Reducing the Tied Up Capital Through Investigation of Production Postponement and Inventory

Lina Hedvall and Hanne Olsson
Department of Production Management and Economics
Lund University, Faculty of Engineering
SE-221 00 Lund, Sweden

Most industries are today global and the competition is fierce. Companies need to work on all fronts to achieve profitability and thereby survive. One factor of increasing importance has been to reduce the tied up capital. This could be done in several ways, where two common are to reduce the quantity of stored items or to store items earlier in the supply chain where the value of each item is lower. In this article, an investigation of how the strategies inventory management and postponement could decrease the amount of tied up capital at a Swedish company is presented. For confidentiality reasons the company is referred to as Hyde AB.

Introduction

This article is based on a master thesis project that was the concluding part of a Master of Science degree in Industrial Engineering and Management at Lund University. The project task was initiated by the financial manager at Hyde who believed that an intermediate storage at a point of product differentiation would enable a reduction of tied up capital for one of their product families. In an early stage of the project it was obvious for all stakeholders that a review of the inventory levels would be necessary as well. This was to enable correct estimations of potential savings from an intermediate storage. In addition to this, the personnel perceived the finished goods inventory to be crowded with high inventory levels. The two main strategies used in this project were inventory management and postponement.

This article is divided into two main parts. First, the possible gains from reducing the total inventory levels by an inventory management strategy are discussed. This is followed by a presentation of how a postponement strategy could decrease the inventory level and product storage value in Hyde.

Inventory Management

The goods stored in a warehouse all withhold an accumulated cost, originating from the procured raw material but also from the used machine time in the production. This cost and the money spent are tied up in these products until they are sold. If more products than required are stored in the warehouse, money that could have been invested in a more efficient way is locked in unsold products. This causes a loss of potential earnings, which is referred to as the cost of tied up capital. To reduce inventories could enable substantial
opportunities for increased profit for most companies.

However, the customers do not want large inventories either, thus they want quick and reliable deliveries. If the product is not available when needed, the customer could just move to the next supplier. The risk of shortages and hence losing a customer becomes more imminent when the inventories are reduced. Therefore there is a trade-off between the cost of tied up capital and customer service, and their interrelationship is much dependent on the product, customers and competition.

**HYDE INVENTORY LEVELS**

Hyde has some characteristics that make it harder to reduce the inventory levels. The company has few but large orders (and customers), therefore it is very expensive to lose an order or a customer. Customer satisfaction is also one of the most important competitive advantages for Hyde why an impaired reputation could be troublesome for getting new customers.

The personnel at Hyde cannot remember a single late delivery during the last ten years. This sounds like great information, but what about the costs for carrying all these inventories? Is this the most suitable way to run the production?

To ensure the timely deliveries, Hyde has built up large inventories as shown in chart 1. The dotted red line describes the planned inventory level (safety stock + forecast) while the black line presents the actual inventory levels Hyde have had. The green line in the chart shows the shipped volumes in each month. The green line is well below the black in most months indicating that the inventories have been very large. It is also possible to see that the black line is high above the red most of the time which shows that the actual inventories have been much larger than what was planned.

What can also be seen in chart 1 is how well the forecasts represent the actual sales. When the behaviour of the dotted red line is compared to the green line, it is possible to see that the forecasts often are quite good. Most peaks in shipping are accounted for in the forecasts, even if they sometimes are slightly shifted in time. Good forecasts are important; if the company can predict when and how much

![Chart 1: A comparison between the actual inventory level 2012 and the planned level for YA100. The shipping is also included, which show that the planned levels would have been enough to satisfy the demand.](chart1.png)
a customer will order, the safety stock could be decreased and there would be less surplus of goods left between months.

In the project, the safety stocks were also studied by comparing the safety stock of Hyde with a theoretically calculated level. As the demand of Hyde is very irregular and a normal distribution was nonexistent, the most common safety stock dimensioning methods could not be used. A new method was developed that accounted for these difficulties, which was based on the forecast bias and the maximum forecast error for each product. This method gave almost the same results as the safety stock used by Hyde today.

In the study it was found that the company on an average carries about twice as much total inventory as they are supposed to have when comparing the actual level to the planned level (safety stock + forecast). Important to remember is that no larger issues were found either for the safety stock or the forecast.

If there was a better match with the planned inventory levels, the cost of tied up capital in 2012 could have been 871 kSEK lower. The obstacle to reduce the inventory to this level is mainly the risk of shortages. This proved to be a valid worry since a review showed that during 2012 there would have been two shortage occasions if the planned inventory levels had been used. At those two occasions, it would have been hard to deliver in time.

To solve the problem with risk of shortage when the inventories are reduced, Hyde should make the production and its planning more flexible. To produce in large batches is positive when it comes to reducing the fixed cost per product, but could be disturbing in the aspect of being responsive to customer demand. In Hyde, the fixed equipment setup cost is very small in comparison to the variable setup cost, which speaks for a more flexible solution.

**POSTPONEMENT**

In this part the original question from the financial manager at Hyde is answered: “Is it possible to store goods in an intermediate storage and thereby reduce the cost of tied up capital?”

The solution is about being so flexible that the products are produced first when a customer places an order. This results in the right product being produced in the right quantity, but what about right time and right cost? The two latter aspects, time and cost, were central in the analysis of whether or not postponement could be possible and beneficial at Hyde.

As mentioned above, to store unnecessary goods is expensive since it ties up capital and occupies storage locations. To avoid this situation, semi-finished products could be stored in an intermediate step before a differentiation point instead of in the finished goods warehouse. At Hyde, the initial generic semi-finished product splits and evolves in three points of differentiation, and ends up as 23 finished products. This behaviour, where the number of semi-finished products increases in subsequent production steps, enables something called risk-pooling. If the goods are stored as a generic semi-finished product, the uncertainties in demand for the individual end-products can be added together. Peaks and declines in demand will not appear at the same time for all products, leading to a situation
where the total safety stock can be reduced. Furthermore, the products have less value in a semi-finished state. Below is an example presented to clarify risk-pooling and product differentiation.

A company sells shirts. They have chosen to finish all parts of the manufacturing before the customer orders arrive, except the dying. The dying is a very important point of differentiation since there is a large increase in the number of different products when the decision about colours is taken. When postponing the dying, they only have to worry about how many shirts in total they will sell, which is easier to forecast than how much they will sell of each particular colour. To dye as the last step reduces the risk of producing the wrong product. Furthermore, the safety stocks can be reduced.

**INVENTORY LOCATIONS**

Hyde has a production that can be divided into two parts, A and B. All products are produced from the same raw material and remain the same during part A. The first point of differentiation appears in the beginning of part B. This part has three main steps, which all differ in throughput rate and characteristics. The first step (granulation and shaping) is fairly short (about 12 hours) while the second (oven) takes approximately 41 hours, there are five ovens working independently. The last step (mixing) takes between 4.5-9 hours per load carrier. The batch size in each oven is one load carrier of 625 kg, and the mixing machine could be loaded with eight load carriers (5 tonne) at a time. It would be possible to have an intermediate storage before any of these productions steps; the possible locations can be seen in figure 1. Important to notice is that the beneficial storage positions are where there is an increase in the number of product groups. In figure 1 it is also possible to see how the number of product groups increases from one to three, to six and lastly to 23 finished products.

Postponement could be beneficial even without risk-pooling possibilities if the value of the product increases a lot in the last stages of the production process. Then, if the semi-finished products are stored early the amount of capital that is tied to the products is much less. This second aspect was partly outside the scope of this study.

**LEAD TIME**

Even though products are produced after the orders have arrived, the delivery time to the customer cannot be allowed to increase. Hence, the gains from reduced tied up capital need to be compared with the investments in production capacity that is required to deliver in time. If the gains are smaller, postponement is not an option. Another negative aspect of postponement is the sensibility in case of stand still. If the

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![Figure 1: There are three points of differentiation in the production, which occurs when the semi-finished products go through the steps of shaping, oven and mixing. To make use of the opportunities with risk-pooling, the order penetration point will have to be moved to before one of these stations.](image-url)
production only works partly or not at all it is impossible to deliver to customers in time.

It is hard to predict the production lead time of a specific postponement scenario without simulating. In this project, a simulation software called ExtendSim was used to facilitate the work. With simulation it is possible to do a simplified model of the production system and in that model try what the result would be before doing an implementation in reality.

If the simulation is carefully analysed, it is a great way to get a good understanding of the implications of a project at a relatively low cost. To build a 100% correct imitation of the real system in a simulation software would take years. Because of that it is important to understand how necessary assumptions and simplifications will affect the end result. If this is not understood, the result from the testing loses its value.

In the project at Hyde AB, simulation was useful to obtain information about how long time it would take to finish the products from the time of an order arrival until the products are shipped. This time was dependent on the amount of machines used in the factory. By alternating the number of machines, different maximum and average production lead times were achieved.

**Feasibility in Hyde?**

In the case of Hyde, it was shown that a partial postponement of the production would be the most beneficial, if any. Only one scenario was found feasible and in this, one product group was postponed to just before the last production step. For the other scenarios, a production step that took very long time aggravated the attempts to put the order penetration point earlier in the production process. Those scenarios could not manage the delivery time even with substantial investments in new production equipment.

In the feasible scenario, the safety stock could thanks to risk-pooling be reduced with 59% for the product group in question, which represented annual savings of 98 kSEK. There would also be a limited saving from the lower value of the goods, an additional 17 kSEK per year.

At the moment there is just one machine for this last step. The current machine could work out fine when considering the possibilities to manage the delivery time to customer. A problem though, is that there is not much margin between the simulated maximum time and the customer delivery time. To be on the safe side, regarding for example machine break down, the company is recommended to have another machine. The savings from postponement are not large enough to cope with this cost though. So in case Hyde does not already plan to procure an extra machine of this type due to growth, postponement could be hard to manage in a safe way.

**Conclusion**

There were mainly two findings in this project. As there is little excess capacity in the production, it is probably too risky to postpone any product group without investing money in more capacity. The negative thing is that the savings from postponement are too small to afford this investment. So what is recommended from the study is that a postponement solution only should be regarded if the last production step is already to be extended during an expansion project and the
intermediate storage could be arranged in a cheap and easy way.

The second learning was that the largest possible savings lay in a reduction of the inventories to the planned level. This change also inhibits the lowest risk as it only demands a more flexible production, where just the amounts that are forecasted are produced.