operation of tracking the working progress will involve reading from the tag as well as writing into the tag, we choose a table top reader with read/write capability. The experiment used a compatible passive tag in which Read/ Write operation is possible. In order to accommodate all the information in the route card, tag with about 4 kilobit user memory capacity. The desk top reader type is Model No. R-DT-15693 and the compatible tag is Infineon my-d vicinity type.

The proposed system, highlighted the architecture with individual PC units in the prototype. When extended for real time, standalone hardware modules can be designed and used. Server and Client configuration is constructed for database access. The solution introduced a comfortable color coding to be used for process sequential track. The contents of the tag are optimized in such a way to balance both minimum memory as well as data authentication. The system is developed with proper time stamp requirements. This facilitates to track whether the operator has started his process in time and how much time he it spending for one job order. Another major feature of the proposed solution is tracking the quantity of rejection. This is more comfortable in the proposed solution.

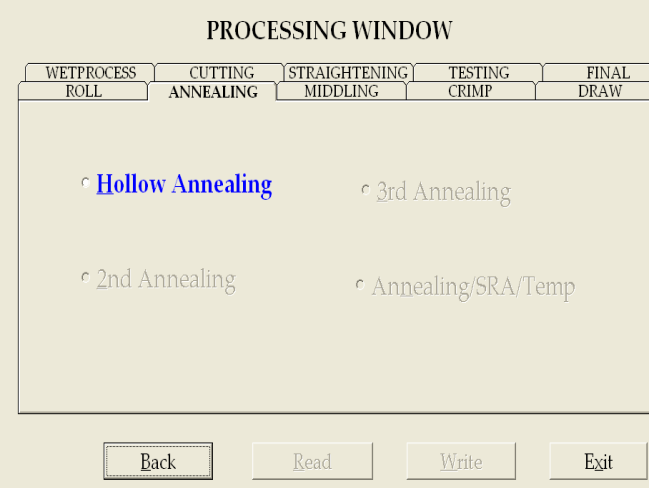
In general the key requirement of the middleware is to provide data filtering and data management. In the proposed system since the tag will be exposed to one reader at a time, there will not be an unwanted data reading by another reader. Therefore data filtering is not a part of our middleware. Data Collection and Management is the major work of middleware. The various data that are collected includes

- Stage of the tube bundle in the processing line
- Status of the stages (e.g. Quantity accepted in every stage, shift and operator details)
- Process reports of various stages (e.g. Rolling, Annealing, Wet process, Drawing etc.,)
- Details of the tube bundle (e.g. Hollow and CWD job order no. , Customer details and material specifications)

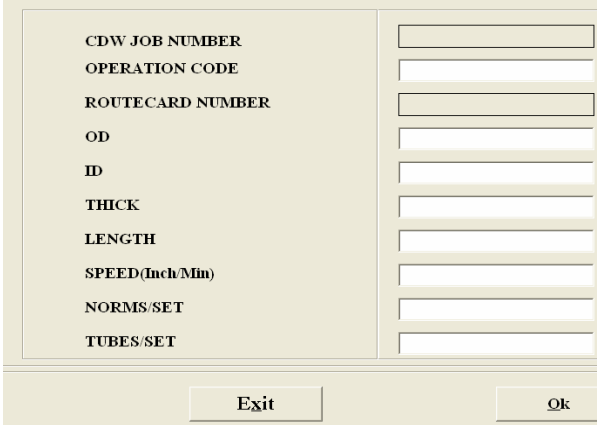
All the above said data are collected in a fast, accurate and in an efficient manner using RFID technology. Some of the snap shots of our tested prototype are shown below.



Route card in the form of tag



Processes view



Sample report

6. Conclusion

The prototype demonstrates the advantages of implementing RFID technology in a Shop floor which makes it smart. The real time testing requires the middleware to be extended to adapt the environmental effects. The further research will focus in enhancing the system with multiple solutions of Industry automation like logistics, inventory control etc.,

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4. Wal-Mart RFID, A Case Study Fall 2005 information is extremely powerful in understanding and controlling the supply chain and provides much more detailed behavior of the supply chain than can non- serialized bar codes such as UPC (Universal Product Codes) and EAN (European Article Numbering). Serial numbers have many advantages such as food freshness/expiration. Radio frequency identification technology commonly known as RFID technology is now widely used because it can increase productivity, efficiency and convenience. RFID has also been used in the manufacturing industry like shop floors where production data can be collected from production lines and sent to the information center for further analysis. Big data analysis provides a good opportunity, which can help the management of the shop floors. This paper reports on a case study using RFID datasets from a manufacturing shop floor to achieve performance evaluation. The datasets are processed by m...Â RFID-enabled learning supply chain: A smart pedagogical environment for TELD. Article. Full-text available. Chapter 8 Case studies of RFID as a green technology. Chapter 9 Conclusions and the way forward. Annex I: Estimations for the modelling of waste streams in EU Member States.Â The study, funded by the European Commission, aims to obtain expert input necessary for assessing (i) the environmental impact of RFID tags and (ii) the environmental advantages that RFID can provide for product lifecycle management.