QR Code on Mobile Platform for Improving Order Picking Process of Lean Factory Warehouse

Anirut Pipatprapa

***Abstract*—Driven by rising customer expectation for good quality product, accurate order fulfillment and fast delivery, which factory warehouse management plays important role for linking manufacturers and customers. With regarding the factory warehouse problems, order picking process has high labor intensive cost and operational cost and non-value adding activity for almost every factory warehouse. Therefore, to increase order picking efficiency, the objective was to investigate QR code on mobile platform for improving order picking process of lean factory warehouse. To eliminate waste in order picking process, quick response code (QR) on mobile platforms of smartphone was proposed for factory warehouse solution. The operation research was used with Nakhon-Ratchasima province's electronic manufacturing company of Thailand. The results indicated that QR code on mobile platform was an effective tools to reduce order picking process waste (i.e., travel time and waiting waste) and increase productivity. The picker can directly scan the QR code using smartphone after that can find the items immediately. According to the results, firm's manager should employ the finding of this study to support decision making to smart factory warehouse management through using technology and electronic device such as smartphone.**

***Index Terms*—QR code, lean factory warehouse, electronic device, manufacturing industry.**

I. Introduction

Faced with increasing competitive in global market from all sectors of the world business, almost every industry is restructuring itself to operate more effectively. Cost effectiveness, product reliability and quality, and customer satisfaction are the important keys to enhance firm's competitive advantage of all areas of industry successfully. With regarding effective tool and management for industrial continuous improvement, lean management was employed to increase firm's productivity cost effectiveness, working efficiency to meet customer demands with limited waste (i.e., overproduction, over-processing, motion loss, waiting time, defect, transportation, and over inventory) [1].

Factory warehouse is a part of supply chain of manufacturing industry. The numerous industrial scholars and industrial practices paid attention to factory warehouse performance increasingly [2]. Lean concept was used in warehouse context, Naim and Gosling [3] established lean manufacturing concept for reducing inventory level and warehouse response time. Davararzami and Norman [4] and Gong and De koster [5] investigated warehouse management to support online retailer transections. Moreover, Tien, Ellinger and Chen [6] explored third party logistics provider to manage complex warehouse. The basic process within factory warehouse consist of receiving, transfer and put away, order picking and selection, delivery, and shipping of goods [7].

One of the main cost areas within the factory warehouse is in order picking process, which almost the cost is the movement of people and equipment between pick locations. Depending on the order picking operation, this can account for up to 50 percent of a picker's time. Therefore, to enhance firm's productivity and efficiency the aim is to eliminate travel time and waiting time, and also produce an acceptable return on investment significantly [8], [9]. Order picking methods are used in today's factory warehouse currently such as paper pick lists, pick by label, pick by voice, barcode scanning, radio frequency identification, pick by light/ pick to light, put to light, and automated picking [9], [10].

With the growing push towards technology, the onboard mobile sensor of a smart phone and mobile application software that can use for the mobile devices benefit to industrial management. The 3D sensor of smartphone capabilities are used to allow mobile phones to provide location based service and collect data that input data from camera. One of the newest developments is the Quick Response codes (QR code) to quickly facilitate the uptake of relatively large amounts of data in compact fashion [11]. QR code was employed in many field of research such as organizational service or traceability system, which the main reasons that used QR code was easy, cheap, standards for data integrity, data accuracy, redundancy, availability, and secure method for transmitting to individuals who have ability to read the code by smartphone application [12].

Therefore, this study proposes QR code on mobile platform for improving order process of lean factory warehouse. The remainder of this study is organized as follows. Literature review is provided in Section II, which described a background of lean factory warehouse, a relationship between order picking and factory warehouse, QR code approach. Section III represents research methodology. Subsequently, research results are provided in Section IV. Finally, Section V presents conclusion, contribution, and suggestion for future research.

II. Literature Review

In this section presents the necessary background of lean factory warehouse and a relationship of order picking problems particularly in factory warehouse and then focus on

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QR code concept as the method that used to reduce order picking effect such as travel time and waiting waste especially in this study

A. Lean Factory Warehouse

Lean manufacturing concept is a management system, which established by Toyota Company to eliminate waste in production process, reduce variation, improve productivity, and increase firm's competitive advantage through creating value adding activity. With regarding waste, any activity that does not add value in the customer's point of view is a waste. The customer defines product value. If the customer does not want to pay for it, it is a waste. Taiichi Ohno, identified seven categories of waste. This categories have become popular in lean organizations and cover many of the ways organizations waste or lose money, Ohno's seven wastes are as follows [13], [14].

Overproduction: Producing more than the customer order or producing early (before it is demanded) is waste such as pre-packing of goods before it is required, picking orders too far in advance.

Queues: Idle time, storage, and waiting loss (they add no value). For instance, the material is not enough or available to pick, when the employees are ready to pick a certain order.

Transportation: Moving material between plants or between work centers and handling it more than once is waste.

Inventory: unnecessary raw material, work-in-process (WIP), finished goods, and excess operating supplies add no value and are wastes.

Motion: Movement of equipment or people that add no value is waste. For example the goods or product is not stored in the correct area. The reverse is also true, when employees have to store items at ergonomically uncomfortable.

Over processing or insufficient processing: work performed on the product that add no value is waste.

Defective product: Returns, warranty claims, rework, and scrap are waste such as the employee is picking the wrong item or wrong quantity, which it further leads to returns that needs to be processed.

According to lean concept abovementioned, lean management approach can support company to identify the value-adding activities within factory warehouse as follows: 1) on-time delivery and low cost service through improving warehouse management system to increase quality and accuracy in preparing orders or material for production process, 2) improved stock integrity and better control over services by preventing picking disruptive, lack of material availability, and 3) accurate levels of information flow and traceability between the factory warehouse and production process.

Factory warehouse management of the ever changing customer requirements and market complexities through forecasting customer demand, trend, and seasonal, which all the factors will be affected to factory warehouse capacity [15]. The activities for factory warehouse consist of receiving of law material, product of WIP, finished goods, transfer and put away, order picking process, sortation, and delivery. An order picking process is the operation of retrieving products from picking list that shows the product items, quantity, and storage locations in the factory warehouse on the basis of production plan or customer orders [16]. The objective of order picking process is to maximize service quality level, increase productivity and customer satisfaction subject to the constraints of human factor, machines, and management system factor. The order picker has to retrieve more items in one trip, which if an order is late for its production process due time, it may have to delay and waiting waste for next production process [8], [17], [18].

B. Overview of QR Code

Quick response codes or QR code is a two dimension matrix barcode, which developed by Denso Wave Incorporated, Japan and used for industrial standard ISO/IEC18004 [9]. The Denso Wave Incorporated is a member of Toyota motor group. With regarding QR code characteristic, QR code size of one module is 4x4 pixels, resolution 300 dots per inch, and structured binary digit (i.e., black= "1" and white= "0"). Furthermore, data capacity of QR code based on data type such as numerical data with a maximum of 7,089 characters, alphanumeric data allow for maximum of 4,296 characters, byte or binary data has a maximum capacity around 2,953 bytes. In term of factory warehouse context, QR code is used to identify products, location of products in factory warehouse, serial and batch numbers, and containers such as totes, cartons, and pallets [19] QR code structure is represented in Fig. 1.

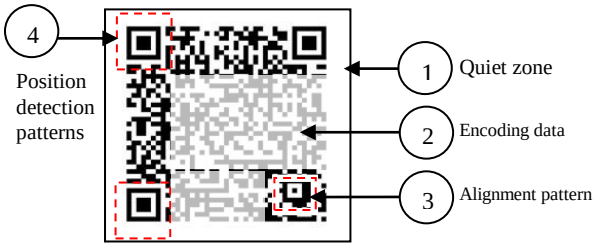

Fig. 1. QR code structure.

According to Fig. 1, the QR code structure consists of 4 parts: 1) Quiet zone/ Separators, this part is a margin space of QR code, which used for reading the code. Quiet zone is designed for symbol detection process to separate the QR code and text, picture by using 3D sensor of smartphone or tablet devices, 2) Data cells / Date Area, this zone is designed for collecting data and information such as text, picture, audio, and video format. With regarding encoding process, the data will be enciphered into binary code then arranged and compiled into the data area, 3) Alignment pattern is employed to decipher and verify the code ever it is distorted by noise and environmental factor, and 4) Finder patterns is created to detect edge position of QR code, which represented three squares at the corner of a symbol. Moreover, the position detection pattern can detect 360 dimensions.

The main reason that QR code is suitable tools for this study: 1) QR code can gather more information through coding and tag data into the space, 2) Fewer error and more secure mean that QR code has high capacity and built in error checking system, which it is easy to read and detect the error code when the code is damaged, 3) easier to read, electronic devices (i.e., smart phone and tablet computer) can be used to read QR code through employed their built-in digital camera, 4) transferring data, QR code can be transferred data as text

message or picture format between electronic device such as smart phone to smartphone.

Various researchers and scholar have applied QR code abilities for improving operational or working process in many fields, Tarjan, Šenk, Tegeltija, Stankovski, and Ostojic [12] employed QR code approach in traceability system of food product. Huang, Chang, and Sandnes [20] explored QR code to enhance the transferring ability ubiquitous in a museum system successfully. QR code was an effective approach for sharing interesting information of exhibition contents such as text, pictures, and video through different platform (i.e., smart phone and tablet). Moreover, Amrutker, Palsokar, and Raibagker [21] employed QR code to improve stock management system in book shop and avoid maintenance of stock record book. This study establishes QR code to reduce waste and improve order picking process of lean factory warehouse.

III. Methodology

This study is operation research, which explored in Nakhon-Ratchasima province's electronic manufacturing company particularly. The principal step in a motion and time study of Freivalds and Niebel [1] was used. The concept includes select topic, get and present data, analysis data, develop ideal method, present and install method, develop job analysis, establish time standards, and follow up. The main target of this study was to investigate QR code on mobile platform for improving order picking process of lean factory warehouse. QR code reader and creator is an application of smartphone, which can use in IOS and android operation system. Regarding data analysis process, Designtools software was employed to analyze data and compare the results between current state and proposed state, which the software was designed suitable for motion and time study in manufacturing industry especially. Additionally, elaborate semi structure questionnaire was designed to interview 7 operators who work in factory warehouse's order picking and analysis this section using content analysis. For entire of the factory warehouse activity, the proposed system can separate to explain both sections (i.e., receiving process and retrieving process) as shown in Fig. 2 and Fig. 3.

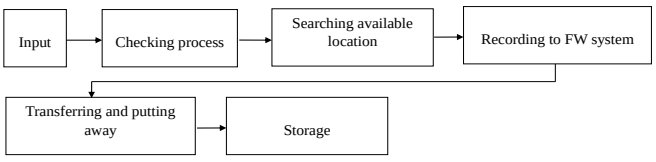

Fig. 2. Receiving process.

According to Fig. 2, receiving process includes receiving inventory such as raw material, WIP, and finished products then the inventories are checked before transfer to warehouse. Subsequently, searching available location to ensure that pick faces are not overfilled, which the available location data (i.e., zone, aisle, bay, and level) will be appeared in the factory warehouse system, then generate QR code and record item information to the system. Transferring and putting away by forklift and operator to transfer product pallets from checking area to the rack area.

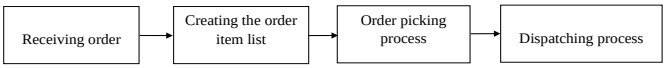

Fig. 3. Retrieving process.

From the Fig. 3, with regarding retrieving activity this process is started from the request of production department or marketing and sale department to create paper pick list. Afterwards, the ordering data will be transferred to order picking process. Order picking relates to define a sequence for visiting the specific location in suitable factory warehouse area where the item of order is stored. To decode the item location, 3D scanner from built-in camera smartphone or tablet is employed to scan QR code, which attached in paper pick lists then after the QR code is scanned the item related information is showed on the screen of smartphone or tablet (Fig. 4). Subsequently, the order picker walks or drives forklift along aisle to specific location for picking items then checking process and dispatching of all items to operation process.

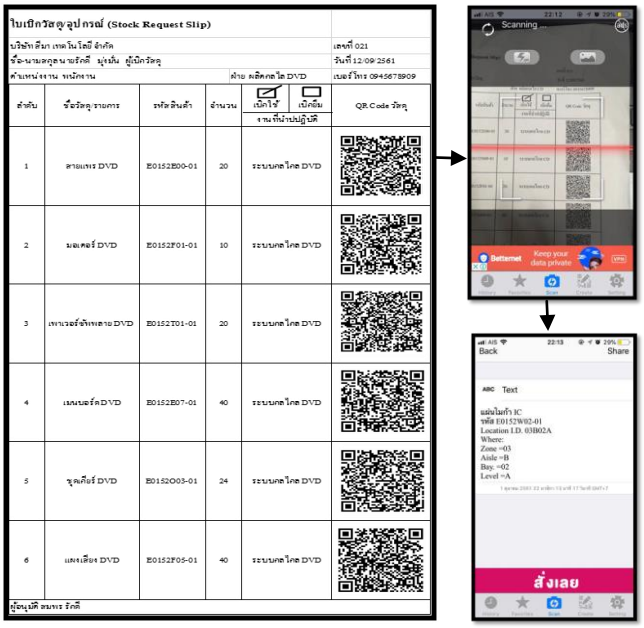

Fig. 4. Paper pick list.

IV. Results

Based on the motion and time study principle of Freivalds and Niebel [1], the warehouse of Nakhon Ratchasima province's electronic company of Thailand was selected as research area in this study. With regarding present data analysis, 7 waste or Muda concept was employed to collect data that affect to factory warehouse management and create order picking process' flow process chart by Designtools software as show in Fig. 5. We collected data for 30 days. The results of the examination in mathematics by creating proposed method, which is provided in the Fig. 6.

Fig. 4 represents a present state results of order picking process. With entire process spend around 16.06 minutes and transportation in the process including travel time, search time, and retrieval time around 145 feet. For picking item

process has the highest transportation time 60 feet and operational time 10.13 minutes and follows by walking to dispatching area.

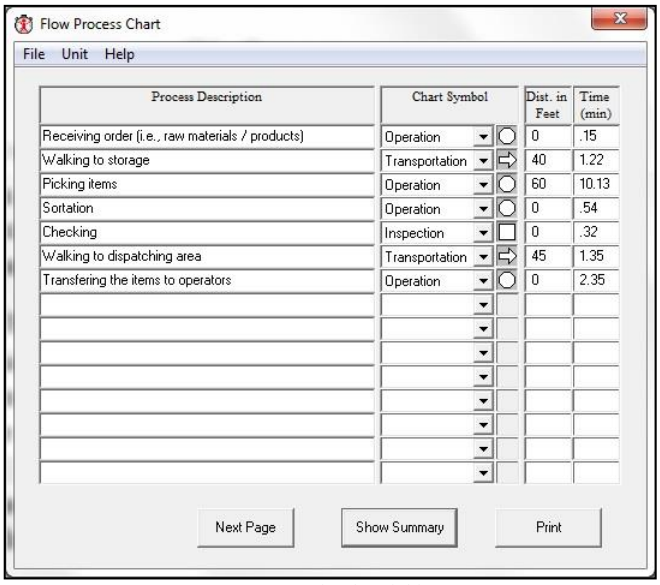

Fig. 5. Flow process chart of order picking's present state.

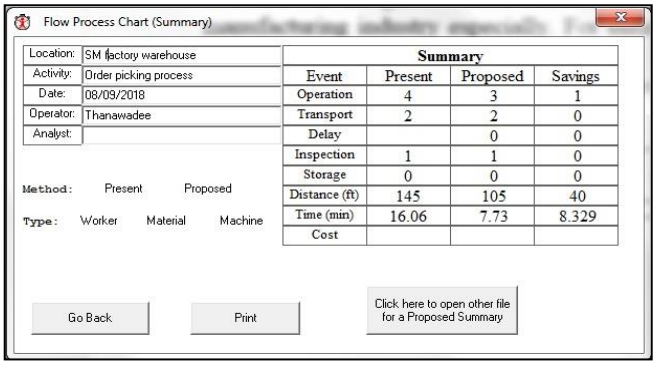

Fig. 6. A comparison results.

Fig. 6 showed a comparison results between present state and proposed state of order picking process. The proposed method that used QR code on mobile platform can reduce the distance of order picking process 40 feet, saved time 8.329 minutes, and reduce operation process one process. Moreover, the interviewed results indicated that the proposed method was easy to use, save firm's cost, and increase productivity.

V. Conclusion

Due to achievement of factory warehouse performance and sustainability aspects, innovation of technology electronic devices such as smartphone and lean principle are integrated to reduce firm's cost and waste. In this study, we have investigated ways in which QR code on mobile platform for improving order picking process of lean factory warehouse. The approach of smartphone's 3D sensor and quick scanner application were used for developing factory warehouse management especially in order picking process. According to the results, the process of order picking was significant process that affect to factory warehouse management system. Furthermore, the proposed method can increase order picking productivity and eliminate travel time, waiting time, and returning time waste. Moreover, with regarding a contribution of this study, we represents how relatively QR code on mobile platform, lean factory warehouse for order picking process solution, and raise awareness regarding the context of factory warehouse management's order picking process.

Based on the results, firm's manager can benefit exceedingly from implement QR code to enhance factory warehouse efficiency such as operational performance, productivity of order picking process, and waste reduction especially traveling time, searching time, retrieval time, return time, and waiting time waste. Future research, firm's manager and scholar may be able to adopt such proposed technique to assist firm's automatic production management field, reduce waste, and achieve in customer satisfaction and extend QR code capabilities to other part of business and industry function.

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