THE APPLICATION OF RFID IN WAREHOUSE PROCESS: CASE STUDY OF CONSUMER PRODUCT MANUFACTURER IN THAILAND

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ABSTRACT. Background: This warehouse has three main problems: poor accuracy of inventory location, long cycle time of receiving process and non-real time empty storage location. Therefore, the objective of this research is to improve the process in the warehouse by applying radio frequency identification (RFID) technology.

Methods: There are four steps in this research. First of all, the current of the receiving process and the picking process are studied. Second is to give the guideline for RFID application. Third is to implement of RFID system in this warehouse. The last one is to compare the result of the current process and the proposed process.

Results and conclusions: The passive ultra high frequency (UHF) RFID is selected for used in this warehouse. The RFID readers are attached on forklift trucks, the warehouse entrance and loading dock area. The system used RFID tags in two forms: one form used to identify pallets and another to indicate the locations of shelves on which pallets are stored. After using RFID system in this warehouse, the results showed that the accuracy of inventory location increased from 78.2% to 100%. The cycle time reduces from 66 minutes to 47 minutes which is down to 28.79%. . Moreover, the empty storage location are known real time.

Key words: RFID, Warehouse, Receiving process, Picking process.

INTRODUCTION

Warehouse management is one important activity of supply chain management. There are four main activities in the warehouse processes [Rouwenhorst et al., 2000]. The receiving process is the first process encountered by an arriving product. The products may be check and wait for transportation to the next process. Second activity is the storage process that products are placed in storage locations. Third, the picking process is a process of retrieving products from warehouse storage locations to satisfy customer orders. The last one is the shipping process that orders are checked, packed and eventually loaded the carrier. The efficiency of a warehouse depends on how efficiently it can perform the activities.

In warehouse of consumer product manufacturer, it is very difficult to management. The complexity of warehouse management depends on the number storage keeping unit (SKU), quantities of each SKU and the number of orders received and shipping. This warehouse has three main problems: poor accuracy of inventory location, long cycle time of receiving process and non-real time empty storage location. It is necessary to improve warehouse management efficiency and decrease error rates.

Radio Frequency Identification or RFID is the technology which uses radio frequency to identify objects and transfer data by the wireless non-contact and it can be automatically tracked and traced on each

product item or pallet by using the RFID tag. RFID technology consists of an antenna, RFID reader and RFID tag. When the RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna and it transmits the information on its microchip to be picked up by the scanning antenna. RFID tags can be read in a wide variety of circumstances, where barcodes or other optically read technologies are useless and it is developed for collecting and tagging data will help managing warehouse data more effectively.

Therefore, the objective of this research is to improve the process in the warehouse by applying RFID technology.

The remainder of this paper is organized as follows. The related literatures are reviewed in section 2. In section 3, the methodology of this research is explained. In section 4, the results of the methodology are proposed. The last section is conclusion and recommend.

LITERATURE REVIEW

In the past decades, RFID technologies have attached considerable attentions [Sarac et al., 2008] Currently, RFID is an importance technology for revolutionizing a wide range of applications including supply chain management [James et al., 2013]. RFID can apply in different parts of supply chain such as warehouse management, transportation management, production scheduling, order management, inventory management and asset management systems [Banks et al., 2007].

The RFID system consists of three components: reader, tag and host computer [Sulaiman et al., 2012]. The tag is the part that collects real time data and then transmits that data via radio waves. The tags usually have two parts, a small chip and an antenna. Information is stored and processed by the chip while the antenna is used to receive and transmit information. RFID tags can be either passive or active tag. An active tag has a small battery on board and is activated when in the presence of an RFID reader. A passive tag is cheaper and smaller because it has no battery.

The information is read by an RFID reader when a tag passes by it. The reader can track the tag's movement in real time and pass its digital identity and other relevant information to a computer system.

There are many researches in field of RFID. For example, Spekman and Sweenry [2006] presented a comprehensive overview of RFID technology. The goal is to provide insights regarding the implementation and use of RFID by focusing on its advantages and its problem. Schultae et al. [2006] presented that the RFID-based navigation and position system shall support wood carriers to cut back on unproductive times in the forest by localizing woodpiles in a more efficient way. Janke et al. [2007] proposed the German logistics company that has successfully implemented and tested a system to backtrack goods dispatched through the transport chains of two large food suppliers. Wang et al., [2010] proposed a digital warehouse management system in the tobacco industry based on RFID technology. Cyplik and Patecki [2011] compared the possibilities of applications of identification methods based on RFID and RTLS (Real Time Location Systems) in certain economic conditions. Zhu et al., [2012] provided an overview of the current state of RFID application in different industries and its impact on business operations. Dwivedi et al., [2013] studied the factors affecting the use of RFID systems and user satisfaction in a library context by empirically testing relevant constructs from DeLone and McLean's IS Success Model. Liu et al., [2013] viewed the RFID technology as an operation strategy to ensure food safety, and proposed three pricing decision models according to different operation strategies and market situations. Fan et al. [2014] considered the situation of a retailer subject to inventory inaccuracies stemming from shrinkage problems. They apply a newsvendor model to analyze how to reduce inventory shrinkage problems by deploying RFID.

METHODOLOGY

The methodology of this research is shown in figure 1.

First of all, the general information of an existing warehouse such as receiving process and picking process are studied by using 3G principles. The first G is Genba or the actual place. The second G is Genbutsu or the actual thing. The last one is Genjitsu or Genshou or the actual situation. Moreover, the cycle time of receiving process and the accuracy of inventory location are collected. Second, the fundamental level of RFID is studied. For example, what is RFID? How do the parts fit? After that, the RFID system of this warehouse is designed. Third, the RFID system is implemented in this warehouse. After that, the RFID system is tested. The last step, after the RFID system is used, the cycle time of receiving process and the accuracy of inventory location are collected. Next, the data are compared between before and after using RFID.
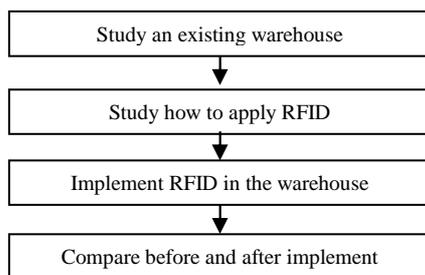
```
┌─────────────────────────────────────┐
│   Study an existing warehouse        │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│     Study how to apply RFID          │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│   Implement RFID in the warehouse    │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│  Compare before and after implement  │
└─────────────────────────────────────┘
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Fig. 1. The methodology of this research
Rys. 1. Metodologia badań

RESULTS

The general information of an existing warehouse

This factory manufactures consumer product such as toothpaste, washing powder and hand soap. After the goods are produced, they are transported to the warehouse. This factory has two warehouses. One warehouse is next to the production line that is not considered in this research. The other one is far from the factory that storage the export product. The distance between the factory and this warehouse is approximate 4 kilometers. The finished goods are transported from the factory to this warehouse by truck which contains 10 pallets per trip. Figure 2 shows the existing of receiving process in this warehouse. The information of the receiving process used

paper-based; therefore, it is not real-time. In the storage process, this warehouse used the random storage policy that allows the storage location for a particular product to change or float overtime. Moreover, the picking process is shows in figure 3.

However, this warehouse has three main problems. The first problem is the long cycle time of receiving process that the cycle time of receiving process (10 pallets per trip) is 66 minutes per trip. The second problem is the poor accuracy of inventory location which the accuracy of inventory location is 72.87%. The last problem is the non-real time empty storage location which effect to the quantitative of storage location for the finished goods and the time for finding the storage location. Therefore, the RFID system is selected to improve warehouse management efficiency and reduce error rates.

The guideline for the application of RFID

The RFID system consists of three components. The first component is the antenna. This research selects the passive ultra high frequency (UHF) RFID base on EPC class 1 Gen1 standard for this warehouse because it is inexpensive price and not require power source to operate. The second component is RFID tags. Two forms of RFID tags are selected to use in this warehouse. First form is called a pallet tag that is used to identify pallets (figure 4). Another is called a location tag that is used to indicate the locations of shelves on which pallets are stored (figure 5).

The last component is RFID reader. There are three forms of the RFID readers. The first form is the desktop reader (figure 6) that is used in production line to generate data to RFID tag before attach to finished goods pallet. The second form (figure 7) is RFID reader and antenna which mounted on the warehouse entrance and loading dock. It can be automatically traced on each finished goods pallet to be moving pass. The last one (figure 8) is the reader which mounted on forklift trucks with antenna and touch screen computer. This reader can read both pallet tag and location tag for verifying the correct location of shelves.
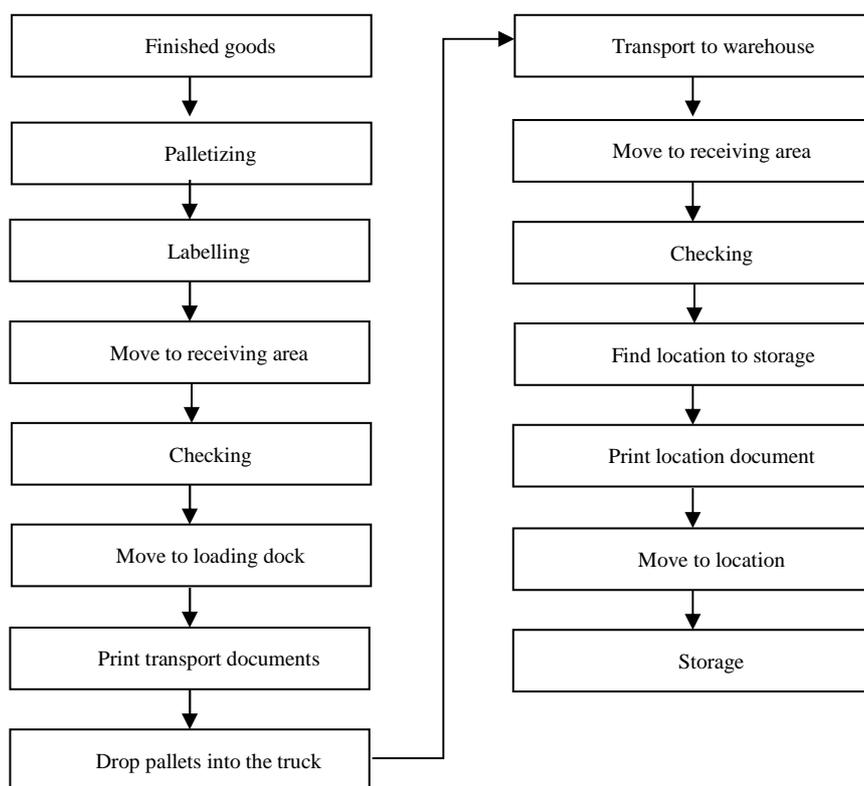
```
┌─────────────────────┐         ┌─────────────────────┐
│   Finished goods    │    ┌───▶│ Transport to warehouse│
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│     Palletizing     │    │    │ Move to receiving area│
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│      Labelling      │    │    │      Checking       │
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│ Move to receiving area│  │    │ Find location to storage│
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│      Checking       │    │    │Print location document│
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│ Move to loading dock│    │    │   Move to location  │
└─────────────────────┘    │    └─────────────────────┘
          │                │              │
          ▼                │              ▼
┌─────────────────────┐    │    ┌─────────────────────┐
│Print transport documents│ │  │      Storage        │
└─────────────────────┘    │    └─────────────────────┘
          │                │
          ▼                │
┌─────────────────────┐    │
│Drop pallets into the truck├──┘
└─────────────────────┘
```

Fig. 2. The receiving process
Rys. 2. Przebieg procesu odbioru

```
┌─────────────────────┐
│    Receive order    │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│  Print picking list │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Receive picking list│
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│   Picking pallet    │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Move to loading dock│
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│      Checking       │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐        ┌─────────────────────────┐
│Update inventory stock├──────▶│Detect empty storage location│
└─────────────────────┘        └─────────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Drop pallet into truck│
└─────────────────────┘
```
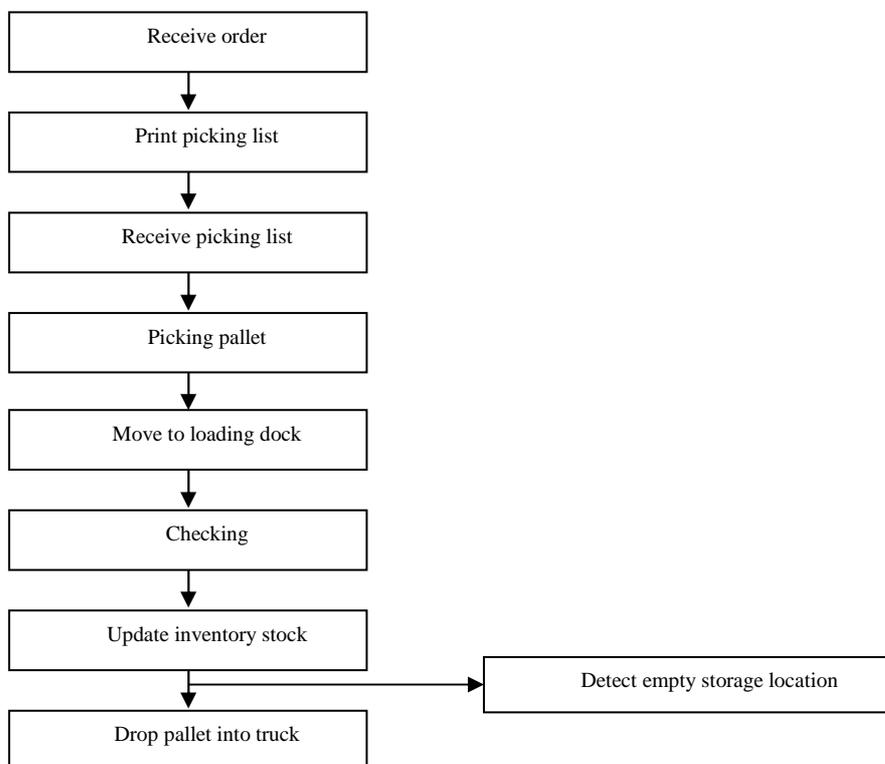
Fig. 3. The picking process
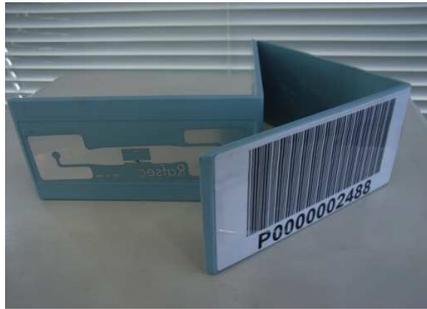Rys. 3. Proces podjęcia

Fig. 4. Pallet tag
Rys. 4. Tag na palecie

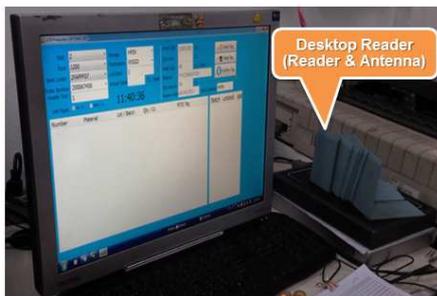Fig. 5. Location tag
Rys. 5. Tag lokalizacji
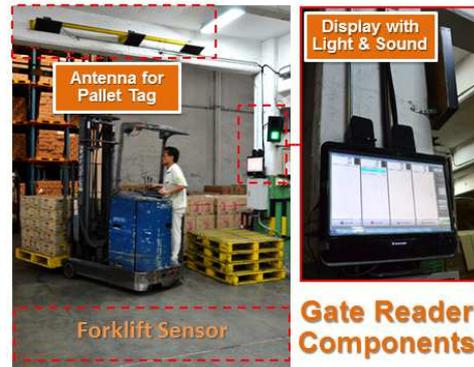

Fig. 6. Desktop reader
Rys. 6. Czytnik

Fig. 7. Gate reader and antenna
Rys. 7. Czytnik na bramce i antena

Fig. 8. Reader which mounted on the Forklift truck
Rys. 8. Czytnik zamontowany na wózku widłowym

The implementation of RFID in the warehouse

Integrating RFID technology into warehouse process, based on the analysis of the current processes, the receiving process is changed after using RFID system to be the receiving process in Figure 9.

From the figure 9, after the finished good is produced, production data is linked to the RFID tags which attach to each pallet. Warehouse staff will know the number of pallet which is transport to the warehouse. Therefore, they will prepare the storage location. The first gate reader where is installed between end of production line and warehouse can be automatically traced on each

finished goods pallet to be moving pass to specify the destination warehouse. The second gate reader where is installed at shipping area can be traced on each pallet to be moving pass and specify automatically the location in the destination warehouse and drop pallets into the truck. When transport pallets to the destination

warehouse, RFID tag which attach to each pallets is read by forklift reader and show the location to be stored on a touch screen computer which mounted on the forklift truck. The forklift truck moves pallet to the location and stores while location tag is read to verify by forklift reader.
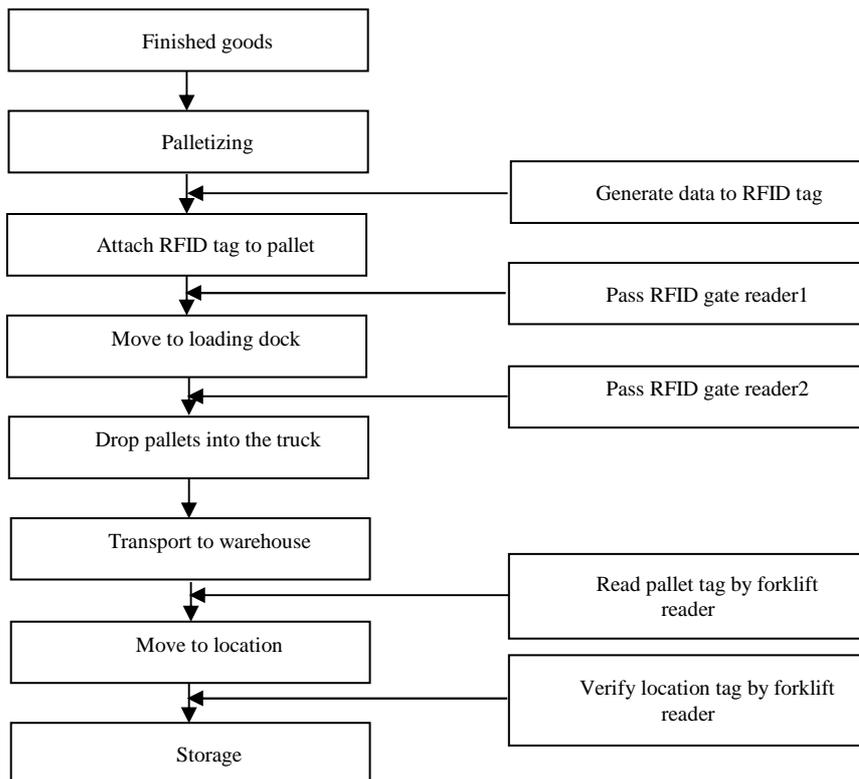
Fig. 9. The receiving process after using RFID system
Rys. 9. Proces odbioru po użyciu systemu RFID

Moreover, the picking process is changed after using RFID system which is shown in figure 10.

From the figure 10, the picking list is shown in the touch screen monitor. After that, the staff will pick the pallet by reading both pallet tag and location tag. Therefore, the inventory stock and empty storage location are updated real time. Next, the pallet is moved to the loading dock. All pallets are checked and dropped into the truck. This process can improve the storage location management which the empty storage location can use in the receiving process real time.

The comparison before and after RFID implementation

After implement RFID system, the data is collected. The results are shown in table 1.

From the table 1, the implement RFID in the receiving process can help to solve the problems. The average total cycle time of receiving process is reduced by 28.79%. The accuracy of inventory location is 100%. Moreover, the empty storage locations are known real time, so it help to save time to find the empty storage location.
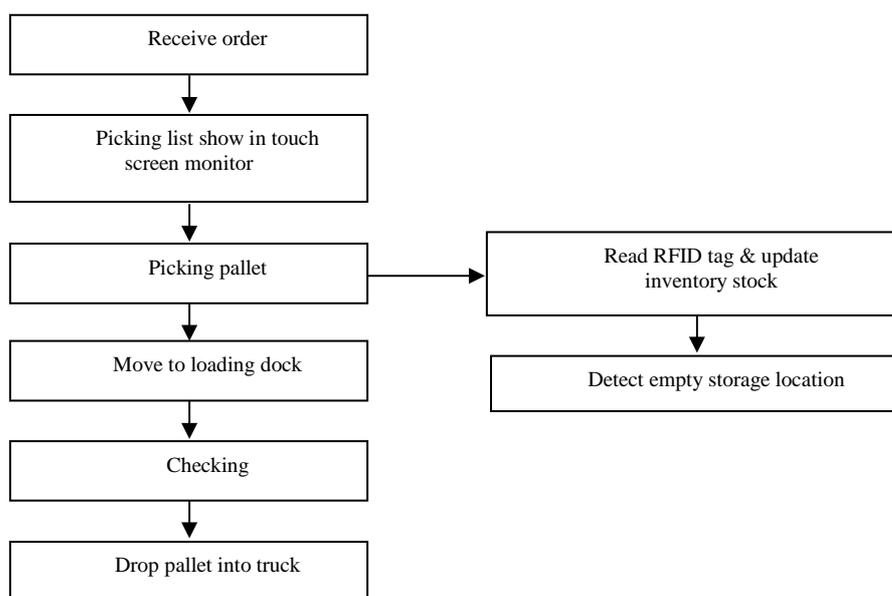
```
┌─────────────────────────┐
│      Receive order      │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│  Picking list show in   │
│   touch screen monitor  │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐       ┌──────────────────────────┐
│      Picking pallet     │──────▶│   Read RFID tag & update │
└─────────────────────────┘       │      inventory stock     │
             │                    └──────────────────────────┘
             ▼                                 │
┌─────────────────────────┐                    ▼
│    Move to loading dock │       ┌──────────────────────────┐
└─────────────────────────┘       │ Detect empty storage     │
             │                    │        location          │
             ▼                    └──────────────────────────┘
┌─────────────────────────┐
│         Checking        │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│   Drop pallet into truck│
└─────────────────────────┘
```

Fig. 10. The picking process after using RFID system
Rys. 10. Proces podjęcia po użyciu systemu RFID

Table 1 Comparison before and after RFID implementation
Tabela 1. Porównanie przed i po wdrożeniu RFID

Items	Before RFID implementation	After RFID implement	Difference
The average total cycle time of receiving process (10 pallets per trip)	66 minutes per trip	47 minutes per trip	28.79%.
The accuracy of inventory location	72.8 %	100%	27.2%
The empty storage location information	Non-real time (wait for warehouse staff input the data)	Real time	

CONCLUSION AND RECOMMEND

The objective of this research is to improve the process in the warehouse by using RFID technology. This warehouse has three significant problems. The first problem is an inaccuracy of inventory location that the accuracy of inventory location is 72.8 percent. The second problem is long cycle time of receiving process that the average total cycle time is 66 minutes per trip while one trip is 10 pallets. The last problem is a non-real time empty storage location. After the RFID system is implemented, the accuracy of inventory location is improved from 78.2% to 100%. The cycle time is decreased by 28.79% or 19 minutes. Moreover, the empty storage location are known real time.

However, this research focuses only one warehouse that far from the factory; therefore, it has gap to improve other warehouse of the factory.

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ZASTOSOWANIE APLIKACJI RFID W PROCESIE MAGAZYNOWYM - STUDIUM PRZYPADKU U PRODUCENTA WYROBÓW KONSUMENCKICH W TAJLANDII

STRESZCZENIE. **Wstęp**: W analizowanym magazynie występowały trzy podstawowe problemy: słaby poziom dokładności określenia miejsca składowania, długi okres cyklu pozyskiwania oraz brak bieżącej informacji o pustych miejscach składowania. Celem tej pracy było poprawienie procesu w omawianym magazynie poprzez wprowadzenie technologii RFID.
Metody: Badania przeprowadzono w czterech etapach. Pierwszym etapem było przeanalizowanie istniejącej sytuacji. Drugim - przekazanie wytycznym dla wprowadzenia technologii RFID. Trzecim - wdrożenie systemu FRID w analizowanym magazynie. Ostatnim etapem było porównanie wyników aktualnego procesu z proponowanym. Wybrano pasywną ultra wysoką częstotliwość (UHF) RFID do stosowania w danym przypadku. Czytniki RFID zostały przymocowane do wózków widłowych, na wejściu do magazynu oraz na polu załadowczym. Tagi RFID były używane w dwóch wersjach: do identyfikacji palet oraz do identyfikacji miejsc składowania towaru na regałach.
Wyniki i wnioski: Po wprowadzeniu technologii RFID, trafność danych dotyczących lokalizacji towaru w magazynie wzrosła z 78,2% do 100%. Cykl roboczy został zredukowany z 66 minut d o47 minut, czyli 28,79%. Jednocześnie uzyskano informację o pustych miejscach składowania.

Słowa kluczowe: RFID, magazyn, proces odbioru, proces pobrania

DIE ANWENDUNG VON RFID-VERFAHREN IN LAGERPROZESSEN - STUDIENFALL BEIM HERSTELLER VON KONSUMERZEUGNISSEN IN THAILAND

ZUSAMMENFASSUNG. Einleitung: Innerhalb des analysierten Lagers traten drei Hauptprobleme auf: fehlende Präzision bei der Identifikation eines Lagerplatzes, lange Zeit für Kommissionierung und Warenausführung und fehlende Information über die freien Lagerplätze. Das Ziel der Arbeit war es, die Prozese im betreffenden Lager mit Hilfe der RFID-Technologie zu verbessern.

Methoden: Die Untersuchungen vor Ort wurden in vier Etappen durchgeführt. Innerhalb der ersten Etappe hat man die bestehende Situation analysiert. Innerhalb der zweiten - erfolgte die Bereitstellung von Richtlinien für die Einführung der RFID-Technologie. In der dritten Etappe - die Einführung des RFID-Systems im analysierten Lager. In der letzten Etappe hat man einen Vergleich der Ergebnisse des herkömmlichen Prozesses mit denen des vorgeschlagenen Systems vorgenommen. Es wurde eine passive Ultra-Hochfrequenz (UHF) RFID für den betreffenden Anwendungsfall ausgewählt. Die RFID-Leser wurden an Gabelstapler befestigt, ferner am Lagereingang und innerhalb der Verladefläche positioniert. Die RFID-Tags wurden in zweierlei Versionen in Anspruch genommen: als die Version für die Identifikation von Paletten und als die Version für die Identifikation von Lagerplätzen im Regalfach.

Ergebnisse und Fazit: In Folge der Einführung der RFID-Technologie ist die Daten- Effizienz hinsichtlich der effektiven Warenidentifikation im Lager von 78,2% auf 100% angestiegen. Der Arbeitszyklus wurde von 66 auf 47 Minuten, das heißt um 28,79%, reduziert. Gleichzeitig gewann man die Information über die freien Lagerplätze.

Codewörter: RFID, Lager, Entnahme-Prozeß, Aufnahme-Prozeß

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