AUTOMATIC & UNMANNED STOCK REPLENISHMENT PROCESS USING SCALES FOR MONITORING

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Keywords: Unmanned stock replenishment, automatic-replenishment, vendor managed inventory.

Abstract: This paper presents a process description for a fully integrated, unmanned warehouse inventory replenishment system. This description serves as a springboard for discussion on the TEMO project (TEMO-Project, 2006), where the Vendor Managed Inventory (VMI) model's current situation and future possibilities in the Finnish engineering industry are being studied. In this paper we concentrate exclusively on C-class product management challenges. Because of the exceptional characteristics of these products, C-class product monitoring cannot be directly adapted to the VMI models used by the food industry, which are usually based on Point of Sale (POS) information. By presenting the "ideal" model, as well as an adapted version which can be carried out using currently available technology, the researchers would like to open scientific discussion on the subject, especially considering challenges in stock monitoring. The main idea is to offer a higher level of service to customers as well as new business opportunities to service providers. This kind of technology implementation would bring new challenges to supply chain management but also new areas for research, such as information management, communications engineering, as well as e-commerce and added value services, to the forefront.

1 INTRODUCTION

The Finnish engineering industry uses a wide scale of different products classified as C-class products. These products are often small in size, lightweight and take up little space (e.g. nuts and bolts). On the other hand, heavy industry uses some mid-sized and heavy products in its processes (e.g. heavy copper cable and axels). Furthermore, heavy industry also makes use of large but lightweight products, such as foam insulation, in their assembly. The selection of C-class products used in the engineering industry is heterogeneous and the category of products is noticeably large.

Monitoring of C-class products is a particularly challenging financial and administrative exercise. Monitoring these as A- or B-products are monitored isn't financially feasible because amount of human labour and the items. To the companies involved in our study, as well as for their customers, balances of these products' are almost without exception not known. Companies are classified as large and medium-sized on the Finnish industry scale by (Federation of Finnish Enterprises).

A similar management problem was present in the previously done SERVIISI project (SERVIISI-Project, 2005), where the product cost varied from cent to tens of euros and unit amounts varied between handfuls to tens of thousands. Researchers asked reasons why the product balances were not kept on IT systems and why companies didn't use technology to manage the whole life-cycle of the products. The most common reason given was the unit level monitoring of products would be such an administrative burden that it simply isn't feasible task to do (products' heterogeneous nature and number of items was cited time and time again).

From a logistics point of view, these C-class products are a challenge for the Finnish engineering industry. Monitoring C-class products is a necessary evil; it takes up a lot of time and it's not the core function of the companies. Product monitoring is also challenging transportation-wise. In Finland, distances are long and the land itself is divided by lake districts along the North-South axis. Also, the load sizes required to make road transportation financially viable is a challenge itself. In addition, labour costs are rather high in our country when

Happonen A. and Salmela E. (2007).
AUTOMATIC & UNMANNED STOCK REPLENISHMENT PROCESS USING SCALES FOR MONITORING.
In *Proceedings of the Third International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 157-162
DOI: 10.5220/0001282801570162

compared to other countries. Because of the reasons mentioned above, companies are outsourcing C-class product inventory replenishment process to companies which offer VMI model-based services.

According to recent studies, metal and engineering industry future trends are looking good, which means that logistical challenges will continue to grow in number (Statistics Finland, Teollisuuden toimialakatsaus I/2006). At the same time, costs connected to transportation operations have raised faster than turnover (Statistics Finland, Palvelualojen toimialakatsaus IV/2005). In practice, this has led the engineering industry in Finland to outsource their C-class products' acquisition, management, delivery and stock replenishment activities to VMI operators. Based on our interviews, we believe that this is one of the reasons why logistics operators have expanded their operations by 10 to 30% yearly over the past few years.

Current VMI stock replenishment model is accomplished mainly through manual labour. This project's one goal is to find a technological solution, through which operations efficiency is enhanced, service can be offered to a larger customer base and current customer base service level is upgraded. Through interviews and fieldwork, the researchers have studied Finnish VMI operations and have found out the basic problems present in current operation models. The researchers also considered the possibilities of mobile technology. As a result an idealistic technological solution's framework is presented as well as an adapted concept of this ideal model, which could be implemented using current technology. The researchers would like to open the discussion on the automated management of C-class products in the scientific world to bring a strong theoretical viewpoint as a part of this research.

The research area is limited to the VMI models customer-supplier relationship. During the project, a practical prototype based on our concept will be built in order to find the practical limitations which usually go unnoticed when models are studied only theoretically. In the next section, the aims of the study, the research process and the methods are covered, as well as the criteria for selecting the technology connected to the model's practical implementation. Section three discusses the current situation of VMI within the Finnish engineering industry. Section four handles the fully integrated technical solution's process description and in section five, a potential way to practically implement the model is described. Practical limitations and the potential uses for the model are reflected upon in section six. Finally, the topics and ideas for further research are presented.

2 METHODOLOGY

The study was carried out as a quantitative and exploratory situation study. Research methods included partially structured, face-to-face interviews as well as workshop-style brainstorming in groups. Methods were chosen to gain an in-depth knowledge about the research subjects and also to make sure that all of the interviewees and researchers understood the concepts being handled in the same way. The groups were made up of the people representing the companies in this project. Both the heads of the business units as well as operative-level employees were involved in our studies. Among the companies were customers, suppliers, wholesalers as well as two logistics companies.

During the first round of interviews the problems were limited to those that could be easily improved with automation. After this, one of the researchers did a field study. He studied the replenishment process at the shelf level in 3 companies VMI cases. The fieldwork supported the findings which were obtained from the first round of interviews and it familiarized the researchers with practical operation. Also during this field work the researcher found out some limitations of the technology-based solution because of manual work. During the second round of workshop-style meetings, the observations based on first interview round were tested and the problems were investigated further. There were numerous stock replenishment processes being implemented in slightly different ways among the companies.

In this study, customer means companies which produce different machines for end users in industry on an assembly and project basis. The VMI suppliers are mainly technical wholesalers. Therefore, this research concentrates on the cooperation between customer and the wholesaler (or other material supplier) in the Finnish industrial environment.

The abovementioned companies will be used as the basis for reflection upon the challenges connected with bringing technical solutions to VMI operations in Finland. In Finnish VMI operations, the largest single cost comes from using manual labour (SERVIISI-Project, 2005). In Finland, manual labour is particularly expensive; the fixed costs related with labour are extensive and each new pair of hands means more costs, for both administration and production. In this study, the expense of manual labour was the impetus for finding technical solutions that would make current VMI model replenishment processes more efficient. Through technology the researchers try to find long-term benefits for many different parts of the process at once. For example: minimalizing manual labour, making follow-up and prediction more efficient and improving the management of exception situations. In practice the management of exceptions leads to manual labour reduction because each exception needs the work of at least two people (one on the customer's end and one on the supplier's end).

The goal is to create a fully integrated VMI operational model including communication, warehouse management and supply delivery improvements trough automation. From this fully integrated model the researchers will design a model which can be implemented using technology that is currently available. In essence, this is cross-road of two objectives – the first is the streamlining of the process and the second is new operational models which are built on the efficient combination of information handling and network technology.

The study began by the researchers familiarizing themselves with the previously done SERVIISI project (SERVIISI-Project, 2005). SERVIISI was a study on VMI models on supplier-customer relationships. Next the researchers continued by going through the food industry's VMI models, where technology was used to minimalize stock replenishment control and the management burden (Pohlen and Goldsby, 2003), (Katz et al., 2000). The researchers realized that in practice the solutions used in the food industry won't directly fit into the engineering industry as is. Storage times are from days to months in the food industry, but they are from months to years in engineering. The food industry's solutions are based on strict inventory accounting and Point of Sale (POS) information (Elvander, 2005). In engineering, the materials have an unknown balance. The materials are located on shelves in workshops, where anyone can come and take whatever they need whenever they need it without book keeping. The differences are so large in practice that the models used in the food industry are not easily transformable to the VMI environment present in engineering industry.

Our research tries to determine whether or not technical management is viable solution. If it is, considering the practical limitations, will the added value provided by technology be enough to justify studying new operational models in the future?

3 THE VMI MODEL'S CURRENT SITUATION IN THE FINNISH ENGINEERING INDUSTRY

This section will outline the typical VMI model used in the Finnish customer-supplier relationship. The description of the operational model focuses on normal functions and will not be concerned with, for example, the "learning curve" that occurs at the beginning of implementation. This description will begin with the initial visit to the shelf by the stock replenisher and will conclude to the next visit.

The stock replenisher arrives at the shelf with the supplies from the previous order. He shelves the products and starts the replenishment order process. The inspection process is based on visual inspection. Each product is assigned with a refill limit and order point which is in direct relationship with the speed of consumption and the time between replenishment rounds. Ordering of individual products happens seldom in relation to the time between replenishment rounds. The stock replenisher checks which products are below the minimal stock limit. Most typical replenishment order process methods are the following: off-line or on-line handheld computer for "instant" order, or pen & paper method with later on updates to order system. If the frequency of replenishment round is faster than the supply delivery round, it is possible that the items have numerous overlapping orders. Usually the stock replenisher has thousands of products to worry about so there is no way that he can remember the unfilled orders outright. In this case, human error can easily result in overstocking or non-filling of the order because the stock replenisher remembers that he has already made an order. There are many ways to resolve this problem but typically solutions involve the management person who checks all orders before the refill order activation in the order system.

After order information is fed into the order system, new supply collection process can begin at the facilities of the supplier. An order-based collection list is printed out for the collection person. The collected items then end up in shipping, where the items are inspected, signed off and cleared for delivery. The products end up with the stock replenisher on the customer's shelves and the whole process begins again. Billing information is usually generated during the shipping stage. The supplier provides a cost report as well as an itemized invoice. At this point it is important to note that no one is aware of the real consumption, just the delivery rates. This means that an in-depth analysis on the item level consumption is an impossible task to do.

4 ICT-BASED SOLUTION FOR A FULLY-INTEGRATED VMI MODEL

The idea behind this system is automated monitoring, order parameter setting, automated order generation based on additional parameters as well as manpowered order collection and shelving.

A fully integrated stock replenishment process is based on exploiting the maximum benefits from technology and minimizing the involvement of human labour. The main problem with the current nowadays VMI model is that shelf rounds have to be made according to a timetable. It is possible for the stock replenisher to go through several shelves, or even through several customers, without making a single refill order. The stock replenisher has to make his rounds at appropriate intervals so that an understocking situation does not occur. For this reason, the supplier is forced to play it safe, both with stocks on the customer's shelves and with the time between rounds (a noticeably tighter timetable than what might actually be necessary on average). For this problem we propose usage of dynamically changed parameters. The proposed dynamic setting of parameters in IT based solution could be achieved in the way described in paper (Disney and Towill, 2002). Disney and Towill present a scheduling algorithm Automatic Pipeline, Inventory and Order Based Production Control System (APIOBPCS) to be used within VMI operations supply chain.

In this model, all of the customer's products are monitored trough computer system. Monitoring system can be based on for example, micro switch, Radio Frequency Identification (RFID), video surveillance, measuring technology, etc. which provides measuring precision that is equal to or better than visual inspection. Technical solution will allow item checks without doing it manually on site. Product's inventory is then continuously monitored, the information is analysed, cleaned up and used to make refill decisions fully automatically. The refill decision is based on the customer's confirmed order base, predicted sales, production plans, product make-up information, etc., as well as real consumption information received through monitoring. By combining all of this information, the supplier can make an optimal refill order. In this case, optimal means the kind of refill that minimizes the amount of manual labour but at no time risks the provided service level. The main principle behind this is that when ordering, the order is as large as possible at once and the period between orders is maximized, in a "reasonable" manner.

When the order is placed on system, it is transfers automatically to the supplier's system, which then prepares to print out a collection list. Before this list is printed, system checks for changes at the monitored sites and updates the list accordingly. The supplier collects the products, checks the order and clears the shipment for delivery.

A site-specific route can be optimized so that the stock replenisher drives a geographically optimized route but still in a way which prioritizes the route according to the calculated rate of product consumption. The idea is to minimize the travelling costs without jeopardizing service level. This way the time used to travel (or total travelling cost depending which is preferred) is minimized but there should not be any shortages at the serviced site. The stock replenisher's product delivery times are entered into the system, the current balance of items is updated and the company is invoiced either on a per order basis or later on by monthly invoice. The system checks automatically that the customer's invoice corresponds to replenishments.

Customer gets delivery time, consumption rate and exception reports automatically. In theory, this type of a system would guarantee that the product will never be out of stock because the supply system continuously monitors product consumption. Particularly large consumption can be dealt with on an emergency basis, instead of having the situation exposed only after the customer has informed the supplier or discovering it too late during regular replenishing rounds.

By breaking down the ideal operational model into parts, one can very quickly see the "impossibility" of it because of the limitations set by the technology. A fully integrated model would not, in practice, need a user interface for managing information but an interface on the system is needed for example to manage exceptions etc. In the TEMO project, a prototype will be built, which is based on practical implementation and which the researchers will be able to use to further explore the problem areas related to information management and communication technology in VMI context.

5 A SUGGESTION FOR IMPLEMENTATION USING CURRENT TECHNOLOGY

The prototype will be built upon an implementation model using current technology. Some of the following technological choices, for monitoring, were examined and considered: camera surveillance, RFID, weight measurement, sliding potentiometers and switches, etc. The characteristics of these technologies were checked and suppliers and customers were interviewed about the practical limitations connected to these technologies.

After weighing up the needs of the suppliers and customers, the researchers decided to base the prototype solution on scale technology. Measuring the items weight offered the best overall compromise based on the following criteria:

- real time inventory balance information (with enough precision)
- no manual labour for data entry required
- ease of historical data collection
- ability to analyse consumption trends, such as top and bottom 100
- automatic order replenishment
- dynamic parameter setting (order limit, refill limit)
- real time emergency situation alarms
- delivery time monitoring
- simple technology from a functional standpoint
- solutions response to change

Next, the imaginary progress of the replenishment process achieved through scale technology is described. As before, this cycle will begin on the initial replenishment visit and it will end on the following visit.

The stock replenisher arrives at the shelves with the previous order's delivery and proceeds with the shelving. At the same time he visually inspects measuring apparatus for malfunctions. When the replenisher finishes the replenishment process he moves on to the next replenishment point. Refill orders are made by the monitoring system. The system inspects the inventory balance on the shelves and sends an order as soon as one of the products drops below the order point. Products are not ordered individually. Actually, as soon as one product drops below its order point, all of the products near their order point are also ordered. This process should decrease the number of orders.

The refill order is transferred as an order proposal to the supplier's system. The proposal is analyzed and items are classified into product groups such as even consumption rate, easily forecasted and unsure. The person handling the order (order manager) adjusts the order based on experience and the prior information received from the customer, and confirms the order. The system is aware of unfilled orders and does not make overlapping orders. At least the system informs the order manager and he can then check the overlapping orders in order to avoid overfilling the shelves.

As the refill order is done in this manner, shelves have to bee visited only if there is replenishment work to be done. The automated system updates order point and replenishment parameters automatically (taking space restrictions into account) and in this way, reduces again need to visit at the shelves. Built in this way, the system is simple enough so that all of its users can understand the principle of the system. In addition, the system can easily adapt and be adapted to changes.

After confirming the order, the products are gathered on the supplier's end according to current practice and the stock replenisher delivers the goods, stocks them on the shelves and the process begins from the beginning once again.

6 DISCUSSION AND CONCLUSIONS

In discussing the presented implementation solution during the second round of interviews, a very positive interest in this project was raised but at the same time, the practical problems were seen as a large challenge. For example, how service provider can handle exceptions like Internet communication problems. There were some concerns about system robustness against changes of the system state on monitoring network down time. Depending on the construction of the monitoring system it might handle changes easily but the statistics collection part of the system has to be able to figure out differences between before and after situation and the changes between, which might not be an easy task at all. For this reason a prototype is under construction through which the scale technology's practical limitations can be studied.

The savings that need to be achieved through the minimizing of manual labour and the costs of implementation should be noted and the question should be asked whether or not benefits justify the system being developed into an operational model in industry. The researchers hope to get an answer to this problem through building the prototype.

It is the researchers' opinion that the system offers operational cost savings as well as new business models. Operational cost savings are achieved by optimizing refill amounts, by reducing the frequency of visits on factory sites and by improving the reaction to understock situations. In addition deepened co-operative relationship between customer and supplier results in synergy benefits. Supplier expands supply to customer and service improves for the customer. With the most efficient stocking strategy, a supplier is able to deliver service to customers which are far away from the delivery centre (can't be served using current operational model). Furthermore, when competing for new customers, the supplier has a competitive edge. The clear advantage to the customer is the availability of more detailed reports. For example, the analysis of an understock situation is easier than before because the supplier will be able to give detailed shelf inventory balances and historical data to the customer. From the supplier's point of view, one can be assured of maintaining the current customer base and raising interest of new customers by offering a better reporting system than the competition.

Will this implementation model be too expensive compared to its benefits? It's the researcher's opinion that this will only be clarified through the prototype as well as through inspecting constructing and maintaining tasks of the system in practice. The businesses involved in the study also felt that it would be important to find out customer groups that are best suited to the proposed system. Even though the proposed solution might be financially non-viable in its entirety at this stage, it's good to be aware of how the technology and costs should develop in future in order to achieve the necessary economic benefits which would make the proposed solution viable.

7 FURTHER RESEARCH

The topic areas for further research will be price-quality ratio analyses, the possibilities of optimization of visit frequencies through simulations and future cost predictions based on historical data (basically mathematical analysis). Cost research will concentrate on the total costs including servicing, maintenance, installation, calibration, system integrations and information engineering costs.

The researchers are also considering doing a theoretical study about information exchange and the problems associated with it. The Collaborative Planning, Forecasting and Replenishment CPFR framework will be studied as a development direction for VMI operations and also the exploitation and prediction of measuring data, to assure that the "service quality" of automated ordering is not forgotten.

Because C-class products have an indeterminable balance in the engineering industry, their management models have been some what ad-hoc in nature. Proposed solution would change the nature of C-class products to that of B-class products, so it would be natural to investigate B-class management models in this context. It would be particularly interesting to study how well current Enterprise Resource Planning (ERP) systems could be integrated into this type of "approximate" inventory balance produced by this kind of monitoring system. In other words, can current ERP systems and their B-class management models be directly adopted (for these C-class products) as is, or does a completely new management theory have to be developed for them?

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