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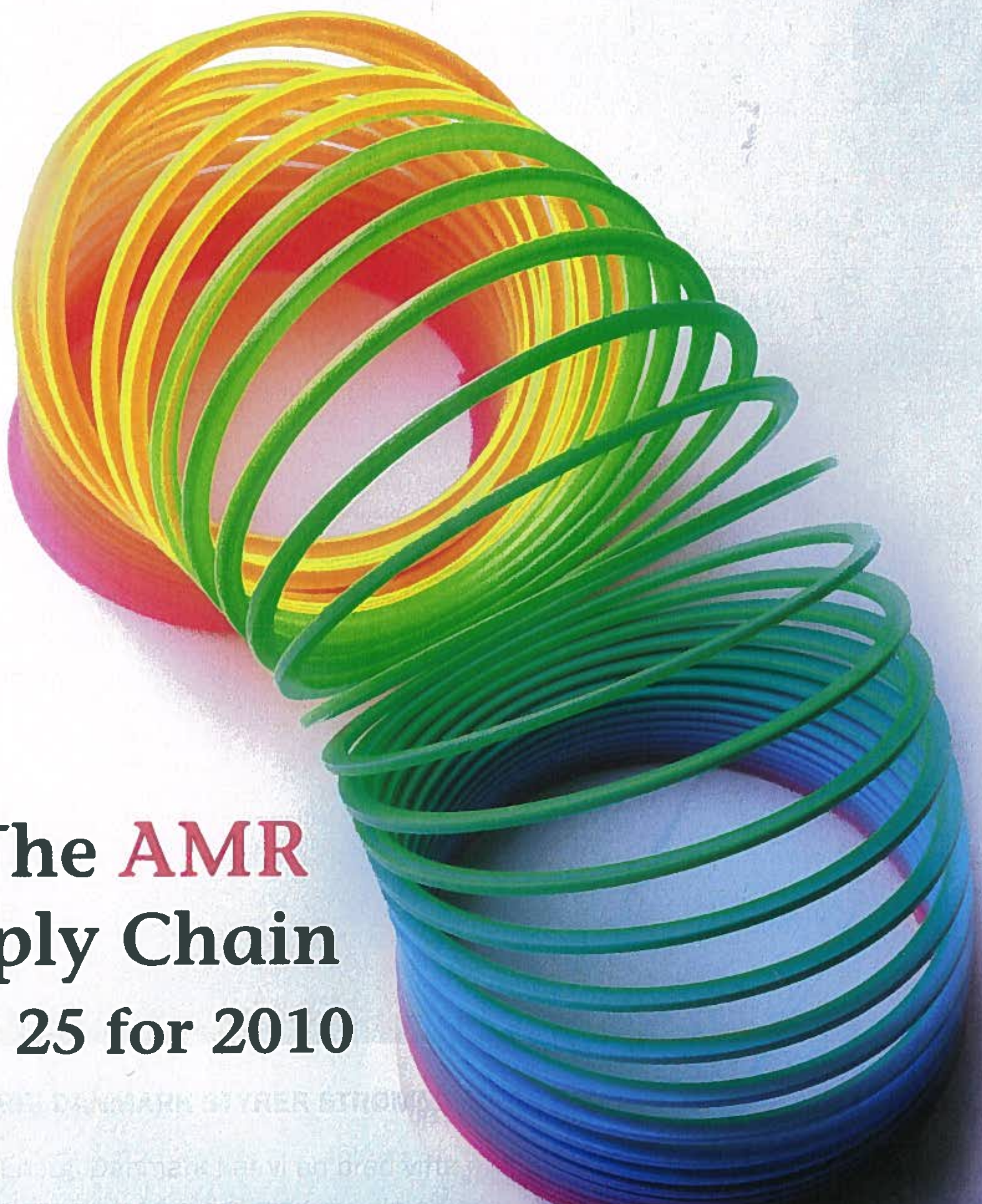

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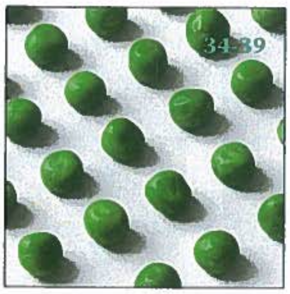

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An RFID implementation in the automotive industry – improving inventory accuracy

This paper explores and describes the impact of radio frequency identification (RFID) technology on inventory accuracy within a production and assembly plant, and proposes a model for assessing the impact of the technology on inventory accuracy. The empirical investigation, based on case study research, focuses on a RFID implementation at a supplier of bumper and spoiler systems to the automotive industry. The results indicate that RFID ensures that inventory inaccuracy will be kept at minimum, providing practitioners with the opportunity to further eliminate waste and improve factory performance.

FOTO: ISTOCK


BY DANIEL HELLSTRÖM AND MATHIAS WIBERG, DIVISION OF PACKAGING LOGISTICS, DEPARTMENT OF DESIGN SCIENCES, LUND UNIVERSITY

RFID is an emerging technology in various industries. The technology provides an opportunity to improve returns management, tracking and tracing systems, process control, security, and sales, and enhance consumer experience.[1,2] Furthermore, it has been argued to improve inventory management by reducing inventory, operational errors, labour, and amount of discrepancies, and increase inventory accuracy and visibility.[3,4,5]

The phenomenon of inventory inaccuracy is well-known (see for example note number 6). Inventory inaccuracy can lead to higher inventory levels, lower fill rates and poor customer service, thus it is very costly. The literature on inventory control has not considered the discrepancy between inventory records and physical stock which is caused by shrinkage, misplacement and transaction errors.[7,8] Fleisch and Tellkamp[9] illustrate the effect of managing inventory systems with a discrepancy problem in three simulation scenarios; by ignoring it, using statistics, and by using RFID technology to eliminate it. The simulation results showed that choosing an RFID-enabled system can save 15.72% compared to ignoring it, and 0.86% compared to a system which uses statistics.

The purpose of this paper is to explore and describe the impact of RFID technology on inventory accuracy within a production and assembly plant and to propose a model for assessing the impact of the technology on inventory accuracy. The focus is exclusively on an RFID implementation conducted at a supplier of vehicle components to the automotive industry. Consequently, the paper provides insights into how RFID technology impacts on inventory accuracy.

Methodology

In order to explore the impact of RFID technology on inventory accuracy, a single case study was performed. The main reason for conducting a case study is to gain an in-depth understating of a phenomenon being studied.[10] The case study method was also considered appropriate since RFID implementation is an emerging empirical topic.[11]

The case study focuses on a RFID implementation at a supplier of bumper and spoiler systems to the automotive industry. The case was primarily chosen based on its uniqueness; it is the largest of the few item-level, open-loop RFID implementations in northern Europe. Furthermore, the implementation decision was based on the advantages provided by RFID technology and not driven by mandate. The implementation did not make it possible for a quantification of the impact of RFID technology based on historical data. However, the results and conclusions drawn from this case study and the proposed model provide insights into how RFID technology impacts on inventory accuracy. The case is presented in the following case description section.

During a period of six months, data were gathered using direct observation, archives and internal documentation. Furthermore, semi-structured interviews were conducted with key personnel to bring depth to the investigation. The respondents were chosen based on their involvement and knowledge of the RFID implementation. In order to increase reliability, every interview was recorded and transcribed. Some of the questions were asked again in a second interview to ensure validity. Moreover, regular e-mail contact was established with the respondents for questions that were overlooked during the interviews.

Case description

Plastal is a supplier of injection-moulded, surface-treated interior and exterior plastic components, mainly bumper and spoiler systems, to the automotive industry. It is one of the 100 largest automotive suppliers in the world with a wide range of customers. The case study was conducted at Plastal's production and assembly plant in Gothenburg, Sweden [PAGO].

PAGO's main customer is Volvo Cars Corporation. Every half hour PAGO sequence delivers bumpers, spoilers and complete bumper sets (also including lamps, parking sensors, etc.) directly on to Volvo Cars' assembly line. The deliveries are based on just-in-time and just-in-sequence, which means that PAGO must not only ensure that the ordered parts are supplied punctually in the required quantity, but also that the sequence of the ordered parts is correct. The time from Volvo's sequence order to final assembly is approximately eight hours, while PAGO's production and assembly processes have a longer lead time. Accordingly, PAGO has an assemble-to-order production strategy. In total, PAGO delivers approximately 1600 different types of assembled products.

The RFID implementation and technology

PAGO applies RFID tags to all bumpers and spoilers. Thus, every car with a PAGO-manufactured bumper system has four tags, one on each spoiler and bumper both front and back. During 2008, PAGO applied approximately 300,000 tags. The reason why PAGO implemented RFID technology was to decrease the risk of having an incorrect stor- →

age status, increase traceability in the production and assembly processes, utilise the possibility to control the equipment in these processes based on the information stored on the RFID tag, and reduce manual reporting, which is error-prone. PAGO chose to implement RFID technology amongst the other competing Auto-ID technologies for a number of reasons. The main reason was that RFID could identify bumpers and spoilers on the different load carriers (racks, skids and cassettes) without any visual contact. This minimises the need to move the parts when loaded on load carriers and thereby also minimises the risk of causing scratches on the surface of the parts. RFID technology also provided PAGO with the ability to read many tags simultaneously. However, a bar code system is used as a fall-back system to ensure that the Auto-ID system does not fail.

The RFID tags used are 96-bit, passive RFID tags which operate in the ultra high frequency (UHF) area. This frequency was chosen due to reading distance, its non-interference with consumer electronics, and its good propagation characteristics. Each tag contains a unique serial number that PAGO staff have themselves constructed. It consists of a country code, an area code, a unique number and a factory code (there was no data structure standard available when the system was implemented in 2005). This serial number is also stored in a secure database where attributes such as colour, product type and what gate (i.e. location) the specific product has passed are stored.

Production and assembly processes

PAGO's production and assembly plant is highly automated and comprises nine production and assembly processes: (1) Injection moulding, (2) high storage one, (3) masking, (4) paint shop, (5) polishing and checking, (6) high storage two (and assembly station), (7) assembly, (8) sequencing, and (9) loading. Figure 1 illustrates these processes, also showing where RFID gates are located. In total, 24 RFID gates are implemented. These are located in the following steps: The injection moulding process, in and out of high storage one, the paint shop process, in and out of high storage two, and between sequencing and loading processes.

PRODUCTION AND ASSEMBLY PROCESSES AT PAGO

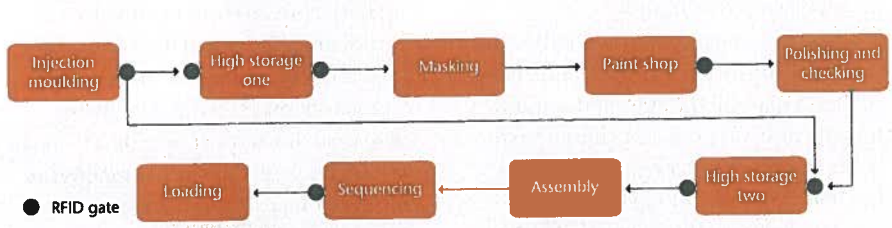

Figure 1.

Results and discussion

In this section, the RFID impact on inventory accuracy is described and the model for assessing the impact of the technology on inventory accuracy is presented.

RFID impact on inventory accuracy

Even though PAGO's production and assembly plant is highly automated, there are several manual tasks for reporting and updating the IT system. These manual tasks occur at the entry and exit points for high storage one and two, and in the assembly process. All these manual tasks are error-prone and the sources of inventory inaccuracy (figure 2). For PAGO, the main consequences of inaccurate inventory are higher inventory, rush orders (and its consequences), out-of-stock, waste and longer inventory turnover.

At the entry point to high storage one there is a manual station where an operator can unload damaged products from racks. If a damaged product is found and removed, the operator needs to update the number of products available on that rack. It is during the updating that a problem sometimes occurs; the operator accidentally enters the incorrect number available. This problem is solved by placing an RFID gate at the entry point to high storage so that it automatically identifies the products on the rack and updates the amount of products entering storage.

At the exit points to high storage one there are two stations where operators unload products from racks. The most common error which occurs in these stations is that an operator updates the wrong

TASKS WHERE ERRORS, I.E. SOURCES OF INACCURACY, OCCUR AT PAGO

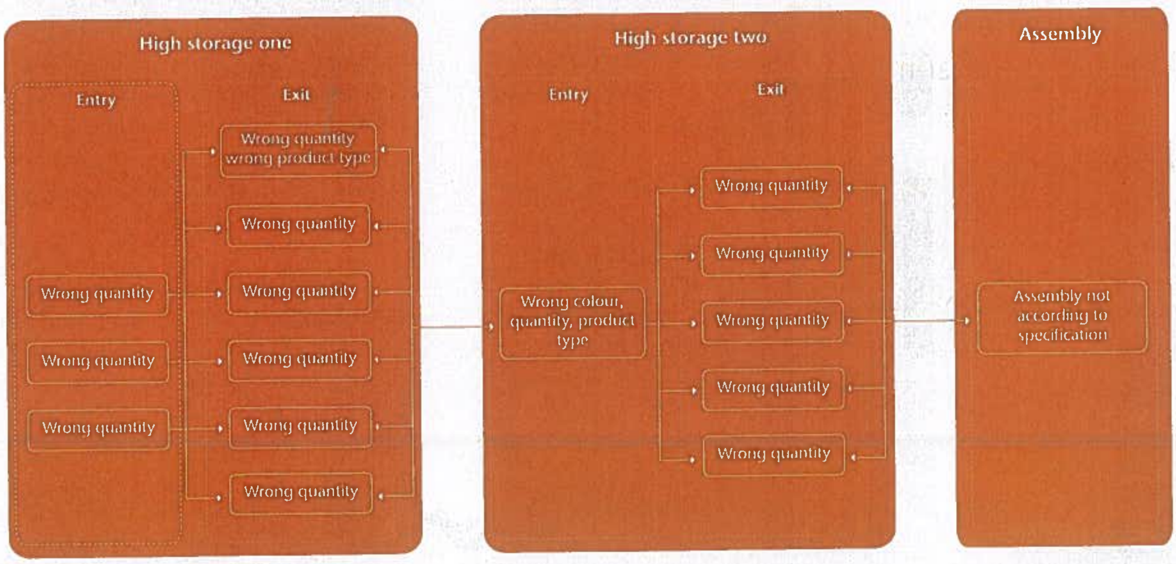

Figure 2.

Figure 3.

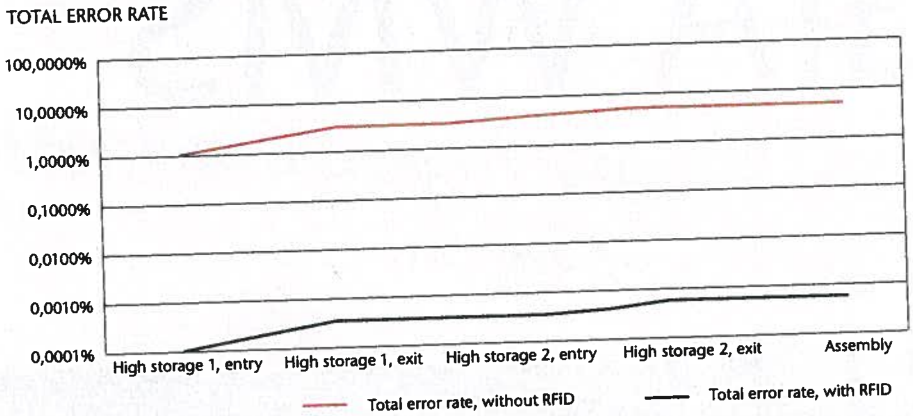

Figure 4.

number of products which are left on the rack and sent back into high storage one. At one of the stations, another problem also occurs; the wrong type of product on the rack is specified. These kinds of errors are all corrected by the RFID gate at each exit point which identifies the product type and amount and automatically updates the IT system.

At the entry point for high storage two there are three kinds of manual error which can occur: Wrong amount, product type and colour specified. As manual tasks, these are all prone to error. For example, an operator need to specify what colour each article is. There are various colours and many of them are exceptionally hard to distinguish from each other, especially in a production environment. Thus, the specification of colour is error-prone.

At the exit point for high storage two, the start of the assembly process, an error which occurs is that an operator can unload more articles than the IT system has specified. This normally happens when an article has been damaged or scrapped, and thus the assembly is missing, and urgently needs, one or several articles. As the IT system automatically updates the number of articles left on the cassette by subtracting its specified amount of articles to be unloaded, the number of articles on the cassette will be incorrect, i.e. resulting in incorrect storage levels. As a consequence, this can cause an extra colour swap in the paint shop, which decreases production performance and increases production costs by increasing scrap rate and requiring additional labour.

In the assembly process, several errors occur. For example, a grained spoiler is sometimes assembled with a coloured bumper or vice versa; a spoiler and a bumper are assembled, but their colours do not match; or the assembled product does not match the customer order specification. Without RFID to identify each spoiler and bumper and compare with an order specification, these errors are hard to find and often result in new rush orders. The RFID gate in the sequencing process checks for these kinds of errors before complete bumper sets are loaded onto the trucks and delivered to customers. The RFID gate is located after the sequencing and not after the assembly due to technical limits and lack of space in the assembly.

In the IT system there is an autocorrecting effect based on using RFID technology. For example, let us say the RFID system only reads eight of nine products on a load carrier at an entry point to a high storage. When the load carrier then reaches the exit point and the RFID system identifies all nine, it will automatically update storage status or suggest that an operator updates storage status.

Assessing RFID impact on inventory accuracy

In order to understand and assess how RFID technology improves inventory accuracy a model has been developed. The model shows the inaccuracy caused by manual updating and how it is reduced by the effects of RFID technology.

The model is based on the tasks where manual errors occur (figure 2). If the mean error rate of a task is denoted as: ε_n, and Y_{n-1} denotes the number of non-faulty articles entering the task, then the mean number of non-faulty articles leaving the task is going to be (number of non-faulty articles entering the task minus number of faulty articles leaving the task) $Y_{n-1} - Y_{n-1} * \varepsilon_n$. If the number of non-faulty articles entering the first task is denoted as Y_0, and all errors are assumed to be uncorrelated with each other, the following formula can be given:

$$\begin{cases} Y_n = Y_{n-1} - (Y_0 * \varepsilon_n)\left(\frac{Y_{n-1}}{Y_0}\right) = Y_{n-1} - (\varepsilon_n * Y_{n-1}) \\ Y_0 := \text{Number of articles entering the first task} \\ \varepsilon_n := \text{Error rate for task n} \end{cases}$$

According to Smith and Offodile,[12] the mean error rate for human data entry is one in 300, while Williams[13] argue that manual keyboard entry is about one in 250. According to Smith and Offodile,[12] the error rate for scanning bar codes is between one in 394,000 to one in 5,400,000. Williams[13] states that "RF identification systems are remarkably accurate, frequently achieving error rates of better than one in every 10,000,000; some systems have been able to demonstrate error rates of better than one in 800 million." However, modest assumptions were made in the PAGO case in order not to overestimate the impact of RFID on inventory accuracy. The mean error rate for manual updating and assembly was assumed to be one in 300, while the RFID system was assumed to have an error rate of one in 2,500,000.The number of articles entering the system Y_0 was set to 10,000.

The result of using the model to compare manual updating versus an RFID system on the PAGO case is presented in figures 3 and 4. Figure 3 illustrates the decrease in the amount of non-faulty articles in production and assembly processes using manual updating, while figure 4 illustrates the increase in the total error rate. The model does not consider the autocorrecting feature of an RFID system. However, the model (with its assumptions) illustrates that implementing an RFID system and eliminating manual updating are major steps towards improving inventory accuracy. Even if the error rate for the human data entry was ten times less, i.e. 1/3000, the consequence for PAGO would be the same. PAGO produces nearly one million articles (bumpers and spoilers) each year and is allowed by its customers to have an error rate less than 100 ppm. Thus, the implementation of the RFID system ensures inventory inaccuracy will be kept at minimum thereby allowing lower inventory, fewer rush orders, less out-of-stock, less waste and higher inventory turnover.

Concluding remarks

This research makes a modest, but important, contribution to the understanding of how RFID technology has been implemented in practice in order to improve inventory accuracy in production and assembly processes. Moreover, a model for assessing the RFID impact on inventory accuracy is presented which can be used by practitioners in their quest for eliminating waste and improving production and assembly performance. There is a scientific and industrial need for more research covering the implementation and impact of RFID technology. One approach might be to expand this single case study research to cover additional case studies, enabling cross-case comparisons. Moreover, the proposed model can be further developed to include stochastic distributions on error rates and the autocorrecting effect of RFID technology. /

Acknowledgments

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