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Original Paper

RFID Tracking Implementation for Supplier Chain Management at Toyota USA: Proposal of Development of Advanced TPS for Global Production Strategy

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Abstract

In order to achieve simultaneous, worldwide high quality assurance and other global production developments, Advanced TPS was proposed as a global production technology and management model, especially designed to realize high productivity and cost performance in global production. On this model, the inventory management is the key method at any manufacturing facility operating with Just-in-Time (JIT). On the other hand, the current inventory systems at manufacturing facilities do not provide real inventory data. So out-of-stock conditions sometimes have caused major productivity losses by causing the production line to stop. Therefore, the authors have proposed to create component inventory tool, which RFID tag can be replaced onto the containers with the trial parts and thus both the supplier and main manufacturing facility. This tool could provide constant feedback to ordering, logistics, and assembly conveyance groups in order to maintain and improve current JIT system. Concretely, this can also provide current information on components being shipped by the supplier and list what items are available in the production area by part number and supplier. The effectiveness of this proposal has been verified into Toyota Motor Manufacturing, Texas (TMMTX), which is unique for onsite supplier locations. This has been proven that RFID can prove to be an efficient tool with which to track inventory and generate cost savings.

Keywords

Advanced TPS, RFID, Inventory Management

1. Introduction

To achieve simultaneous, worldwide high quality assurance and other global production developments, today's task is to maintain high reliability in production facilities and operations. In response to the increasing expansion of overseas plants, it is necessary to improve and maintain highly accurate production equipment and operations through the development of intelligence operators. The authors have clarified Advanced TPS as a global production technology and management model designed to realize high quality assurance in global production.

Furthermore, the authors have proposed to create component inventory tool to track current stock that produces monetary savings and leads to efficient inventory management practices. Currently, RFID tag can be replaced onto the containers with the trial parts and thus both the supplier and Toyota USA. That will be informed of what has been shipped and what is currently in stock. The effectiveness of this proposal has been verified into Toyota Motor Manufacturing, Texas (TMMTX), which is unique for onsite supplier locations.

2. Background

2.1 Current Inventory Problem with Standard Ordering and Inventory Management Procedures

Utilization of current ordering procedures at manufacturing facilities often leads to an interruption in the JIT system due to an array of factors which include: late routes, missed orders, misplaced inventory, no inventory, incorrect parts in packaging and quality quarantine. Cost reductions will be seen on other areas which will reduce the overall supply chain costs (Attaran, 2007).

Current inventory systems at manufacturing facilities do not provide real time data on all shipment locations and component tracking inside the facilities. Out-of-stock conditions have the potential to cause major productivity losses by causing the production line to stop or forcing production to skip vehicles which will be later repaired. The action of skipping vehicles means that the vehicle will not have the out-of-stock part installed at the assembly line but will later be installed by a repair team. In the case that the part out-of-stock is vital to the assembly of the vehicle, then production will be forced to stop until more parts are available from the supplier. These cases do not apply only to vehicle manufacturing, but they apply to almost any manufacturing operation which relies on outside suppliers to maintain the production process. Stopping the line for any amount of time directly translates to productivity and profit losses. Out-of-stock conditions during production are primarily caused by a lack of visibility. One of the fundamental processes in client-supplier operations is to match current orders to current inventory (Attaran, 2007).

2.2 Heading of Inventory Management by RFID for Supplier Chain Management

Radio Frequency Identification (RFID) was first utilized during WWII for the identification of allied aircraft which was meant to reduce the rate of friendly fire for incoming aircraft (Attaran, 2007). Recently, the adoption of this technology into inventory management by manufacturers and retailers to reduce inaccuracies in lost items, miss-shipments, inconsistencies between digital systems and physical inventory (Ligang, Jie, Fan, Yajun, & Maozeng, 2017).

Implementation of RFID on inventory management at any manufacturing facility operating with Just-in-Time (JIT) can benefit by obtaining reliable and accurate data on all inventory levels for production parts. RFID can continuously provide information to the manufacturer about the status of their parts; ranging from: supplier departure time, part arrival time, current location inside the facility, and current stock levels. Past studies have shown positive evidence on the correlation between RFID utilization and a positive effect on manufacturing effectiveness, efficiency, and an improved overall performance (Zelbst, Green, Sower, & Abshire, 2014).

Companies in several manufacturing industries attempt to absorb discrepancies in their ordering and inventory management systems by storing higher levels of inventory. High inventory leads to waste in the production process by creating both conveyance and movement for "muda", and increasing the inaccuracy of First-In, First-Out (FIFO) (Fikes & Sakai, 2016). Through the introduction of an effective RFID system into the supply chain, companies can improve their performance on inventory management by obtaining reductions in inventory levels, efficient deliveries and reduction of out-of-stock incidents (Zhong, Huang, Lan, Dai, Xu, & Zhang, 2015).

2.3 Proposal of Advanced TPS for Global Production

The authors have proposed the Advanced TPS in order to attain high quality assurance in global production (Sakai & Amasaka, 2005). Advanced TPS is comprised of four different pillars: productivity, cost, workability, and quality. This proposal focuses on the pillar of productivity by implementing a system which will be able to improve and maintain efficient inventory management throughout the plant as shown in Figure 1. Because parts ordering or logistics cost including inventory has been the critical point in productivity for global production. Today the authors will describe the inventory management subject which is mainly in relation with the cost and productivity pillars of Advanced TPS.

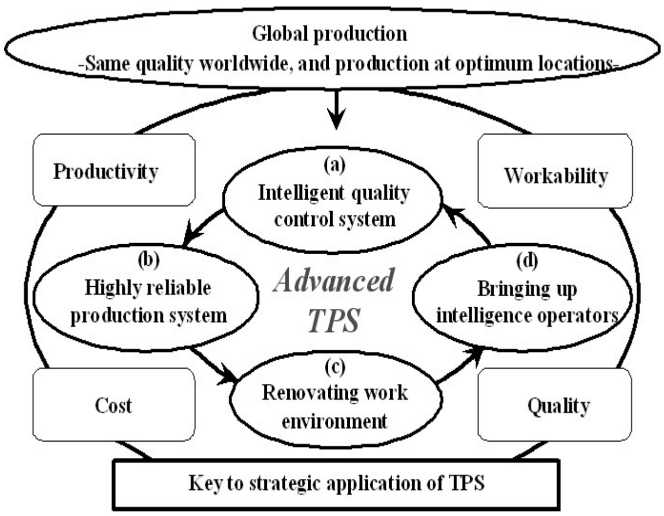

Figure 1. Advanced TPS Model

2.4 Current Order Procedure between Manufacturing Facility and Its on-site Supplier

The on-site supplier is known for producing parts in a part all in one body in the plant of the last finished product maker becoming the Maine (Fikes & Sakai, 2016). When it is necessary, it is necessary and develops it more and synchronizes it with a completed article and is the highest manufacturing facility method that by one can cast into the line. However, when the last process has the faults and stopped, it is "the series message student model" that the line perches on together. There is much waste in distribution cost and other elements by distance and a timing problem even if I hand the parts which I made to other factories and makers. The on site is the organization where power is given to in an on-site.

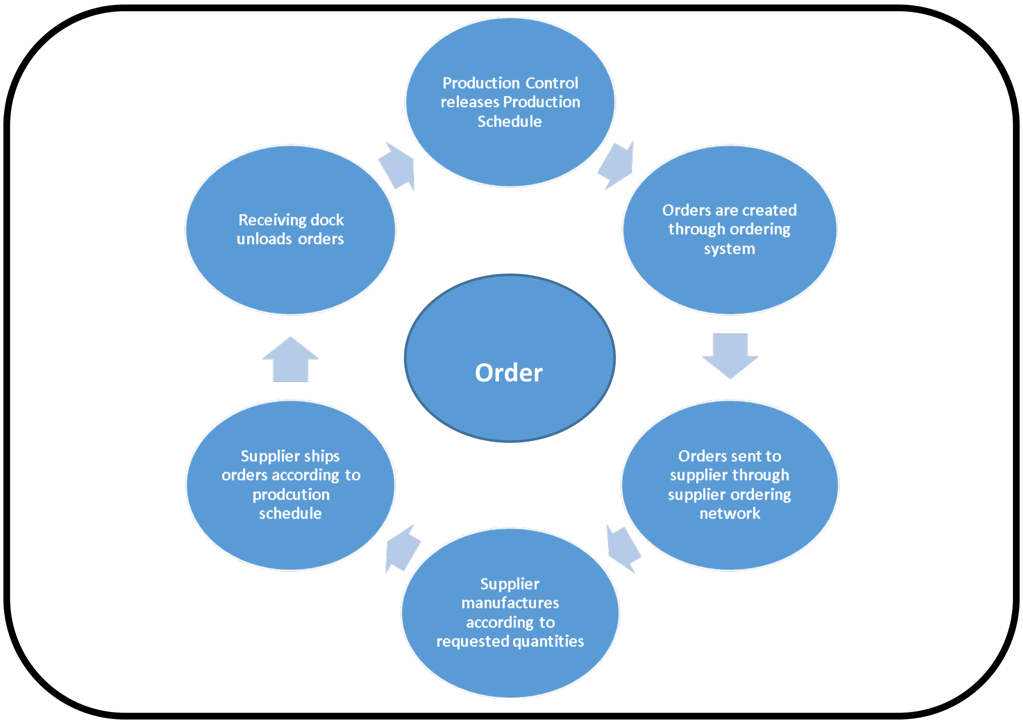

Figure 2. Order Flow between a Manufacturing Facility and On-Site Suppliers

Figure 2 shows the current order flow between a manufacturing facility and its on-site suppliers. Current issues include the inability to revise if orders being shipped match actual orders. Another issue is the lack of visibility of current stock in transit inside the plant along with a lack of visibility of stock in the "warehouse". According to consulting firms such as Accenture, the implementation and utilization of technologies in warehousing and receiving can reduce the cost of checking inventory by almost 65 percent through the elimination of processes such as counting boxes (Attaran, 2007).

Some challenges involved with the implementation of this technology involve the cost expenditures needed for equipment, training, and the creation of new standards which also involves working with suppliers to implement such standards (Osyk, Vijayaraman, Srinivasan, & Dey, 2012). Some companies also perceive the utilization of RFID could lead to privacy complications hence the need for the creation of a strict set of standards which can guarantee data protection along the supply chain (Osyk, Vijayaraman, Srinivasan, & Dey, 2012). Often there is a lack of consensus amongst the involved parties (client-supplier(s)), it is then up to the supply chain captain to execute a strategic plan with required standards and expected timeline for overall implementation (Spekman & Sweeney II, 2006).

2.5 Necessity of Inventory System between Manufacturing Facility and Its on-Site Supplier

This article provides the framework by which a manufacturing company with on-site suppliers can establish a system which can provide constant feedback to ordering, logistics, and assembly conveyance groups in order to maintain and improve current JIT system. Such system can also provide current information on components being shipped by the supplier and list what items are available in the production area by part number and supplier.

3. Proposal of New Inventory Management for Advanced TPS

3.1 RFID Tracking Implementation for on-Site Suppliers

Efficient implementation of RFID system with on-site suppliers will require to take several elements as input for a system which can consider what is needed for our inventory and production requirements. Some of the elements taken into consideration for this investigation are as follows: “kanban” (Ohno, 1978), inventory, order number, departure scan, arrival scan, cycle, route, and location (Fikes & Sakai, 2016). Through a combination of such inputs into the system, it is possible to develop a system to continuously check for this data and provide accurate feedback to the ordering group.

3.2 Implementation Standard Procedure

In the case of a manufacturing facility with an on-site supplier, the supplier selected for the initial stage of this project needs to be notified about the new trial manufacturing facility will have to provide support for their implementation period. Once the standards have been implemented, it will be necessary to audit and revise every single standard. Figure 3 shows demonstrating the development of the first stage of implementation.

Information sharing is of great importance in supply chain operations since it is positively directly correlated to JIT and Total Quality Management (TQM). These two methodologies are also positively directly correlated to operational performance (Zelbst, Green, Sower, & Abshire, 2014). Hence, an efficient implementation and utilization of such system requires constant information input from suppliers and the end-user.

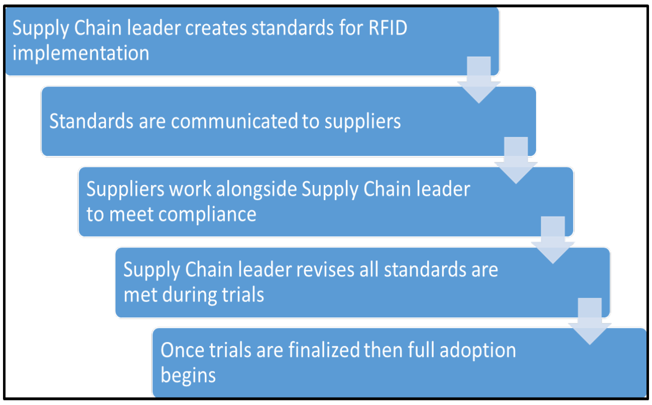

Figure 3. RFID Implementation Based on Supply Chain Leader

4. Example: RFID Tracking Implementation Application at TMMTX

4.1 Onsite Suppliers at TMMTX

Figure 4 shows the current location of on-site suppliers at TMMTX. These suppliers have been placed on this campus due to several factors concerning the Toyota Production System (TPS). First, these on-site suppliers have been placed in the TMMTX campus to support the flow of industrial manufacturing and JIT methodologies. Second, Toyota USA wanted to make an impact for the city of San Antonio by creating numerous work opportunities for the local population. Thus, the addition of these suppliers guaranteed a wider reach for a diverse demographic inside the TMMTX campus. Lastly, the placement of these suppliers inside the campus helps to reduce logistics costs for many of the components. These are some of the most important factors Toyota took into consideration when creating the TMMTX campus. Amongst these factors, it is important to mention that logistics and being able to comply with JIT methodologies were some of the decisive factors for placing the On-site suppliers within the same campus. In addition, short distances between TMMTX and its suppliers also has an impact on quality. In the case any quality problem where to arise, the TMMTX quality groups will be able to respond immediately thus, eliminating the probability of obtaining bad parts which would cause delays in our assembly process.

Figure 4. On-Site Supplier Overview at TMMTX

4.2 RFID locations at TMMTX

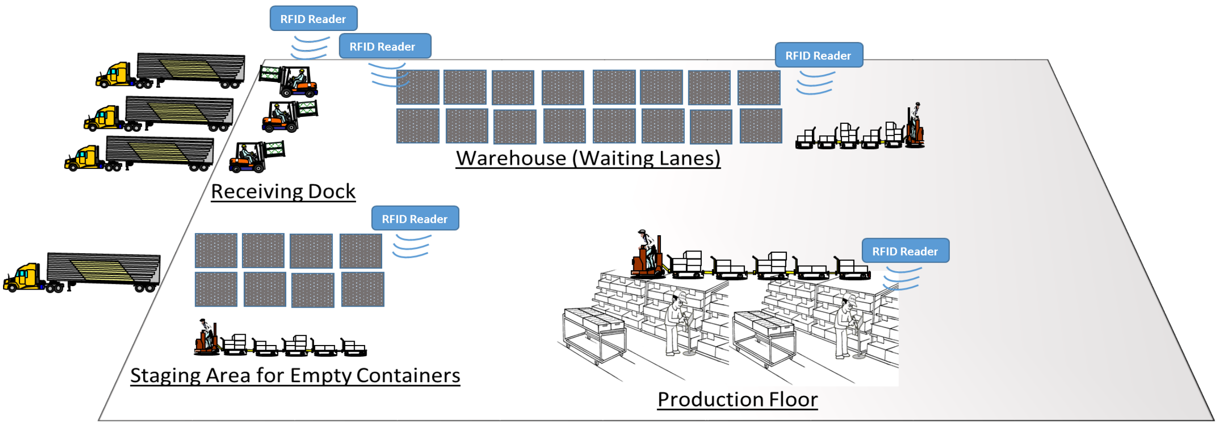

Figure 5. RFID Reader Locations Throughout the Manufacturing Site

Figure 5 represents some of the ideal locations for RFID readers to installed throughout the manufacturing facility. In this figure RFID readers are installed at the unloading docks to scan all incoming material by supplier, "kanban" (Ohno, 1978), order number and compare this to the current cycle (Fikes & Sakai, 2016). This information will be utilized as input in the algorithm which will determine if the incoming material was shipped as planned or if this material is on an ahead/behind condition. This process begins at the receiving dock from where the material is scanned, the material is read again once its placed in the warehouse. Once the material is taken out of the warehouse, it is scanned again. The next scan occurs when material is delivered to the rack and when empty boxes are taken out of the rack. Containers are scanned again when empty containers are taken to the warehouse at the shipping docks.

4.3 High Scale Implementation

A high scale implementation in a manufacturing setting incurs an elevated investment cost which relates to the importance of the setting the intended reach from the conception of the project. For any manufacturing facility it is important to note that having an RFID scanner at every rack at the beginning of this project will have a massive cost. Instead, trials should be run first at the receiving and shipping docks in order to test if current RFID readers are actual capable of scanning all incoming and outgoing material without false readings or skipping tags on certain totes. This is meant the complexity of daily operations at a manufacturing facility and to ensure if the system would be capable of performing its intended use and its 100% accurate and precise with all readings.

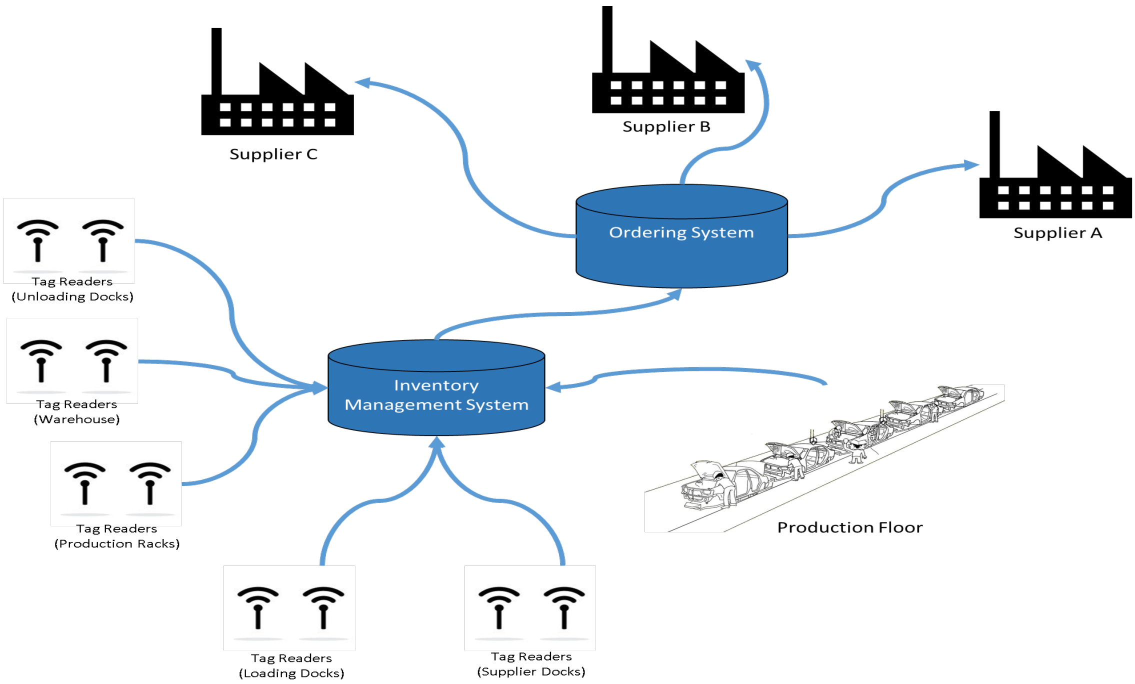

Figure 6. System Information Flow

Figure 6 shown above represents the information flow that will be needed for a system implementation of this type. Utilization of these systems can lead to increased organizational knowledge which as a result can reduce risks and uncertainties (Zhong, Huang, Lan, Dai, Xu, & Zhang, 2015). Also, companies which can acquire new knowledge, can combine this with their pre-existing knowledge which can lead to the creation of new standards and practices for the company (Zhong, Huang, Lan, Dai, Xu, & Zhang, 2015). Technologies such as RFID can create enormous amounts of data which can lead to information for analysis and the acquisition of new knowledge.

5. Conclusion

After implementing the RFID tracking system for inventory management is not a new technology but it still provides great applications for inventory management with its decreasing pricing for acquisition. Utilization of this technology can lead to increased productivity along with cost reductions throughout the entire supply chain. RFID systems can store moderate amounts of information which can be vital for traceability inquiries, such as torque, force, pass/fail testing, date and time of manufacture and so on.

Detailed information on all parts can provide a faster response time in the case of quality issue, defect or part exchange. Even though the initial investment will be costly, the immediate benefits can justify the investment. Medium to long term benefits involve the massive amount of data that will be generated and stored in the servers. Stored data will open further possibilities for research and new knowledge acquisition along with possible optimization information. Once the firm has an established process for their RFID tracking and all the information is being stored, the firm can utilize a data mining algorithm to begin to extract and clean up this data in order to provide the user with a higher understanding of the movements and operations throughout the plant, something which can sometimes prove to be enormously difficult due to the lack of understanding of the raw data and the massive amounts which will exist in the system. In addition, RFID is a highly sophisticated tool for inventory management and tracking for supply chain management which should not be overlooked or dismissed based upon implementation cost. Fortunately, there are many other companies that have already implemented this technology and have proven that this investment does have a return on investment. RFID can prove to be an efficient tool with which to track inventory and generate cost savings.

Acknowledgement

Example of RFID logic at manufacturing facility with on-site suppliers:

Implementation of such system at manufacturing facility requires supplier participation in order to begin data acquisition from the moment the shipment leaves the supplier's facility. For such company the logistics process would be as follows:

- Parts are packaged and scanned by a stationary RFID reader at the dock when they are being loaded to the truck.
- Once parts arrive to the plant a stationary RFID scanner scans all incoming packages and updates inventory system with new information such as: order number, quantities, part number, kanban, and location.
- Forklifts from assembly conveyance can scan the pallets and determine to which waiting lane they need to be delivered.
- If the lane number is currently running and the pallet is still on the waiting lane, this will trigger an alarm stating the inventory is behind delivery schedule.

- Material is delivered to its specified address on the rack, where the rack will also scan the incoming RFID to keep an accurate count of minimum and maximum values along with order numbers. Racks can create alarms for low-inventory or high-inventory.

Table 1. Basic Algorithm for RFID Logic with on-Site Suppliers

IF (Rack Inventory > Min AND Rack Inventory < Max and Order Number = Cycle)

THEN Inventory Status = OK

IF (Rack Inventory < Min OR Order Number ≠ Current)

THEN Inventory Status = NOK (Create alarm for possible internal delay)

IF (Rack Inventory > Max AND Order Number > Cycle)

THEN Create alarm for orders delivered ahead of schedule

ELSE (Rack Inventory < Min AND Order Number < Cycle)

THEN Notify supplier of low inventory

IF (Location Inventory < Min AND Order Number = Cycle)

THEN Notify supplier of low inventory and create alarm for possible scrap

IF (Scrap > 0)

THEN Add # of scrap to inventory loss

IF (# of Scrap for Kanban = 1 Container AND Location Inventory < Min)

THEN Order 1 Container of Parts

IF (# of Scrap for Kanban = 1 Container AND Location Inventory > Min)

THEN Order 1 container of parts

IF (# of Scrap for Kanban = 1 Container AND Location Inventory > Max)

THEN Keep track of scrap containers

IF (Arrival Scan < Standard Cycle Unload)

THEN Orders delayed (Create alarm)

ELSE (Arrival Scan > Standard Cycle Unload)

THEN Orders ahead (Create alarm)

IF (Departure Scan = Standard Departure Cycle AND Arrival Scan = Standard Cycle Unload)

THEN Inventory Status = OK

IF (Kanban ≠ Location Inventory)

Then Create alarm for wrong delivery

IF (Rack Inventory > Max)

THEN Create alarm for possible overflow

IF (Container at Empty Section of Rack)

THEN Count container as empty and eliminate from inventory level

IF (Empties Rack = Max)

THEN Send alarm for rack full of empties

IF (Empties Staging Area = Max)

THEN Send alarm to logistics for empty container pick up

IF (Empty Container ≠ Correct Trailer)

THEN Create alarm for wrong load

IF (Supplier Containers < Min at Supplier Facility)

THEN Create alarm for low container inventory

IF (Supplier Containers > Max at Supplier Facility)

THEN Create alarm for wrong containers in supplier facility

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