For this study a framework based on VSM, Activity Profiling and Benchmarking has been developed. The purpose is to evaluate how this framework can be used to analyse the current state in a warehouse and to identify areas of improvement. In the conclusions suggestions are given to how the concepts overlap each other and complement each other. The VSM is a concept not commonly used in warehouses so another question that is answered is why the VSM should be included in the framework. The case company used for this study is Alfa Laval in Lund with their two warehouses.

1. Introduction

The 21st century has brought significant changes to the market - the uncertainty has grown rapidly, the competition has become even more crucial, a product’s life cycle is shortened, the customer demand is inconsistent and uncertain and the suppliers are unreliable (Rimiené, 2011). The present situation states the importance of a well-functioning supply chain to meet customer requirements and expectations (Christopher and Towill, 2001). The supply chain is the chain of activities that includes planning, coordinating and controlling the flow of information, material, parts and finished goods from the supplier to the customer (Stevens, 1989).

Frazelle (2002a: 5) argues that the warehouse plays a key role in the success, or failure, of modern supply chains. Warehouses have a major impact on a firm’s service levels, response times and overall costs (Bozer, 2012: xii; Bartholdi and Hackman, 2010: 5). To meet customer requirements there is a need of improved warehouse operations, which involve receiving, put-away, storage, picking, and shipping of goods (Constantino et al., 2012). Despite the stated importance of warehouse operations, they are considered as both costly and time consuming (Bartholdi and Hackman, 2010: 3). For this reason firms are limiting warehouse resources in terms of labour, equipment and space. With many actors and decision makers, warehouses are rather complex things to deal with (Manzini, 2012: viii). The prevailing situation calls for new ways to evaluate warehouses and reduce warehouse costs.

During this study, a framework with Value Stream Mapping, abbreviated VSM, in combination with Activity Profiling and Benchmarking has been developed. The framework has been used to analyse the current state in a warehouse and to identify areas of improvement. The research questions for this study are:

RQ1: How do the three concepts complement each other and why should they be used together in order to evaluate a warehouse?

RQ2: How do the three concepts overlap and were there any complications with using them together?

RQ3: Why should VSM be included in the framework and what benefits were found by applying this concept?

To meet the purpose of the thesis a case company was used, Alfa Laval in Lund. Alfa Laval is present on a global market and has production units in several countries spread over the world. Alfa Laval in Lund manufactures plate heat exchangers (www.alfalaval.com). Alfa Laval in Lund has two warehouses at the site, here referred to as warehouse A and warehouse B. They were used to examine and evaluate the framework.

2. Methodology

To receive a deeper understanding of the current situation in the warehouses with
respect to material flows and handling, time was dedicated to meet personnel working in the warehouses and to take part of the daily operations, participant observations. Experiences gained from these visits in the warehouses and the factory was helpful to comprehend the problem scenario.

The next step was to make the VSMs and hosting the workshops. Workshops were held with the purpose to inform about the project and to define focus areas. Customers and suppliers to the warehouse were identified as well as their expectations and requirements. Two separate occasions was used to make the VSM, one for each of the warehouses. The mapping started at the largest customer and then the material flow was followed counter current. Transportation distances, waiting time, storage areas and personnel involved at every activity were documented.

Secondary data were requested from the personnel at Alfa Laval, to accomplish the Activity Profiling and Benchmarking. Employees handling financial questions and supporting the information system at Alfa Laval were contacted. They helped by gathering order data and other information concerning the warehouses and the products stored. When the secondary data were collected, Activity Profiling and Benchmarking were initiated. For the Activity Profiling it involved interpreting the order data files and presenting the findings in an appropriate way. Benchmarking was completed by gathering information about each warehouse that can be compared against each other and against what is considered as world-class standards.

3. Frame of Reference

The most common operations in a warehouse are receiving, put-away, storage, picking and shipping (Bartholdi and Hackman, 2010: 22). In this study a framework based on the three concepts VSM, Activity Profiling and Benchmarking is developed. The three concepts will provide information about how the warehouse operations perform and where improvements are to be found. The understanding of how the warehouse operates and the dependency between activities is important to be able to improve the warehouse operations.

VSM is a paper and pencil method that visualises material and information flows. It can be used to identify where value is added to a product and when wastes occur. Wastes are: transportation, inventory, motion, waiting, over-processing, over production and defects (Rother and Shook, 2004: 2). Figure 1 shows an example of how a VSM can look like. The square indicates an activity, the triangle a storage area, the arrows material and information flows, and the factories indicate the suppliers and customers. The goal with a VSM is to eliminate as much waste as possible and all non-value adding activities (Rother and Shook, 2004: 9-34).

![Figure 1 - An example of VSM (Rother and Shook, 2004: 9-34)](image)

The Activity Profiling describes the activities in a warehouse and it is an essential part for the understanding of what really matters in a warehouse. The profiles serve as a baseline to identify problems connected to information and material handling (Bartholdi and Hackman, 2010: 217). Activity Profiling is divided into several areas: customer order profiling, purchase order profiling, item activity profiling, inventory profile, calendar-clock profile, activity relationship profile and investment profile (Frazelle, 2002a: 15-44).

Benchmarking is the process of gathering and sharing assessments of performance (Hackman et al., 2001; Frazelle, 2002a: 46-69; Gu et al., 2010). An assessment is based on a number of management ratios and performance indicators (Balk and de Koster, 2008; Bartholdi and Hackman, 2010: 239-248). According to Frazelle (2002a: 46), there exist three perspectives of benchmarking: internal, external and competitive. Internal benchmarking is benchmarking within the firm. External benchmarking looks outside the firm’s industry and competitive benchmarking compares firms in the same industry. In all cases, benchmarking is done to identify
strengths and weaknesses and to learn from the best according to the assessment.

Activity Profiling

VSM

Benchmarking

Figure 2 - The order that the framework should be applied

Figure 2 illustrates in which order each of the concepts in the framework should be performed. First the VSM should be done, subsequently the Activity Profiling and finally Benchmarking.

4. Identifying the Current State

The map is done with the aim to identify wastes, activities that do not add any real customer value. Figure 3 and 4 show the result of the mapping.

Figure 3 - VSM warehouse A

Figure 4 - VSM warehouse B

Next step when applying the framework was to collect secondary data and evaluate the data with help from the different profiles included in Activity Profiling. Item popularity was presented and if the most high frequency products were stored at the most convenient locations or not. Order increment distribution was calculated to see if it was profitable to pack some products in more appropriate case quantities, lines per order distribution was identified to see if orders could be batched and an activity relationship profile was performed. The utilisation rate for both warehouses was recorded, the amount of pallet positions that are occupied of the total number of pallet positions.

With Benchmarking some measurements were identified for both warehouses that can be compared against world-class standards. In-time delivery, picking accuracy and receiving accuracy were recorded. The picking productivity and warehouse costs were calculated. These measures provide an indication of the current state correspondence to a desired state.

5. Identifying Areas of Improvement

With the information gained from the VSM and Activity Profiling it was possible to create the gap analysis. A gap analysis visualises the gap between the current state and world-class standards.

From the VSMs it was identified how long distances material and items are transported, from arrival to departure, and how many orders that are waiting to become stored in the main storage or waiting to be processed or used by the customer. All kind of wastes was identified with the VSM except defects. Figure 5 and 6 illustrate how the future state should look like. All steps that are only causing wastes are eliminated in a future state.

Figure 5 - Future state for warehouse A

Figure 6 - Future state for warehouse B

The item popularity profile gives a good foundation for how to localise high frequency products in the future and where in the warehouse products should be stored with
respect to where they arrive and where they depart. The aim is to store the most highfrequency products at the most convenient pallet positions. Cases delivered from the suppliers could be delivered in more appropriate quantity. This would simplify the picking activity and improve the picking accuracy. In both warehouses a large number of the orders are single line orders.

Warehouse costs were calculated for both warehouses and the result presents a number of 20 SEK for each pallet position per day. This number is important to take into account when evaluating changes that involve large investments. It was also identified that in-time delivery not reach the stated goal because of factors that warehouse management cannot impact. The utilisation rate corresponds to what is considered as world-class standard. This indicates that the same amount of pallet positions is required even in a future state. Other world-class measures were also identified and compared against the current state.

6. Recommendations

The VSM has identified that there are a lot of starts and stops in the current state. There are numerous orders standing waiting to either become stored in the main storage or to be consumed by the customer. In a future state a continuous flow should be implemented and all temporary storage areas eliminated. Since there are a lot of transportations corresponding to long distances as well, a recommendation for a future state is to merge the two warehouses and the tents to one warehouse. The new warehouse should be located near the arrival and departure gate at the site and near the two other buildings in order to realise a better material flow at the site. By merging the warehouses similar activities can be merged releasing warehouse personnel and reducing the required amount of equipment.

From the Activity Profiling it was identified that the new warehouse should be divided into zones with respect to the type of product. High frequency products should be located near the floor and at the most convenient pallet positions in the warehouse. Alfa Laval should also negotiate with their suppliers if products could be delivered in more appropriate case quantities. This could increase picking productivity.

The utilisation rate in the current state corresponds to what is considered as world-class, a percentage of 80-90 percent. This indicates that the same amount of pallet positions is required even in a future state and Benchmarking identified this. Another recommendation to Alfa Laval is to evaluate the goals e.g. in-time delivery. Goals should be broken down and be set at levels that warehouse management can achieve.

Since there are some suppliers causing most of the problems e.g. later deliveries, wrong quantities or poor quality, Alfa Laval should work with their supplier process. Demand more from the suppliers not delivering at the level expected. Planning in the warehouse could also be improved if Alfa Laval implemented continuous flow and pull-systems. Benchmarking identified that the picking accuracy was higher in one of the two warehouses that uses a barcode system. It is therefore recommended to implement the same type of barcode system in the new warehouse. That would increase the picking accuracy.

7. Analysis of Framework

Table 1 summarises the findings from the analysis of the framework. For each concept it is presented what parts that are excluded from the framework, problems and benefits.

<table>
<thead>
<tr>
<th>Category</th>
<th>VSM</th>
<th>Activity Profiling</th>
<th>Benchmarking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excluded parts from the frame</td>
<td>The product family matrix and the visualisation of the time spent on</td>
<td>The activity relationship profile.</td>
<td>Some parts of the external Benchmarking.</td>
</tr>
<tr>
<td>work</td>
<td>every activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems with the concept</td>
<td>The involvement of personnel is critical.</td>
<td>Secondary data are used and an immense data set</td>
<td>Measures from different branches are not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>has to be analysed.</td>
<td>comparable.</td>
</tr>
<tr>
<td>Benefits with the concept</td>
<td>Primary data are used. Start and stops are identified and the</td>
<td>Focus on operations that are important for the</td>
<td>Evaluation and assessment of the warehouse.</td>
</tr>
<tr>
<td></td>
<td>material flow is visualised.</td>
<td>warehouse.</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 - Analysis of framework
8. Conclusions

In this study an extensive investigation has been accomplished in order to evaluate if a framework, based on the three concepts VSM, Activity Profiling and Benchmarking, is suitable to present the current situation in a warehouse and to identify areas of improvement. In this section the main purpose is to answer the stated research questions.

*RQ1:* The order that has been applied in this study and that will be recommended is to start with the VSM, continue with Activity Profiling and finally complete the study with Benchmarking.

The initial mapping provides a snapshot of the current state and visualises the physical material flows. It identifies where material and items are waiting and where overproduction occurs. It identifies transportation distances and how many personnel that are involved in different activities and the equipment required. The next step is to perform the Activity Profiling since it complements the findings from the VSM and gives a background for the discussions and the decision-making concerning how to locate products in the warehouse.

Both the VSM and Activity Profiling can identify the actuality, but neither of them can determine if the actuality corresponds to a desired situation. Therefore measures for assessment are wanted and that motivates the Benchmarking. With Benchmarking it is possible to define goals for the future state. It is possible to identify existing gaps between what is referred to as world-class standard and the current situation in the warehouse. Defects are also identified from Benchmarking.

Besides the identification of wastes, the framework evaluates the warehouse operations. Benchmarking evaluates all the operations since it defines measurable goals in order to reach world-class e.g. receiving accuracy and picking accuracy. VSM evaluates all of the operations when mapping and how they relate. Activity Profiling focus mainly on put-away, storage and picking.

*RQ2:* There is only one waste overlapping, namely transportation that is identified by both VSM and Activity Profiling. Another area where the concepts overlap is the identification of how activities depend on each other. Both VSM and Activity Profiling give a base for how activities should be organised and which activities that directly depend on each other. The VSM is anyhow recommended for this purpose because it is easy to understand and it gives a detailed picture.

*RQ3:* When identifying the current state, VSM plays a crucial part. It identifies how material moves around at the site: from arriving to departure. The advantage with VSM is that it can identify the entire material flow in a simple map, which will be essential when discussing areas of improvement. Furthermore, it provides a snapshot of the actuality involving waiting time, storage areas along the flow, personnel involved in different activities, the equipment needed and time required at different activities.

In future research it would be interesting to apply and adapt the framework for the entire supply chain and also include the information flow.

**References:**

*Alfa Laval’s Homepage*, www.alfalaval.com (2014-02-06)


Morse, J.M. (1999) Qualitative Generalizability, Qualitative Health Research, vol. 9, no. 1, January, pp. 5-6


