HOW REDUCED SETUP COSTS AFFECT LOT SIZES
- A case study for QB Food Tech in collaboration with Skånemejerier

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This article is a summary of a master thesis carried out in the autumn of 2010 and spring of 2011 for QB Food Tech together with Skånemejerier and Lund Institute of Technology. The thesis is the final element of the authors’ Master of Science in Industrial Engineering and Management

Introduction
The purpose of this thesis was to derive a general model for calculating how reduced setup costs affect lot sizes. Furthermore, the model is to be used when examining the effects of introducing QB Food Techs mixer in Skånemejeriers production and the effects of other possible measures to reduce setup costs identified by the authors.

The study was limited to the production of flavoured sour products, more specifically yoghurt and sour milk, from mixing to the products leave the packaging.

Method
Earlier research from secondary sources was used to give ideas about how to construct the model. Data about Skånemejeriers production were collected using interviews and observations. The data was analyzed both qualitative and quantitative to find measures to reduce the setup costs and to tests these and QB Food Techs mixer with a model.

Models
Two different models were derived. The first is a rewrite of the well-known EOQ-formula for calculating optimal lot sizes. By setting up the EOQ-formula for a reduced setup cost and using that together with the original EOQ-formula, Equation 1 is easily derived.

\[
Q^*_r = \sqrt{\frac{S^*}{S}} Q^*
\]

The model calculates the new optimal lot size after reductions in setup costs only using setup cost, \(S\), reduced setup cost, \(S_r\), and the original lot size, \(Q^*\). This model is easy and practical to use. However the current lot size must be calculated by the EOQ-formula. This restricts the applicability of the model. A second model was therefore constructed based on the total cost function, Equation 2, where \(h\) is holding cost, \(D\) is demand and \(TC\) is total cost.

\[
TC = \frac{Q}{2} h + \frac{D}{Q} S
\]
Equation 3 shows the total cost after setup reduction and if possible new lot sizes.

$$TC_r = \frac{Q_{New}}{2} h + \frac{D}{Q_{New}} S_R$$  \hspace{1cm} (3)

Equation 2 and Equation 3 give Equation 4.

$$TC - TC_r = \left( \frac{Q - Q_{New}}{2} \right) h + D \left( \frac{Q_{New} S - Q S_R}{Q Q_{New}} \right)$$  \hspace{1cm} (4)

Equation 4 calculates the total savings by reducing setup and if possible reduced lot sizes. This model can be used at any company, regardless of lot sizing methods, and is completely general.

**Case study**

In the last years Skånemejerier has increased their product range in order to keep up with the market. This has resulted in an increased number of batches and decreased volume per batch, thus increasing the strain on the production. The problem increases due to the fact that the products have a short shelf-life. The standard being that these products have to be delivered to the customer within five days of production. Together with short lead times, as short as two hours, the planning of the production is very complex.

The study showed that 220 liters of yoghurt was lost at every product change. This results in a cost of about 3.6 million SEK per year and corresponds to approx. 5% of the total production volume. It is worth noting that some batches are as small as 300 liters, compared to the waste of 220 liters per batch. The average setup time is 30 minutes but can vary between 20 and 60 minutes and consists of washing the pipes and machines and the changing of jam. The setup time cost is about 740,000 SEK per year based on the operator cost. The total setup cost per batch is 1861 SEK.

The reason for the high setup costs are mainly the long distance between the mixing stations and the packaging. The product stays in the pipes when the mixing stops and has to be flushed out with water. The production facility was not intended to house the production of yoghurt and sour milk and the implementation of these products into the production system had to be made with the compromise of these long distances.

**Suggested measures**

One of the main purposes of the project was to examine the implementation of QB Food Techs mixer at Skånemejeriers production facility in Malmö and at the same time find other measures to reduce setup costs.

**QB Food Techs mixer** mixes the product in a tank and therefore enables both continuous and batch production. The waste is approximated to 20 liters per setup and the setup time is reduced as well. One advantage of the QB Food Tech mixer is that the first liter taken out of the mixer is usable. Existing mixers need some time to stabilize the product at the required concentration of jam. The suggestion is to place QB Food Techs mixer directly on top of the packaging machine. This would eliminate the long distances, thus reducing the waste and setup time. Even though the main reduction is due to shorter pipes, the QB Food Tech mixer itself would contribute to some of the reductions. With an approximated setup time of 25 minutes and 20 liters of waste the setup cost with QB Food Techs mixer is only 403 SEK.
Reduced distances are the most obvious measure. This could be done by placing the existing mixers closer to the packaging. However it was not possible to make a relevant estimation of this measure.

Push product through the pipes. Currently the product left in the pipes is pushed out with water to save some of the waste. Large savings have already been realized in this way but the problem is that water gets mixed with the product. If this was to be done using a rubber plug or something similar the waste could probably be reduced even further. It was not possible to estimate the reduction in waste of this measure.

Reduced setup time would not result in a direct saving since the cost associated to setup time is fixed. The saving would consist of the possibility to give the operator other tasks to perform in the freed up time. Another possibility is to change the schedule in order to reduce the number of shifts, mainly the weekend and night time shifts. The minimal realistic setup time is currently 20 minutes, and this would reduce the setup cost to 1756 SEK.

Implementing QB Food Techs mixer and reducing the setup time is possible to combine. This would result in a reduction from the current setup cost of 1861 SEK to 298 SEK.

Result
Skånemejerier does not use EOQ to calculate their lot sizes and consequently the model based on the total cost function, Equation 4, was used in the case study. Since Skånemejerier does not want or can change their lot sizes, the model can be simplified to Equation 6 which only consist of the savings in setup costs per year.

\[ Q = Q_{\text{new}} \Rightarrow \]

\[ TC - TC_R = \frac{D}{Q}(S - S_R) \tag{6} \]

Three of the measures were tested with the model; QB Food Techs mixer, reduced setup time and a combination of them. The results from the calculations with the model are illustrated in Figure 1 below.

![Figure 1. Savings with reduced setup-costs for different measures](image)

With QB Food Techs mixer applied in the current situation at Skånemejerier the savings would be about 3.4 millions SEK, and by reducing the setup time the savings would be about 250 000 SEK.

Conclusions & recommendations
None of the two models fully met the requirements in the purpose of the thesis. The first model does calculate how reduced setup costs affect lot sizes but is not general. The second model is fully general but is focused on savings and does not say how the reduced lot sizes should be calculated.

Some possible measures were found but due to problems getting reliable data it were not possible to compare the measures with the model. However, the model still showed that using QB Food Techs mixer
together with reduced setup the annual savings would be 3.7 millions SEK. The savings are mainly due to the reduction of pipes. Although the reduction in setup costs were large it was not possible to reduce the lot sizes used by Skånemejerier.

The report resulted in a number of recommendations for both QB Food Tech and Skånemejerier.

**QB Food Tech**

- Further evaluation of their own mixer and competing mixers to strengthen their selling arguments. The evaluation should result in quantitative comparable data.
- By using the models QB Food Tech are able to further elaborate their arguments. The models can illustrate how reduced waste will affect lot sizes and potential savings in holding costs.

**Skånemejerier**

- Investigate the possibility of placing the mixer closer to the packaging to reduce waste.
- Investigate the current mixing system and compare it with other systems.
- Continuous follow-up to ensure that the production does not generate waste in the current proportions.
- Look over the entire production flow. Large waste was found in this study in a relatively small part of the production.