RFID Warehouse Management in the Small and Medium Enterprises based on Manufacturing Industry

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Abstract

The recent ERP system has been playing a significant role in most of the large conglomerates as their warehouse management system. However, complex processes of the ERP system, designed mainly for large enterprises, calls for large workforce putting a financial burden on many small and medium industries.

In this paper, we have attempted to find ways for the small and medium industries to reduce their workforce. For this purpose, we present and implement "a RFID system closely coupled with the ERP system" which effectively complements the complexity of the existing ERP system with its functions of simultaneous multiple reading, and automation of the procedures by taking advantage of RFID's merits of untouchability, convenience and data storing capability.

As a result, the small and medium industries as well as large enterprises are able to take advantage of RFID system's merits. They can now control their product management easily, monitoring the status of production in real time as they can conduct warehouse management on the ERP system without extra workforce.

1. Introduction

The ERP (Enterprise Resource Planning) system of today is playing a remarkable role in most of the large conglomerates as a way of production management especially in warehousing.

Since the existing ERP systems have been used and developed mainly for the convenience and interest of the large conglomerates for management of their enormous volume of logistics, many inconveniencies have arisen for this system to directly apply in the small and medium industries.

In this regard, the new technology of the RFID system is designed to overcome demerits of the barcode which demands individual reading of each product. The new technology helps realize more intelligent process such as checking multiple products simultaneously and storing a certain amount of data in each RFID tag. Because the RFID system uses a radio frequency that can read as many tags as possible accurately in a short time, it effectively replaces a human labor in carrying out the warehouse management process more effectively and accurately. By taking advantage of the RFID system, which computerizes the existing procedures small and medium industries are able to cut workload and thus overcoming difficulties caused by the complexity of the ERP system. In addition, the RFID system could prevent from such wastes as overproduction, the excessive inventory of the company's warehouses and additional work processing [1].

In this paper, we present and implement "a RFID system closely connected with the ERP system." By taking advantage of RFID system's merits including untouchability, convenience and capacity to store data [2], it is possible to control products more efficiently than the existing ERP system. By deleting complicated process of the bar code utilizing RFID system, it can both be applicable to the small and medium industries as well as big conglomerates.

2. Backgrounds

2.1. RFID and RFID system

In the past, enterprises used the barcode-based application for the warehouse management system or SCM (Supply Chain Management) system. Because the traditional barcodes have limitations for wireless

multiple recognition, the use of RFID technology has been widespread at an enormous speed from big conglomerates to small and medium industries as a real-time resource management system. The main reason for the enormous use of RFID can be attributed to the capability of tags in providing more valuable information about each product compared with traditional bar codes. The tag chips can store information about product or order number codes etc. Such data can be stored into the tag chips in the form of EPC (Electronic Product Code) [3]. Therefore, many tags can simultaneously be recognized by a RFID reader in a short time. This makes RFID tags be able to solve some of the inefficiencies related to traditional barcodes, such as manually handling cases to read the codes, reducing time consumption and avoiding data capture errors [4]. In addition, the readability of RFID tag can get over a lot of problems caused by traditional barcodes like reducing accuracy and involving low reading rate [5][6], due to dirtiness, damage and bending. RFID system consists of RFID Tag, RFID reader, Back-end database and application [7][8][9].

2.2. ERP (Enterprise Resource Planning)

The term ERP means the planning of how business resources (materials, employees, customers etc.) are acquired and moved from one state to another and the integration of the suppliers and customers with the manufacturing environment of the organization [10]. Not only an ERP system can control business resources but also perform such tasks as the asset or the personnel management. As the size of a company grows, so does the need of the ERP system to manage all processes of tasks.

The ERP system, a software package used for mainly warehouse management of shelf-based products, is very complicated because it must cover all its diverse processes. An ERP system can plan a manufacturing process of each product as well as the whole manufacturing process. The system can also trace location of the individual product. However, the users have to put record information of each product one by one additionally in order to take advantage of this kind of merit in this system.

3. Related works

3.1. Traditional Warehouse management

In the traditional warehouse, the location of the raw materials and the end products in the warehouse must be put record on the warehouse management system or on the paper manually by hands even though the company has warehouse management system [11]. This process is very inefficient and vulnerable to making mistakes.

The ERP systems are in most cases commercial-off-the-shelf software packages and large by their size and complex by their structure [12]. ERP systems can plan the entire process of each product and can keep track of the location of each product. But we have to put record the additional information data of each product to ERP systems before we enjoy the convenience of the system.

3.2. Warehouse management with RFID systems

Using RFID system, we can easily manage the location and quantity of each product in the warehouse by attaching a tag. RFID is the best system for inventory due to its untouchability, rapidity and accuracy. RFID system, however, alone cannot perform such tasks as accounting or personnel management without integration of other powerful systems.

In the past few years, there are some examples of applications of the RFID system for their warehouse management in some countries as shown in Table 1.

Table 1. The application of RFID system

Authors	Title	WMS	ERP
F. Liu and Z. Miao [2]	Production control in the sanitary ware manufacturing industry using RFID technology		○
D. McFarlane and Y.SHeffi [13]	The impact of automatic identification on supply chain operations	△	
Mikko Karkkainen [14]	Increasing efficiency in the supply chain for short shelf-life goods using RFID tagging	△	
B. Yan, Y. Chen, X. Meng [15]	RFID Technology Applied in Warehouse Management System	○	
Hui Tan [16]	The Application of RFID Technology in the Warehouse Management Information System	○	

4. System architecture

The whole architecture of the RFID system is shown in Fig. 1. The suggested RFID system in this paper is composed of four large components: module sets, a tag printer, a RFID reader and databases. In this system, we have created a new database called "RFID

database" for the management of each tag and the synchronization of information between the code of products in the ERP database and the code of tags in the RFID database linked with a RFID database module. Each module connects to two databases, giving and receiving data. Moreover, the company in the test environment which has set up the below system produces goods that are made up of the paper roll.
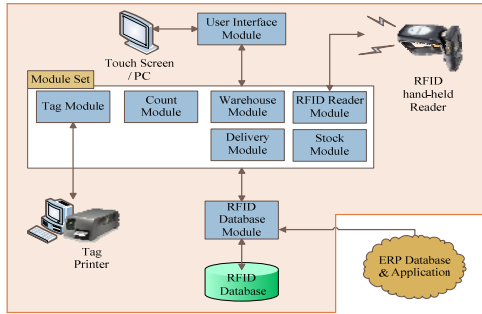

Fig. 1. The suggested system

These products or raw materials are sometimes managed by such uncountable unit as KG (kilogram), RL (roll) or M (meter) and etc in the ERP system. Therefore, we have put an additional unit as well as quantity information of each product into the RFID database. With the existence of the two databases in the system, we can insert, update (modify) and delete information in the ERP database as well as manage tags without using the ERP system. Every device such as a tag printer or a RFID reader depends on each module respectively and operates in coordination with each other within the system.

5. Implementation and evaluation

5.1. Points to be considered

In this paper, we have implemented the system based on a flowing manufacturing industry, in *Korea Computer Form Company*, that produces goods like a bill of expenditures, specifications, or an itemized account and so on. A flowing manufacturing means the reshaping process of the raw materials or changing of chemical property so as to obtain new products [2].

In this system, we conduct a tagging job not only for the original code that a tag contains but also for the information of resources, or products stored in the RFID database directly on a tag by use a tag printer. We also use the following information for identifying each tag.

- Code of each item
- Code of each order number

- The number of sequence for each item

All information in the tag are automatically numbered in sequence and managed in the form of a 4-byte hexadecimal code because the size of the tag's memory is 96 bits (12bytes). We also have created "a matching table" in the RFID database for the management of differences between the newly issued item code of each item code in the RFID database and an original item code in ERP database.

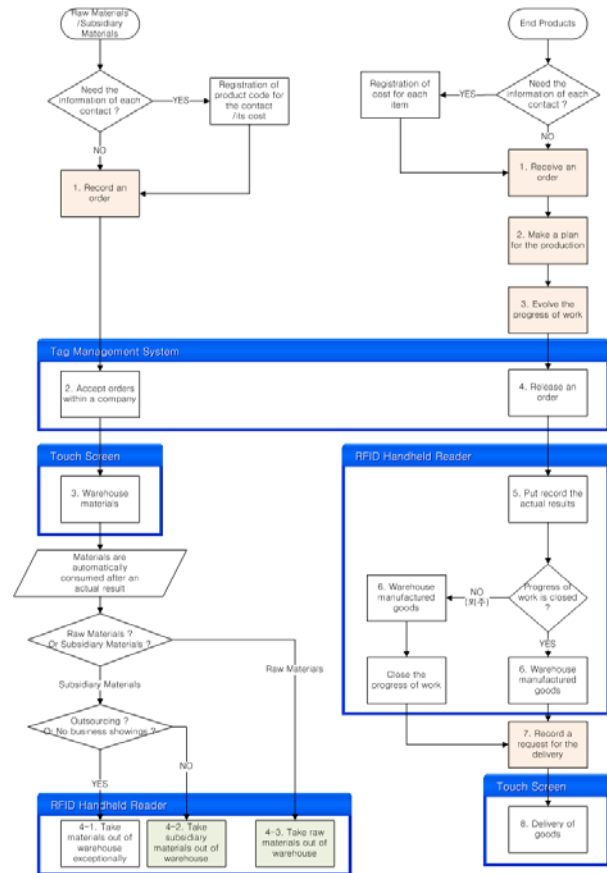### 5.2. The whole process on the ERP system

Fig. 2. Flowchart of the ERP warehouse management

As we mentioned in the previous section, the ERP process that warehouses goods and delivers of goods are shown in Fig. 2. The left flowchart is for the raw materials and the subsidiary materials and the right one is for the finished products in the ERP system. The difference between the two flowcharts is that for the finished products, unlike raw or subsidiary materials, the entire manufacturing process starting from raw materials to end products including the step-by-step manufacturing process or the status of the materials must be shown. For this reason, the verifying process

of the final manufacturing stage can also be seen in the right flowchart.

In the flowchart of the ERP processes, we can see that we are capable of executing the warehouse management processes automatically by using the RFID system. (See the blue boxes on the Fig. 2). As a result, the user or manager can obtain real-time information easily and quickly.

5.3. Connection between RFID system and ERP system

Through the system we suggest in this paper we can alleviate the complexity of ERP process in the warehouse management due to the automatic processing of the RFID system.

From a quantitative point of view, this means a drastic reduction of working hours by making warehouse management convenient with the help of computerization process. The automatic processing of RFID system made a series of manual input of the location and the state of each item into ERP system absolutely obsolete. Moreover, the managers or users can check and obtain real time reports on product changes and other numerical data, because the RFID system as a machine can perform the identical task more accurately and quickly than human hands.

5.4. System implementation

We have implemented the suggested system using C# language, ERP databases in UniERP and SQL 2000-based RFID database. We have made most of the equipment in our laboratory for the implementation of the suggested system. Following are the equipment we used for this experiment.
- Tag printer: EasyCoder PM4i
- RFID fixed reader: ER9501
- RFID handheld reader: IP4

The two main functions provided by our system are: (a) tag management system with a tag printer or a RFID reader, and (b) warehouse management system used by touch monitors or handheld RFID readers.

5.4.1. Tag Management system.
Shown is the initial screen of the tag management system, in Fig 3. We have divided materials into two types: end products and raw materials as in the ERP system.

When the user wants to prepare for the tag print, he or she has to gather the product information from the ERP database. After selecting a particular product or a raw material on the list and clicking the button named "Tag print" which consists of the simpler table created

by previous screen and some additional information for the preparation of tag printing. Before printing a tag, a policy for preparation of tag print should be set up because of the unit disagreement between each tag and the products. In this case, the preparation of tag print policy in this system regards information about how to print tag, how to group products by the upper unit like "palette" and how many tags are needed for each product. Through the tag printing policy window, we can prepare the tag printing policy. After creating preparation for a tag print policy, the user should click "Print Tag" button in order to print tag with a tag printer from the previous screen. If the user wants to print tag with the RFID fixed reader, he or she has to click "Print Tag (manually)" respectively. The printed tag is used for the warehouse management.
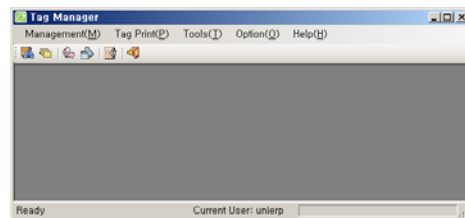

Fig. 3. Tag management system

5.4.2. Warehouse Management System.
By using printed tags, this warehouse management system is able to manage inventory and warehousing in each of the warehouse. We have divided the suggested system into two parts according to the device we use: a touch screen and a RFID handheld reader. The warehouse management system consists of three touch screen buttons but only two following functions are available except for the exit button.
- Storage of goods in warehouse
- Delivery of goods from a warehouse

When a user wants to warehouse an end product, he or she must have the product go through the antennas on the RFID reader by pushing the button on warehouse management system. When all the tags are read, we can warehouse tagged goods. On the contrary, the process of the delivery of goods is similar to the warehousing process.

From now on, we introduce the RFID handheld reader system designed for warehousing of non-finished products or materials or management of each process. Compared with the previous system on the touch screen, this application targets for raw and subsidiary materials that have frequent mobility within the company. First of all, the user has to take out the raw and subsidiary materials from each warehouse by using the second and third buttons on the screen of the RFID

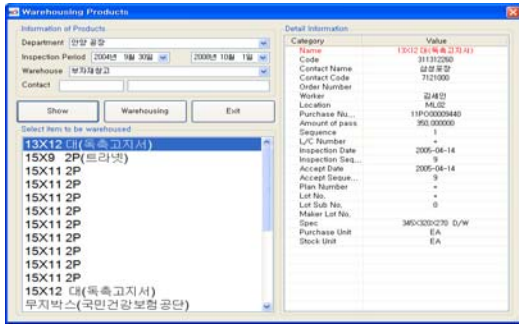handheld reader before proceeding with the production of goods.

Fig. 4. The screen of the warehousing some products

After a product is finished through the production procedures, the user has to put record the result of an actual output of the products through the RFID handheld reader in each work site. This enables the manager to confirm real time production status as well as total output of products and also the remaining quantity of each material for the order through ERP system.

5.5. Analysis

In this paper, we made an attempt to verify efficiencies of the suggested system by showing automation of the ERP processes on each step. This automation has brought reduction of the complex processes as we had mentioned in the section 5.2. The ERP system has originally four procedures for the materials and eight procedures for the end products respectively. However, by using the new RFID system we have suggested in this paper, we were able to cut the number of procedures in half: from four procedures to two for the materials and from eight procedures to four for the finished products. The new RFID system replaced a human labor where in the previous ERP system it was done manually. Therefore, the person in charge need not put data into the ERP system periodically, thus drastically reducing workload. Managers are also able to obtain reports of outputs whenever they want.

We have analyzed our system with a focus on efficiency of workload changes for every stage. In case of using ERP system independently, workers must check the following points when managing products. (1) Decide whether the products or materials correspond to the orders or not (2) Check if the quantity of each product or material to be warehoused or delivered corresponds to the orders (3) Confirm if the worker correctly delivers goods to the right customers.

It is both costly and time-consuming for the workers to perform the above tasks correctly and perfectly

on time. However, with the suggested system, workers can reduce both workload and working hours due to the new technology of RFID system, because much of procedures necessary in the previous ERP system have been shortened. We summarized the actual changes of workload for each step, described in Table 2 and 3.

Table 2. Changes of workload for the raw and subsidiary materials

Workload	Without RFID system	With RFID system
Accept orders within a company	Labelling Confirm data manually	Tagging
Warehouse materials	Check status and agreements manually	Shipping within a company
Take materials out of warehouse	Check manually whether the materials is correct	Only carriage or shipping needed

Table 3. Changes of workload for the end products

Workload	Without RFID system	With RFID system
Release an order	Labelling	Tagging
Put record the actual results	Check status and agreements manually	Check only each status of each product
Warehouse manufactured goods	Check agreements of each item manually	Only carriage needed
Delivery of goods	Check agreements of each item manually	Only loading and unloading

For justification of the suggested RFID system in this paper, we present a result of our experiment of calculating the ratio of productivity improvement in a producing situation [17]. Let us assume that a company produces 1,000 boxes of finished products a day and each process consists of four different steps. Each step is a real production process on an ERP system as shown in Table 4.

In this table, we can see the productivity improvement immediately by comparing the two systems: the existing system and the RFID system suggested in our paper. First of all, as we can see from a quantitative perspective, the work load for both the materials and the finished products have been reduced by 36.5% from the entire production process. Moreover, when comparing the performance capability of counting items manually by workers with the automatic processing by the RFID system, the RFID system shows a remarkably better performance than the existing system. When using the existing method, a worker

has to count each item one by one, while the RFID system enables simultaneous counting of multiple items in a short time.

Table 4. The necessary time for each progress

Step			Existing System	Our system
Ordering			10	10
Planning			10	10
Evolving			10	10
Order Release		Labelling	60	Removed
		Tagging	Not supported	60
Producing	Progress 10	Cutting	30	30
		Checking items	30	Automatic
		Register to ERP	5	Automatic
	Progress 11	Pasting	50	50
		Checking items	30	Automatic
		Register to ERP	5	Automatic
	Progress 12	Form Design	60	60
		Checking items	30	Automatic
		Register to ERP	5	Automatic
	Progress 40	Data Processing	30	30
		Checking items	30	Automatic
		Register to ERP	5	Automatic
Warehousing		Shipping	30	30
		Register to ERP	10	Automatic
Delivery Request			10	10
Delivery		Checking items	30	Automatic
		Register to ERP	10	Automatic
		Shipping	30	30
Total (min)			520 (8 hours 40 min)	330 (5 hours 30 min)

6. Conclusions and Future work

Since the existing ERP systems have been developed mainly for the large industries, the small and medium industries were having difficulty in using the ERP system efficiently due to its complicated and redundant functions. In order for the small and medium industries to utilize the ERP system effectively, automation of operation procedures along with the reduction of work process becomes imperative. Having such advantageous merits as untouchability, convenience, storage capability and speed, the RFID system is able to realize reduction of workload in the application of ERP in the small and medium industries.

In this paper we have introduced and implemented a RFID system in conjunction with the ERP system, in which the small and medium industries can control product management and easily monitor production status in real time as they can conduct warehouse management on the ERP system without extra workforce.

In addition, the new system has enhanced smoother communications between the manager and the person in charge and managers can control manufacturing procedure easily on his chair. In the future, we plan to expand the system to more detailed areas such as personnel management or changes of products in each warehouse. Moreover, we will extend our suggested system to estimation system for production planning

management with expert system techniques and self-diagnosis management for each equipment.

7. References

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