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Optimization of Gateau Fazer's Production Line

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German student ID: 3880044

Bachelor of Engineering

Industrial engineering and management – double degree

Bachelor's Thesis

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Hochschule für
Technik und Wirtschaft
des Saarlandes
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Applied Sciences

21 November 2022

Abstract

Author:	Mika Ylikoski
Title:	Optimization of Gateau Fazer's Production Line
Number of Pages:	74 pages + 2 appendices
Date:	21 November 2022
Degree:	Bachelor of Engineering
Degree Programme:	Industrial engineering and management
Professional Major:	Double degree
Supervisors:	Janne Nikula, Senior production manager Antero Putkiranta, D.Sc. (Economics and Business Administration) Alexander Hamman, M. Sc

Keywords: optimization, dough, guillotine

The objective of this engineering work was to optimize a production line which produces cinnamon buns for Gateau Fazer's artisan bakeries. The secondary objective was to create a manual for the running of the machine which the workers can use to not only solve the most common issues but also help a new worker do maintenance work for the production line based on the manual.

At the beginning the work mostly concentrated on measuring different things on the machine. This was to test whether the machine runs according to the metrics the monitor shows. However, it was quickly found that certain parts of the production line have some problems. Mainly these problems are linked to the dough and guillotine. The dough height varies too much which makes controlling the weight difficult. The guillotine is too inaccurate for some of the products, which results in the same problem of not being able to control the weight precisely enough.

The conclusion was that both the guillotine and the dough do not meet the dispersion tolerances, which meant the solution would be to either increase the tolerances or improve the machinery. Increasing tolerance was not an option, therefore improving the machinery was the solution. Fixing the dough would be costly and difficult. The guillotine on the other hand seemed to be a significant fix with a small amount of capital tied into it.

At the end it was suggested that based on cost effectiveness and lowering material losses the guillotine should be substituted for a semi-automatic guillotine which works for half of the products. The guillotine should be used only for those products which are suitable for it.

Tiivistelmä

Tekijä:	Mika Ylikoski
Otsikko:	Optimization of Gateau Fazer's Production Line
Sivumäärä:	74 sivua + 2 liitettä
Aika:	21.11.2022
Tutkinto:	Insinööri (AMK)
Tutkinto-ohjelma:	Tuotantotalouden insinööri
Ammatillinen pääaine:	Kaksoistutkinto
Ohjaajat:	Tuotantopäällikkö Janne Nikula
	Yliopettaja Antero Putkiranta
	Opettaja Alexander Hamman

Avainsanat: optimointi, taikina, giljotiini

Suunnittelutyön tavoitteena oli optimoida pullia valmistava tuotantolinja Gateau Fazerin artesaanileipomoille. Toissijaisena tavoitteena oli luoda koneen ohjekirja, jonka avulla työntekijät voivat paitsi ratkaista yleisimpiä ongelmia, mutta myös auttaa uutta työntekijää tekemään tuotantolinjan huoltotöitä käsikirjan perusteella.

Alussa työ oli lähinnä erilaisten asioiden mittaamista koneella. Testauksissa testattiin muun muassa, toimiiko kone näytön näyttämien mittareiden mukaan. Kuitenkin nopeasti havaittiin, että tietyissä tuotantolinjan osissa on ongelmia. Pääasiassa nämä ongelmat liittyvät taikinaan ja giljotiiniin. Taikinassa oli liikaa hajontaa korkeuden osalta, mikä vaikeutti painon hallintaa. Giljotiini oli liian epätarkka joillekin tuotteille, mikä johti siihen, että painoa ei voitu hallita tarpeeksi tarkasti.

Johtopäätös oli, että giljotiini ja taikina eivät täytä hajontatoleransseja, mikä tarkoitti, että ratkaisu olisi joko nostaa toleransseja tai parantaa koneistoa. Toleranssin lisääminen ei ollut vaihtoehto yrityksen puolesta, joten koneiden parantaminen oli ratkaisu. Taikinan parantaminen olisi ollut kallista ja vaikeaa. Näin ollen giljotiini vaikutti paremmalta vaihtoehdolta, koska sen vaatima panos pääomassa oli pienempi verratuna taikinan korjaamiseen.

Lopuksi ehdotin, että kustannustehokkuuden ja materiaalihäviöiden pienentämisen perusteella giljotiini tulisi korvata puoliautomaattisella giljotiinilla, joka toimii puolessa käytetyistä tuotteista. Giljotiiniä tulisi käyttää vain sellaisissa tuotteissa, jossa se toimii tällä hetkellä.

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1 Introduction

This engineering work was carried out for Gateau Fazer, which is part of Oy Karl Fazer Ab. This bakery is located in the north-eastern district of Helsinki called Sörnäinen. Fazer is a huge part of Finnish food production industry, and they are most known nationally for their bakery and confectionery products. Gateau Fazer's production is completely focused on bakery products, such as bread and cinnamon buns.

Gateau Fazer is a rather small bakery when compared to other bakeries belonging to the Fazer group. Regarding operations, they are more such as a small baking factory since they mainly focus on hand made products and therefore on craftmanship. In fact, most of the products they make are made by hand. Only a fraction of the products is produced with machine help and by a dedicated production line. These products include for example cinnamon buns and various breads

The issue at hand lies in the fact that large portions of Gateau Fazer's production line products go to waste, since they do not meet the weight requirements. The waste is measured to around 60 to 90kg in a day with the products that are performing poorly in this production line. This is a staggering amount and this needs to be solved. Secondary issues lie in the fact that the workers do not know how to operate the machine effectively. This means that many times the correct setups are work of trial and error, thus the second part of this engineering work involves creating a manual for operating the machinery.

However, setting up a production line for bakery products is extraordinarily difficult. This is because dough is relatively sticky regardless of the type of flour being used. Sticky dough makes the operation of the machine more unreliable as chunks of dough can get stuck inside the machine, thus causing problems such as breakages and unreliable feeding.

The machine that Gateau Fazer is using is a bespoke baking machine made by Jostec Oy. The part of the machine they are using is for cutting, moulding and decoration. The purpose of the machine is to produce essentially semi ready baking products. The exception here is that to achieve the desired shape, they are using workers at the end of the line to shape strips of dough into the proper shape. Thus, the machine's objective is merely to prepare the strips of dough for the workers.

In the current state the line is poorly optimized which can be seen as significant material loss at the end of the production line. In other production lines the dough does not end up as material loss since it can be kneaded repeatedly until the ideal shape and form has been achieved. However, this is not possible due to the design of this particular product. This cinnamon bun product usually has a filling between the two layers of dough. The two layers of dough are then folded across so that the filling lies between the dough. Due to this product design, kneading the dough mix again would result in uneven and varying mix of dough and filling. Because of this the dough can be used again in a small number of products. Regarding most of the products the dough cannot be used again and is thus registered as a loss.

The production line has four distinct mechanical stages, which are the following:

- Extracting the dough from a roller.
- Fine tuning the dough height.
- Injecting the filling.
- Cutting the dough and filling mix into long and narrow strips.

In addition, at the end of the production line their workers then make the dough into the proper form of a cinnamon bun. In order to find a solution, the focus is initially on the filling injection and cutting stage. This is because until this stage the dough can be just taken off the machine and kneaded again. This means that until the dough has had filling injected to it, it is possible to use the dough in some capacity again. The injection has currently two distinct problems. The first and the most obvious one is that the filling is not spreading evenly from the

nozzles. Essentially, sometimes the filling favours the middle nozzles more than the side ones. This might not be such an issue, but it is something worth investigating. Moreover, the spreading board, which is doing the actual spreading of the filling, is spreading the filling unevenly in the edges of the dough. However, this is not a major issue since the unevenly spread filling plays a much smaller role in the overall weight in comparison to the dough. Later it was found that most likely the issues with the filling are caused by the height variation of the dough.

The second problem within the injecting part is the filling itself. It has incredibly high viscosity, making it difficult to flow through the machine. High viscosity basically means that resistance of the fluid flow is high compared to lower viscosity fluid such as water. The filling is a part that could be adjusted to have lower viscosity by adding oil, thus it is possible to solve this problem, but it means changing the recipe for the filling, which is not feasible. [1]

The next problematic stage is the cutting of the dough. The machine responsible for the cutting is not cutting the dough into equal weight pieces. Thus, one worker needs to constantly weigh and communicate with another person who is responsible for adjusting with the cutting speed of the guillotine. The dough is not flowing through the production line evenly, but more such as in a wave pattern. This means that when the time-based guillotine is cutting the dough filling mix, it is cutting sometimes a thicker part and sometimes a thinner part, thus making the huge variation in the weight of some parts of the dough.

The wave patterns could be explained with the fact that the dough folding is done by hand, thus the parts of the dough that fingers touch is stretched and pressed. The extra dough that spreads away from the spot that workers fingers

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[1] (Science Learning Hub – Pokapū Akoranga Pūtaiao, 2010)

touched. This extra material then builds up to the edges where the fingers touched the dough and thus creates an uneven edge. The uneven edge could then influence the weight of the dough by making some of the strips under and some above the allowed tolerance.

Dough is a non-Newtonian fluid regardless of the flour being used. This means that one cannot apply the same Newtonian viscosity laws as used with fluids such as water, milk, oil, etc. The difficulty in working with non-Newtonian fluid lies in the fact that non-Newtonian fluids change their viscosity and flow behaviour based on the stress that they are facing at any given moment. Thus, a non-Newtonian nature generally makes it harder to design machinery that works well with the matter. A prime example of a non-Newtonian fluid and the non-logical behaviour can be found in a ketchup bottle. When a ketchup bottle is turned upside down, the fluid does not want to move that easily, even when pressure is applied. However, when the bottle is given a proper shake, the fluids viscosity changes and, thus the ketchup can flow out the bottle with a relative ease. [2]

It should be noted that the primary reason that makes the dough act in a non-Newtonian way is because the dough has gluten and protein in it. The gluten and protein are the main reason that create the “netting” inside the dough and thus they contribute for the dough’s attributes. [3]

Thus, studies regarding non-Newtonian fluids and rheology are vital science topics, which will be used often during this thesis work and as such those will vitally play a role in the optimization of the cinnamon bun production. Rheology will be more important in the continuing work that may be started after this initial engineering work is completed, since the rheology along with other chemistry

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[2] (Science Learning Hub – Pokapū Akoranga Pūtaiao, 2010)
[3] (Nikula, 2022)

and physic areas will be needed to solve the temperature issues that the dough is having. Rheology studies the relationship between force and deformation of engineering materials, when set up under specific loads and environmental conditions.[4]

1.1 Objective of the work

The objective of this engineering thesis is to fix current issues with Gateau Fazer's bun production line. Along with fixing mechanical issues there may be optimization to be done with the human work stages. First is the mechanical aspect of the production line. This means adjusting with the machine to find better setups, which allows for smoother, more reliable action and more user friendliness. The second aspect is the human aspect. Currently the workers need to constantly change the setups in the machine and check with a scale whether the cinnamon bun slices meet the weight tolerances that have been set.

The machine has four distinct stages: extracting the dough from a roller, fine tuning the dough height, which can also be called the levelling or rolling stage, injecting the filling, and cutting the dough and filling mix into long but narrow strips. Based on observing the machine running the first two stages seem to run quite well. Injection of filling while not perfect is still decent enough. But the cutting stage has the problem of not cutting even portions of the dough filling mix and this means that many strips of dough filling mix that are checked for weigh tolerance are rejected due to being over or under the designated weight limit. However, if the dough can be properly folded before going into the guillotine, then most likely the cuts will be more even, also the stoppages should

[4] (Widyatmoko, 2016)

be kept to the minimum to not allow the dough to have time to rest and shift shape.

Finally, there is the craftmanship stage or the workers stage, where workers mould the strips of dough and filling into the correct shape of a cinnamon bun. This stage mainly needs streamlining in the way of creating a manual and unifying the work steps closer together instead of everyone doing the shape their own way. Importantly it must be noted that this is not necessarily about changing someone preference towards one way of making the knots but instead of creating more standardised system which is easier to explain and teach to new workers coming in. Thus, a manual shall be created for this specific working step.

The aim of this manual is to create parameters and explain a specific way of doing the craftmanship. Optimal way should be researched and then recorded to the manual. This manual should explain things such as starting, operating, and cleaning the production line. It should also be done in such a clear manner that there is minimal chances of mistake and the highest repeat rate, when followed through correctly.

The objectives of this work include the following: decrease the loss of material while maintaining the tolerance weight, lessen the stoppages as much as possible, increase productivity of the line, streamlining the end stage. These are the main goals. The assumption is that many problems will be solved by just getting the machine running constantly and more reliably.

The outcome of this engineering project is a proposal for Gateau Fazer, which aims for a better working production line, which makes more money than before, by not accumulating as much of material loss as before. Additionally, they get a short manual which they could use to teach new and old employees for the most efficient way of running the production line.

1.2 Defining the Scope

The boundaries of this engineering work have to do mostly with space, recipe, labour, and machine. Regarding space the boundaries lie in the space that has been designated for the production line to be in. This means moving the machinery to a space where there is more room is not an option. Space boundary also limits the options for modification that could be added to the machine. For example, the roof is not that high in the factory so modifications should take the roof height into account so that there is still enough room for the workers to work around the line.

Regarding the recipe, it must follow the strict recipe that the Fazer group has given to Gateau Fazer. This means that possibly leaning the filling mixture with water is most likely out of question as well as making the contents of the filling better suited for the machine.

When it comes to labour, the testing board has the current workers at the production line available to help with testing as well as providing them with the information. Meaning that the testing board will study the workers work habits with the machinery, as well as interview the workers for information regarding the best practices, they have found out while working with the machinery. This will also be helpful in possibly creating a manual for the craftmanship part of production line. A good thing in hindsight is that everyone is doing the final work slightly different, which means that most likely some of them have worked out the optimum way of doing the final work.

Regarding the machinery, the company has set boundaries in regards to space. This means that possible modifications have to be able to fit in the current interiors of the factory. However, adjusting with the setup and finding a more optimal setup than they are currently running is something worth investigating. The machine was made by Jostec Oy and their manuals will probably prove vital in finding the right setup.

With these boundaries it is possible to create the first plan for the engineering work. Below is a table where the first plan was condensed as tightly as possible. Moreover, the plan explains the logic behind the engineering work, and it expresses what is for example the wanted outcome and the means of how the outcome is achieved.

Table 1. Planning of the engineering work.

Stage	**Content**	**Outcome**	**Means**
Objective of research	Streamlining and optimizing the production	Lessen material losses and improve efficiency	The production line machinery, manuals, and the workers
Improving the dough fold	Creating a better mechanism for folding the dough filling mix	The dough is more equal in width.	Folding iron to help the fold being cleaner and more equal
Trying different lengths of dough	Different lengths of dough. Especially the length of the folding stage.	The dough will flow through the machine without stoppages	Asking the supervisor if this is something that we can try

Improving the cutting procedure	Checking if the blade timing is accurate	The strips of dough will be more equal in length.	Blade timing, sharpness of the blade and setup

This is base structure of the different objectives of this engineering work and the means that will be tried out to fix the different issues in the production line. It must be noted the first and foremost objective of this project is to lessen the loss of material. After that objective has been achieved in some form, the tackling of other objectives can begin. This is because alleviating the losses immediately makes the company more money which is essential goal of any company.

1.3 Work method

Since the optimizing work is conducted in a production line, it is vital to have the whole line in a state of balance. The critical factors that contribute into building a successful production line are the following: Cycle time, synchronized timing, rate of incoming material, and mixed model processing.

Cycle time in this instance expresses the time that a single product completes the production line is as equal as possible. In practice this means for example setting up a target time for each individual work stage. The times of the individual work stages are then added together along with the transportation time between the stations. The end time that comes after everything is added together is the time where a single product should complete the whole production line.

In the case of Gateau Fazer, the talking point is about completely ready products, rather semi ready products. This is because the products still need to be baked in the oven until they are completely ready products. On the contrary, before the products arrive in the production line there are steps such as baking

the dough chunks and putting the chunks to freezer and later fridge units. However, since the scope of this engineering project is limited to the production line, these aspects will not be considered.

Synchronized timing in this instance means that the production should be timed with a method that ensures that there is no time wasted, waiting for the arrival of new dough filling mix to the final work stage. On the other hand, synchronized timing should be able to keep away the excess material, meaning there should not be a situation where the machine is pushing out material faster than the workers can handle at one moment. Therefore, it can be concluded that synchronized timing and rate of incoming material are intertwined.

In mixed model processing the production is in short cycles and the same production line is making many different products and lots of different batch sizes. This is the model that Gateau Fazer is operating in their production line since the production line can produce lots of different products.

Along with these work methods, problem solving will be one of the key aspects, while dealing with these problems. Especially logical thinking and not jumping into conclusion without too much information can be a deadly sin in these kinds of project because fixing a part of the production line can lead to other problems in the other end of the production line.

1.4 The contents

This thesis has 7 chapter. The first chapter is the introduction, which discusses the general issues within the production line that this engineering work is trying to solve. The first chapter contained details about the scope, the boundaries and the proposed methods, which will be used to solve the issues at hand. The chapter highlighted the goals in detail, such as the first and foremost objective, which is to lessen the loss of material that are the result of failing to fit inside the given tolerances.

The second chapter discusses the relevant theory regarding problem solving that helps to understand the bigger picture and thus, give a more complete solution at the end. This chapter discusses troubleshooting analysis theory. The purpose of this section is to explain the logic that was used to get from the starting point to the end.

The third chapter provides information detailed information on Gateau Fazer and their mission and vision that they are trying to impose into the Finnish cake- and desert culture, as well as the overall concept of the Gateau Fazer bakery at Sörnäinen. Essentially, this chapter hosts the basic entry information about the company and include things such as how many workers they have and how many different products they make.

The fourth chapter is about the current state analysis which include things such as how the production is specifically ran now, what are the issues and what is the reason that these issues have not been tackled before. This chapter will include actual data about the company and based on this current state analysis we will begin figuring out the necessary steps to solving the issues.

The fifth chapter presents the testing results that were gathered from the engineering work. In this chapter each machine is discussed in detail. The discussion ranges from general function of the given part or a machine, down to the statistic of the machines and the dispersion that they might give in any given operation. This chapter also starts the climax of this engineering work.

The sixth chapter presents the proposed solution, as well as the proposed action that should be taken into account when improving the production line. This chapter has conclusions about chapter five, which are then used as a guidance for finding a good solution. It has also the calculation that justify the solution from a monetary point of view.

The seventh and final chapter summarises the whole engineering work together. Regarding content, it is quite similar to this subchapter in a way that it also ties everything together and gives a fine closure to this work.

2 Troubleshooting process analysis

Troubleshooting is a process that is used to find the root cause for failed products in a production line or in a service. It is an important tool to not only fix the problem but to rather understand the problem, thus creating a more permanent solution. Without troubleshooting one may fix a single problem in one part of a line but then create another problem at the other end of the production line. [5]

The goal of troubleshooting process analysis is to increase the overall productivity of the whole production line, not just a single stage of the line. In Gateau Fazer's case this means reducing the waste of dough that is registered as a loss because of failing to meet the weight requirement. To achieve this goal, it is vital to establish a proper framework around the object of the work. This means that the object which is subject to improvement needs to be properly measured and written down to the smallest of details. This information can be found in more detail in chapter 4 which describes the present state of the company as well as the production line.

2.1 Process analysis of the production line

Nowadays it can be argued that many companies identify themselves as process driven companies. This because many companies are aiming to become less dependent on individuals and their skills. In the case of Gateau Fazer, the reason to get a dedicated production line and machinery capable of producing bespoke products is to make more products that are deemed satisfactory in terms of quality while producing them with less skilled workers

[5] (Branten, Mahmood, Karaulova, Maleki, & Shevtshenko, 2016)

that are ultimately cheaper work force than that of qualified confectioner. This can be described better with a “quality, time and money triangle”.

The triangle explains that from quality, time and money only two of these are achievable at the same time. This means that one of these characteristics needs to be sacrificed in order to achieve the synergy bonusses of the two characteristics, which are wanted.

Figure 1. Quality, time, and money triangle.[6]

It can be seen from the triangle that usually something that is made of cheap materials and quickly is usually lower quality in contrast to something that is

[6] (Madurai, 2018)

given more time and money. However, the triangle is not only applicable to products as it is usually seen, but also on processes. For example, if a company wants to produce products quickly and with a low cost it must understand that to do this it needs to have efficient processes. [7]

The relevancy of this is explained more in chapter 2.3 but for now the key thing that should be digested from this picture and the chapter before is that the ultimate problem with the baking industry is that the workforce is quite meagre. Especially for those that want to stay in the baking industry. Solution for this would be to make the industry more attractive for the workers that have the skills. On the contrary if the production is automated then the demand for skilled worker decreases. The automation allows less skilled workers to be employed there, which decreases the overall cost spent on workforce.

The key to having capable and efficient processes lies in the testing and troubleshooting process. Essentially this begins by establishing as-is maps and in the end to-be maps. As-is map basically tells how the processes are currently and to-be map describes the goal of where the process is desired to be.[8]

[7] (Branten, Mahmood, Karaulova, Maleki, & Shevtshenko, 2016)
[8] (Branten, Mahmood, Karaulova, Maleki, & Shevtshenko, 2016)

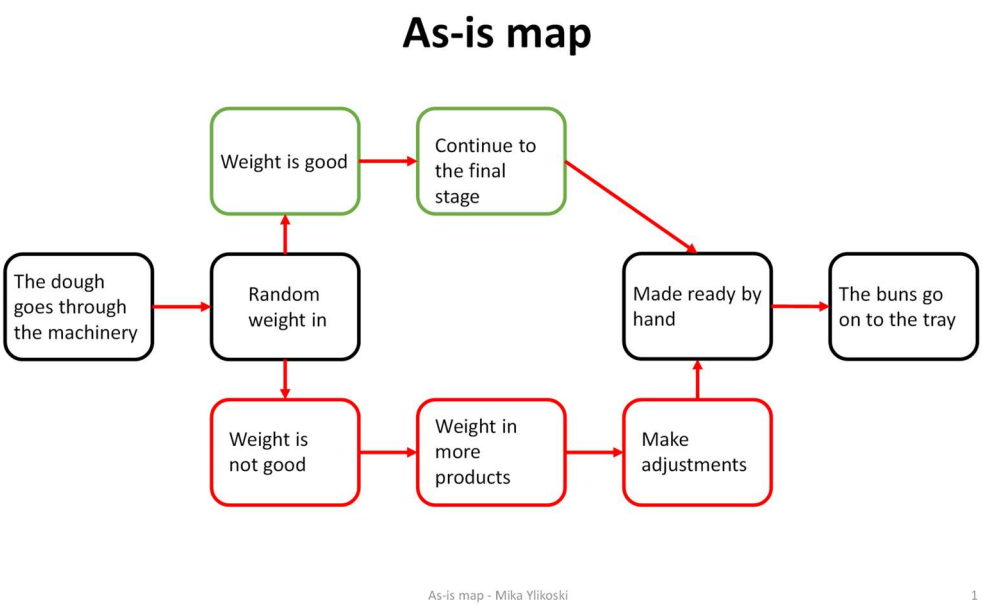

Figure 2. As-is map of current procedures in the production line

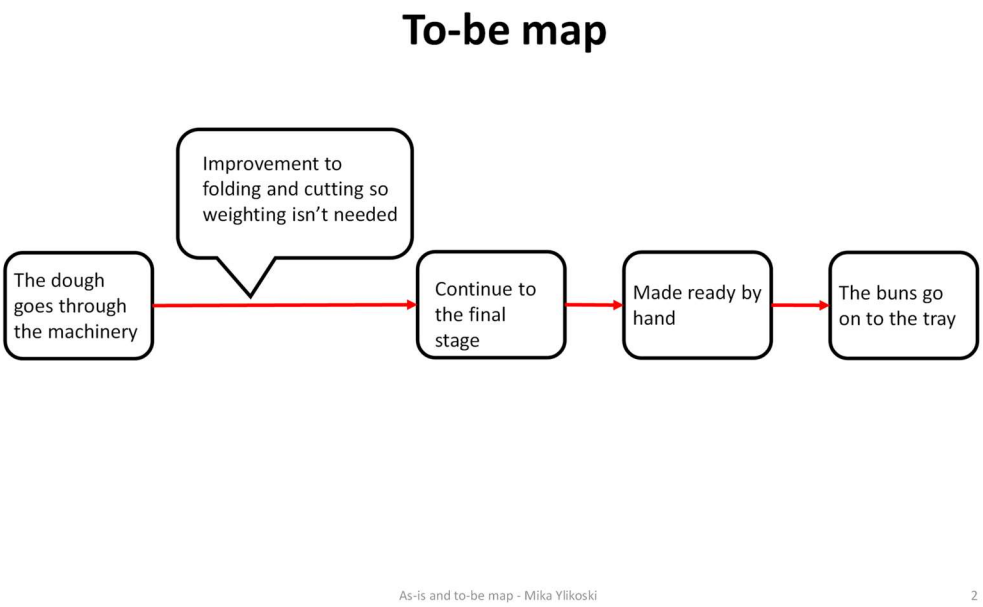

Figure 3. To-be map of the optimized process

As can be observed from these two maps the goal is to streamline the process in a way that does not allow for weights of dough strips to be over or under the limit. This has the benefit of eliminating one the major hiccups in the production

line. What it also can do is limit the amount of time that the strips of dough need to be weighed in since this action is non-productive action.

2.2 Troubleshooting difficulties

In a production line it is quite difficult to pinpoint the root cause of an issue. This is because the problems can be a combination of several smaller problems and culminate into a single large problem. Thus, for a less experienced troubleshooter the urge to jump into conclusions and repair one small problem is quite high. However, repairing one small problem is not the solution to the bigger picture. In fact, jumping into conclusions and repairing without leaning heavily into data is something that can make the troubleshooting process go one step forward but two steps backwards.[9]

Measuring data and measuring it right is just as important as basing the repairing actions to actual data. Especially measuring data reliably means ideally that one specific test is ran repeatedly in different days, setups, and people to get a strong fact-based result. The limiting factor in the case of this production line comes down to the loss of dough, since every time something is tested using dough and the dough does not meet the requirements that had been set up, it means that the dough is thrown away. This means that testing has cost in terms of money and material, thus testing cannot be done the ideal amount.[10]

People have a huge part in the testing as well. Since people are trained to do things certain way, it can be difficult to relearn to do things differently. For example, one issue that is suspected to be an issue in the production line is that people change the settings in the production line too easily when the weight of a

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[9] (Branten, Mahmood, Karaulova, Maleki, & Shevtshenko, 2016)
[10] (Branten, Mahmood, Karaulova, Maleki, & Shevtshenko, 2016)

small batch of dough strips is too light or too heavy. This then has the effect of first of all interfering with testing results but also difficulty in identifying if the repairment measures taken were the action of the repair itself or a worker changing the machine settings. [11], [12]

One aspect is measuring the frequency of failures with various products. Based on this information one can for example drop a poor performing product of the production line while favouring products that can meet the tolerances more often.

2.3 Lean management

The goal of lean management is to create more value for customers by using the same or less resources. Essentially what this means is to cut out everything that is not accumulating value to the organization and operations. Lean management has been quite popular at times of recession. The reason for this is that during economic downfall companies may find themselves in a back against the wall situation. In these situations, the companies use lean management tool to reduce the layers of management so that the emphasis is transferred to value creation for customers. [13]

The fact is that lean management does not only focus on reducing management layers but also operations and processes inside a company. These areas for the implementation of lean management can be defined as follows:

- talent
- defects

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[11] (workers, 2022)
[12] (Nikula, 2022)
[13] (Putkiranta, 2006)

- overproduction
- over-processing
- waiting
- motion
- inventory
- transport

The following chapter deals with these areas in more detail. In these subchapters it is discussed that how they are interlocked to the baking industry. We will also shed light on how these problems could be seen in everyday operations at a bakery. It should be noted that this list was primarily created for the IT-service environment and not strictly for the baking industry. Because of this only a handful of them are discussed in detail. [14]

Lean does not also work the best with the simplest of products such as bakery products. This is because the processes are already so streamlined that it is more difficult to get better performance out of the system with less. Therefore, it could be stated that lean works better when it is used in complex process sets, which produce products that are much more complicated to produce. Baking is as a process relatively speaking much simpler than making a car for example. [15]

2.3.1 Talent waste

Talent plays a big role in the baking industry. Baking cakes and other products that require more skill than baking a simple bread requires talent, skill, and dedication to learn how to make a perfect bespoke cake every time. However, when it comes to simpler products such as bread and cinnamon buns, a

[14] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[15] (Kadarova & Demecko, New approaches in Lean Management, 2015)

shadow of frustration might settle in, which then is harmful for the worker and the company. [16]

For the worker he does not feel that he is doing challenging enough or meaningful work. This then might lead to the worker leaving the workplace which then is harmful for the company because it needs to replace that worker with equal amount of skill and then teach them the way's and how's of the workplace.[17]

Workers leaving the workplace is not harmful at first. However, once it becomes a pattern, it can be described as high employee turnover, which is indeed harmful. Later on in this document it is discussed in detail why baking industry has such a high employee turnover ratio but to put it shortly in the baking industry one must work for long hours and wake up early. It is physically very demanding and there are health risks associated in working in the baking industry such as getting asthma from the flour clouds. [18]

Having too skilled workers working on a simple production line is also a waste of money and human potential. If a confectioner is put to strictly working in a production line and there is no room for creativity, he might get bored and keener to search for a job that either pays more for the same job or to somewhere where he feels that he fits better. On the other side the company is wasting money for overeducated people, and they should try to seek for less educated people to do production line work. [19]

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[16] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[17] (Brito, Ramos, Carneiro, & Goncalves, 2019)
[18] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[19] (Brito, Ramos, Carneiro, & Goncalves, 2019)

2.3.2 Overproduction

In the bakery sector overproduction can be most seen when a product is overproduced in the way that there simply is not enough demand to answer for the supply of the products. This a real risk especially with specialty products such as some of the baking products that go to cafés, since in Finland the café culture is not as strong as in other European countries. Therefore, there is not necessarily a point in making more than a certain number of cinnamon buns for example. [20]

Another way of overproduction could be that the company insists on making products that clearly do not have enough demand to make making them justifiable. This can be seen in some of the specialty products.

Then there are the things such as unnecessary amount of quality and effort that is put into a product. If we have data backing up the claim that the customer does not care if the bun is for example too big, then why would there be a reason to have such tight tolerances set for the product. Of course, putting it like that, one could think that the difference now is that there was been a shift in the weight tolerance upwards since the customer will adopt the norm that the buns are overall bigger. Therefore, the normal size bun would become underweight in their eyes. However, it mostly depends on the customers. If they are highly critical for the weight, then it should be valued but if it’s not the biggest priority then it should not be valued as much. [21]

The same thing can be said with the looks of the bun. With edible products one could ask that would they buy the product if it were for example 30% off. If they would buy, then again, one could say that too much time is spent on a quality

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[20] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[21] (Shah & Ganji, 2017)

meter that does not have the amount of impact on the customers decision as the company thinks it has.[22]

2.3.3 Waiting waste

In a production line waiting waste could be explained the easiest if we have a case where the production line must stop constantly for example, due to the workers not being able to make products in high enough speed when compared to the conveyor belt speed. [23]

In a production line stable speed is better than too fast because if the production line works too fast and results in unnecessary stoppages it means that when the production line needs to be stopped, there are workers that are idle. The reason for them being idle is that they are not able to work because of stoppages caused by other people. If the line or working methods would be slower and thus allowing more time to do each individual work steps it would allow for more stable running and more importantly not having workers being idle and waiting. [24]

Waiting is not only an outcome of too fast production line, but it could be the result of the machinery not working well enough or the shortage of material. When it comes to the machinery, there should be regular maintenances conducted on days when the line is not worked. This is because regular maintenance prevents machine failures during working hours which is horrible from a production point of view. Not only does the maintenance result in workers waiting, but it results in the means of production not working towards making more capital, thus resulting in double the net cost in compared to

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[22] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[23] (Shah & Ganji, 2017)
[24] (Kadarova & Demecko, New approaches in Lean Management, 2015)

maintenance work that would been conducted at times when the production line was not running. [25]

Shortage of material should be avoided by having meters that estimate the necessary production needed as accurately as possible. In the case of beer production this is simple to explain. If a beer production company keeps material level same for Friday and Saturday, they will not be able to match the growing demand of people wanting to have beer for the weekend resulting in waiting and loss of profit. [26]

2.4 Process strategies

It has been stated that companies primarily use four different types of process strategies.[27], [28] These strategies could be divided into:

- Process focus
- Product focus
- Repetitive focus
- Mass customization

[25] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[26] (Kadarova & Demecko, New approaches in Lean Management, 2015)
[27] (Render, 2000)
[28] (Putkiranta, 2006)

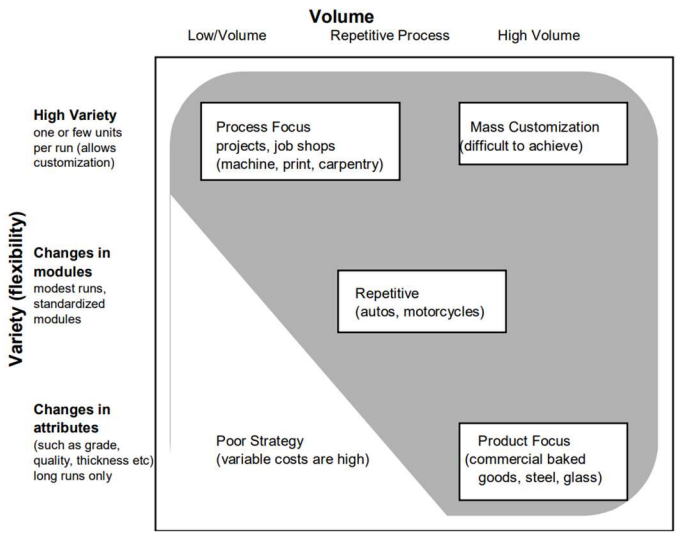

Figure 4. Relationship between the selected process, volume, and variety.[29], [30]

Essentially, process focus is a low volume but high variety production. This means that the company employing this strategy is trying to get maximum flexibility to manufacture different products on different batch sizes. Sometimes this kind of process strategy is referred to bespoke products such as bespoke cakes in the baking industry. Other industries where this might be common are plumbing and household appliance industries. [31]

Product focus meanwhile focuses on the variety processes of high volume and low volume production. The company plans its layout, tooling and facilities around a product or products. The primary objective of this kind of company is achieve continuous flow and long production runs. This means that everything that helps the ability to pump out products on high volume and simultaneously have good quality control is key with these kinds of products. Typically, these companies have high fixed costs tied to things such as tooling and factory, thus

[29] (Render, 2000)
[30] (Putkiranta, 2006)
[31] (Putkiranta, 2006)

the usage rate is important. Because of the high fixed cost, the company has to offset those high fixed costs by having the machine or production line ran as much as possible and as productively as possible. If this kind of company loses its ability to conduct high volume production, then the fixed costs will eat the company's revenue. The production line that this engineering work is optimizing, falls into this category. However, the rest of the production does not and falls rather to process focus or repetitive categories. [32]

Repetitive category is the between territory between process and product focus. Typical products in this category are products that can have some sort of variability in the production, but it still has some parameters around that cannot be crossed in order to create truly bespoke products. Great examples for these kinds of products are Subway sandwiches and cars. Both can be modified to customers wishes with a car paint, engines and interior can be changed. However, a customer cannot walk to Volkswagen shop with a 3D sketch and ask for the company to build that exact car. The same thing can be said about Subway, even though they surround themselves with the illusion that one is having a bespoke sandwich, this is not the case. Subway has many options to choose from but again if a person where to ask them to make a bread that is for example shaped such as a circle, they would say no. In summary these companies offer modifications for their products but from the process strategies point of view they are thriving for limited modifications that they have deemed to be necessary for their strategy. They do not make bespoke products nor products that have only change in the attributes so in things such as steel thickness and such. [33]

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[32] (Putkiranta, 2006)
[33] (Putkiranta, 2006)

2.5 Flexibility and dependability

Flexibility as word has many meanings in the business world. It can mean things such as product, volume, and delivery flexibility. New products, technologies or modifications on existing products bring in flexibility in ways of flexibility in the attributes of different products. This added flexibility is good because it can bring in more customers based on one company having more variety and product flexibility in comparison to another company. In the baking industry this product flexibility can be seen in the way of how products are made so that people who have certain preferences. For example, people who prefer vegan options have their own products and people who for example need to eat gluten free products have also their own products or the products are made with these things in mind from the beginning. [34]

Volume is something that is easier to control and change, at least when it comes to less production but harder to control when more is needed if the production capacity is already running close to the maximum. This means that to allow for volume flexibility the company should have invested enough into tooling and machinery to allow reaching the highs of the demand but at the

[34] (Putkiranta, 2006)

same time not having that much money tied to the assets that the company goes bankrupt if the volume decreases suddenly. [35]

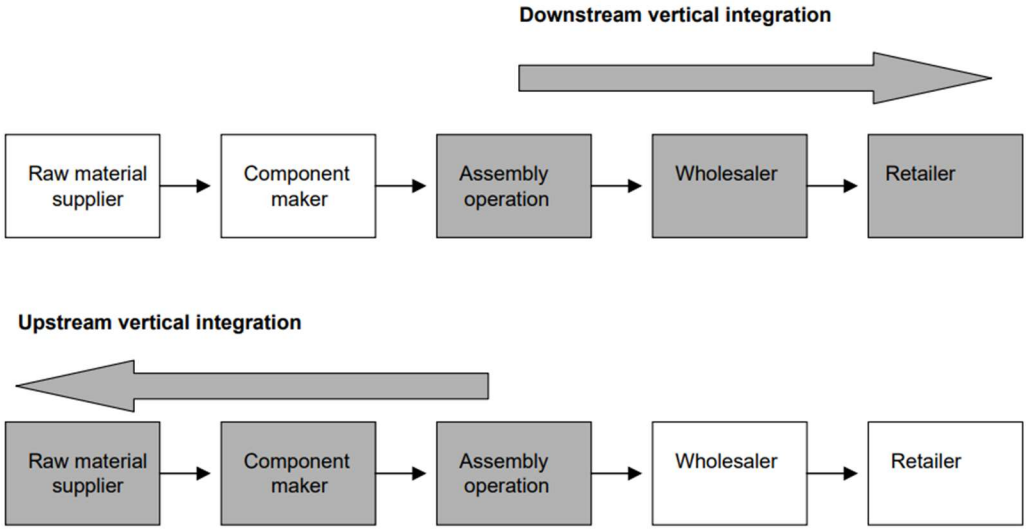

Figure 5. Vertical and horizontal integration.[36] [37]

The ease of volume flexibility also depends on whether the vertical integration is downstream or upstream. If it is downstream then the changes are easier to fulfil but on the upstream, the effects of good commercial benefits may be better than in the downstream example. [38]

Delivery flexibility affects customer perspective the most and the lack of it does not directly turn into loss in revenue if company has a policy of *money first, delivery second* such as many retail companies have. However what delivery flexibility allows is the quality aspect that the company shines with great flexibility in deliveries. This ultimately turns into part of the customer satisfaction

[35] (Putkiranta, 2006)
[36] (Slack, 1998)
[37] (Putkiranta, 2006)
[38] (Putkiranta, 2006)

or dissatisfaction. For example, a company that can have fast and reliable delivery is usually valued higher in the eyes of the customers than a company that is unreliable in this aspect. [39]

Dependability is part of the vertical integration along with flexibility, quality speed and cost. Having dependability may affect positively the business – customer networks by giving better forecast for the number of sales that can be realistically expected. It also allows for more realistic promises in delivery times, which builds the customer – business relationship. This can be for example seen in bespoke companies such as car modification shops, which in a way depend on the good reviews that their customers provide them. Also, because their work is such a specialty, it means that many times when that dependability between customer and business is lost, the customer goes to another shop and the business goes bankrupt. Therefore, in an industry such as that it is extremely important to keep the customer in a good mood and sometimes even go a slightly beyond in the compensation just to keep the customer happy. [40], [41]

2.6 Quality dilemma

Companies make their profits by producing products on large quantities. For them quality and product reliability are important in order to keep the old customers but also to attract new ones. However, the dilemma with quality is that quality costs and especially perfect quality costs. In the following figure this is demonstrated.

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[39] (Putkiranta, 2006)
[40] (Putkiranta, 2006)
[41] (Belekoukias, Garza-Reyes, & Kumar, 2014)

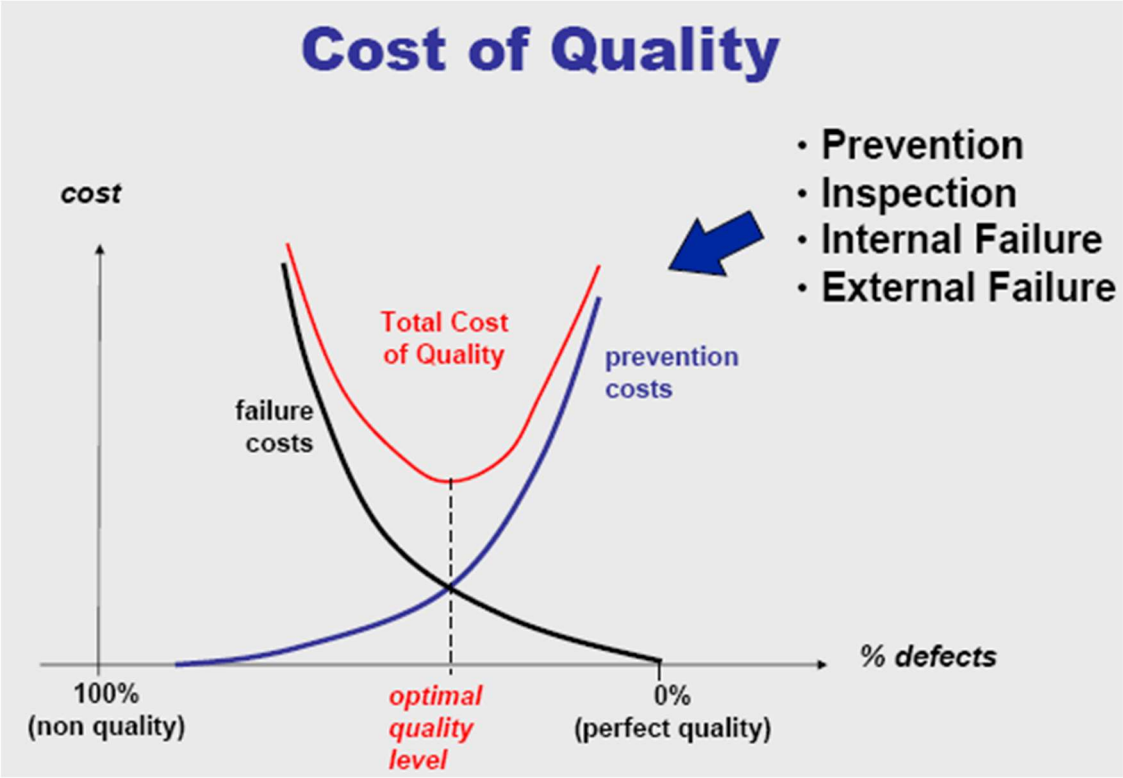

Figure 6. Cost of Quality Graphical Representation. [42]

As can be seen from figure 6 it can be observed that with poor and perfect quality the total cost of quality is high. Thus, in order to make the most amount of money, a certain number of defects must be accepted. However, on the other hand not caring about quality enough will lead to high failure cost. This can be seen for example in the baking industry where after certain work step is completed it is the dough becomes unusable if a mistake is being made. [43]

Quality is a priority and should be made a key component of the values that a company stands behind, but it should not try to reach perfection in the quality point of view especially if the object to make repetitive or mass production. In

[42] (Teli, Majali, & Bhushi, 2010)
[43] (Teli, Majali, & Bhushi, 2010)

the bespoke production industry making higher quality products is more important but even in there, there is a limit to how much quality is to be strived for. Too much quality ends up in the accumulation of as much cost as if the quality is poor. [44]

2.7 Reason for automation and the issues

The baking industry has been traditionally handmade products which emphasize the excellent craftmanship that the confectioners make. However, due to the rising demand of the bakery products many bakeries had to resort in some sort of automation to stay competitive. This has been the case with Porto's bakery, which is in the United States They traditionally made handmade products and tried to stay on making handmade products as long as possible. Porto used to be a true artisan bakery, but due to the shortage of qualified work force had to opt for some level of automated production. [45]

However, the baking industry is facing a crisis regarding the work force or more precisely the lack of work force. The reason so many companies want to stay in handmade products is that they are better quality but more importantly it is usually easier to make complex products by hand. This comes down to the construction of the dough which is non-Newtonian fluid and viscoelastic properties. This makes the dough quite hard to work with if it is not in a rested state which needs to be taken care in a machine or a production line. For example, when the dough has been stretched out, it is hard to cut to dough cleanly. Also, the dough rebounds. This rebounding effect can stretch the dough, which then makes it harder to cut cleanly through the dough. [46], [47]

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[44] (Putkiranta, 2006)
[45] (Atchley, 2019)
[46] (Science Learning Hub – Pokapū Akoranga Pūtaiao, 2010)
[47] (Atchley, 2019)

For the work force the problems lie in the fact that the work conditions are not the greatest. For example, in Finland the average confectioners earned 2 625 euros in a month in 2020. According to the workers this is enough to cover the bills but not much else. Because of this there are not many workers who work with the best salary in mind but rather because they like the work that they are doing as well as for the obvious benefits food wise. However, it should be noted that if a worker decides to work between 21:00-06:00 he is eligible for double salary. But at least in Finland most of the confectioners work in normal daytime shifts because usually people buy their products during the afternoon. [48], [49]

Some of them work in a bakery because they like baking that much, especially when doing more special products such as cakes. Others like the work since the easier bits are so easy that the work itself does not require that much attention. Still the big and small struggle to find the work force required. As Mr. Porto said it, the owner of Porto's Bakery:

> "It's becoming difficult and expensive to find bakers or people with any knowledge of baking who want to work those hours. If you're able to find them, it gets very expensive." [50]

[48] (Duunitori, 2020)
[49] (Nieminen, 2021)
[50] (Atchley, 2019)

3 Gateau Fazer and scope of the work

Gateau Fazer at Sörnäinen is a small bakery factory, which produces artisan bakery products to the Fazer Cafes and Gateau bakery shops around the Helsinki area. For example, all the breads that are sold in those small shops come from the factory at Sörnäinen. The small bakeries do have a tiny bit of their own production if they have the facilities for that but in most of the cases the products are only in the factory at Sörnäinen. They employ total of 35 persons which includes bakers, confectioners and two saladettes. The products they make include the following: Cinnamon buns, bread, Wieners etc.[51]

They swear on their motto: “maku edellä”, which ruffly translates to *taste first*. This can be seen in their production since the quality is the most important aspect in their products. They are also keen on using as much of domestic raw materials as possible. For example, all the flour used for baking comes directly from a single flour mill at Lahti.[52]

The whole Gateau Fazer vision and mission is aimed at creating and improving Finnish cake and desert culture by introducing fresh flavours from around the world, such as the Gateau cheesecake. Without forgetting about their past, they also are offering the more traditionally popular products such as the famous Princess cake.[53]

In the factory most of their products are manufactured with machines helping the employees. However, a few years ago they bought a dedicated production line in assumptions of increasing the production of buns. This is quite a jump from the normal production since most of their products are made by hand,

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[51] (Gateau Fazer, 2022)
[52] (Gateau Fazer, 2022)
[53] (Gateau Fazer, 2022)

even in the production line, most of the products are finished by hand. Usually, the finishing touches include things such as stretching the strip tying a knot or adding a bit of filling.[54]

The object of the work is optimising the manufacturing line at the Sörnäinen factory. This is the line that produces all the bakery's buns and wieners. The line is poorly optimized and there is considerable amount of material losses occurring at the line. These material losses are quite heavy regarding costs when compared to the losses before having the production line. Before there were not material losses or if there were they were so minimal that they did not have an impact on the profit. [55]

Key word here is to get the line working better mechanically, since the scope of this engineering work is restricted to the production line specifically and not the variables that might influence the work prior or after the production line. This means that for example baking and storing will not be taken into consideration in this engineering work, although they might influence the dough's properties in the production line.

The second part is optimizing the working procedures of the workers. These include things such as streamlining the processes better and more standardization. For example, it is suspected that some of the material losses contribute to the setups being wrong for each of the products. Thus, if better machine set ups could be made and proper adjustment interval given in the manuals it could eliminate the guessing game that the workers must do when they start the production line or change the products.

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[54] (Nikula, 2022)
[55] (workers, 2022)

Additionally, some of the manuals could be condensed more together. Currently many of the pages in the manual consist of a picture and one sentence worth of description. The manual has a section where it instructs about the disassembly and cleaning of one machine in the line. This section is multiple pages long, even though the same content could be compressed to just a few pages that serve the workers better. The general view of the workers and management is that these manuals do not give enough information to the user and, they are dreadful to read through.

4 Present state

In its current state, Gateau Fazer production line produces six different products in its production line as well as some seasonal products, which will not be covered in this engineering work. These products will not be referred to with their real name but as bun x and y. The primarily focus on bun x, which has more problems in comparison to bun y. There are other products as well, but those will not be covered in this work. The reason is that these products have lower demand and less material loss than bun x and bun y. However, the other products are quite similar to bun x and bun y, which means that the improvements can be adopted to those other buns as well. It should be noted that there is one bun that has had an explicitly high material loss but because it was run only once during the time there, because of that these products were accounted out of the equations.

Bun x and its sister products make up around half of all the products that are normally made on the production line. They have different fillings inside them, but they are common made in the same manner. Regarding all the different buns that made on the production line, they have +/-7% in the tolerances and the final product from the line is strips. This means that by creating a solution for bun x means that the same solution will also work for the sister products of bun x. In the bigger picture this means that with one fix we can fix half of all the products that are made on this production line.

Currently the production line is divided into 5 distinct machine sections and 3 distinct human sections. This brings the total sections in the production line to 8. However, the 3 human sections do not need to be manned always nor permanently. Instead, the sections can be manned only when needed. An example of this kind of station is the filling machine, which only needs to be filled up when the filling runs out. These sections will be called the following: linking station, folding station and craftmanship station. The 5 machine sections are the following: extracting the dough from a roller, levelling or rolling the dough, shape cutting station, injecting the dough with filling, and spreading of the filling, and cutting the dough and filling mix. One section that is not in the scope of this engineering work but is nevertheless part of the line in some capacity is the rolling machine which is before the production line. The rolling machine prepares the dough to be sent through the production line's rollers. Essentially dough is run multiple times through it and every time the dough passes through the machine, the operator adjusts the rollers to be closer to each other. In the end the operator has a nice thin layer of dough, which is then rolled on to a rolling pin.

Figure 4. Gateau Fazer's production line. Green for machine and yellow for human interaction.

The rolling pin with the dough is then lifted to the production line where it is normally then linked up to an already existing end piece of the previous dough. The end piece and the starting piece in the rolling pin are then conjoined together with a fluid that acts as a glue between the two pieces. However, to conjoin the two pieces together the speed needs to be sufficient for the linking process. The other option is to stop the production line entirely. Stopping the line is usually made if the speed is too much to properly conjoin the two pieces together. Also, the production is stopped if the workers are weighing the products or if the line is going so fast that the products are in danger of falling out from the end of the line.

4.1 Rolling machine

The rolling/levelling machine is the second mechanical machine in the production chain. The rolling machine's task is to level the dough as much as possible for the next steps. The rolling machine has two rollers inside which squeeze the dough through them. This then creates the level dough mat.

The troubleshooting process for the rolling machine is difficult since the rollers are not easily seen during operation. Moreover, the rollers are encapsulated inside a steel hull, which is not easy to take apart and if it were to be taken a part, it would be a time-consuming process. Thus, even though in the initial inspection it was noted that the rollers might be the reason for problems, it is difficult to reliably verify this hypothesis with time that was given for this engineering work.

Figure 7 below shows the rolling machine. These pictures will be used to give a reference to the reader how the machinery would look like. This

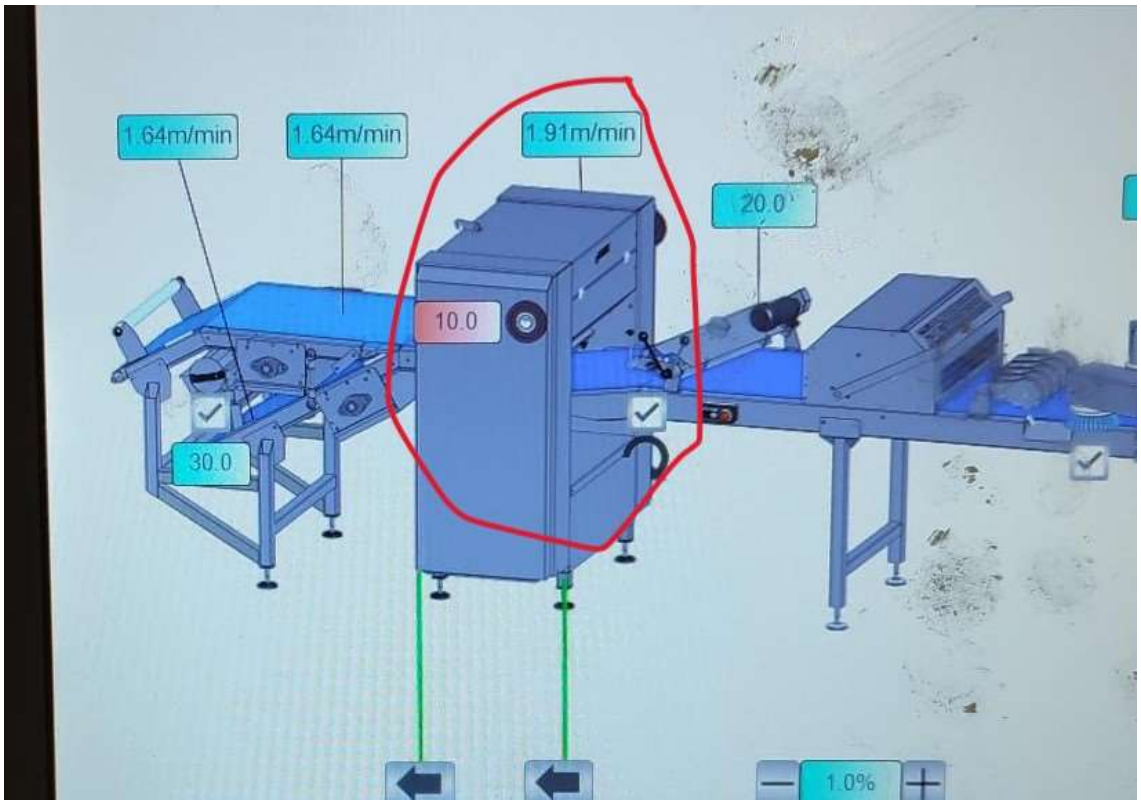

Figure 7. Rolling machine illustrated in the monitor screen.

The rolling machine's most common problem with the machine is the second belt pulling and stretching the dough as well as a strange phenomenon where the machine clearly has bias towards left alignment. Pulling of the dough occurs when the 1st conveyor belt is feeding the dough too slow in comparison to the 2nd belt, or the rollers are turning too slow in comparison to the 2nd belt speed. The slight bias towards left is a slightly trickier question to answer due to limited measuring means. Usually if there is bias towards one side after the rolling machine it could indicate that the rollers are not squared away in relations to each other or if there is a miss alignment between the rollers and conveyor belts. Due to the construction of the machine and the production cycle, it was not possible to check these alignments.

4.2 Conveyor belts

Before moving any further it must be noted that the machine is ran without any linkage to the other machines in the production line meaning that the machine operates on its own without sensors that could for example warn about the dough stretching or packing up too much. Every machine has its own set of setups that are not integrated together. An exception to this is the second conveyor belt and the guillotine, which strangely enough have some sort of linkage between them. However, most do not have any linkage, which means that for example, once the speed of the 1st conveyor belt is changed, the 2nd conveyor belt is not changed automatically. It is up to the user to change the speed of the 2nd belt from the monitor screen if equal velocities are wanted. However, while conducting tests on the actual speed of the belts, it was found that the 1st belt is significantly slower than the speed that it should have.

Table 2. First speed test showing the difference with belt 1 and 2.

Speed test	1st belt	2nd belt
Shown speed	1,9 m/min	1,2 m/min
Actual speed	1,2 m/min	1,2 m/min

This was quite a shocking finding that there are speed differences between the different belts. To ensure that there was no mistake in the way that the test was measured, it was decided that to confirm each result the test would be run 3 times and if the average of those 3 times was close enough then the results would be accepted as legimate.

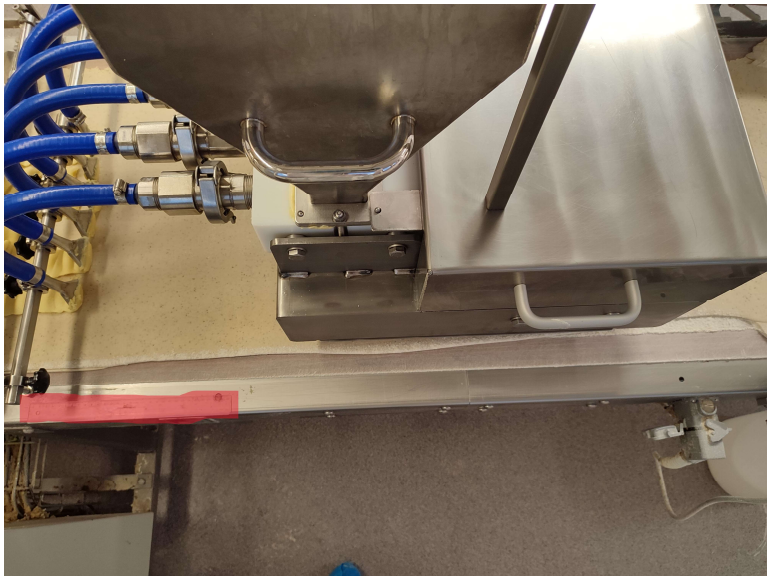

Figure 8. How speed tests were conducted. Notice the painted red area where a 30cm ruler was placed. Later, 1 meter ruler was also used in the same place.

The speed test was repeated with a different speed 2 hours later. The 2nd belt ran the exact speed that the monitor had in it. The 1st belt was set up to run at 1,78 m/min and this time the actual speed of the belt was 1,05 m/min. Thus, it is quite safe to say with these samples that the 1st belt is running slower than the value it says in the monitor. Later in the afternoon the test was yet again repeated with different speeds and the results were following:

Table 3. Speed test with belt 1.

Shown speed	Actual speed
0,5 m/min	0,4 m/min
1 m/min	0,66 m/min

1,5 m/min	0,87 m/min
1,9 m/min	1,2 m/min

The table above shows that the speed difference seems to get level more at the 0,7 m/min difference. The unusual thing about the speed difference is that it seems that on lower speeds there is not much speed difference. However, it seems that the higher the speed, the bigger the difference is, at least until the speed difference is around 0,7 m/min. When the speed difference is 0,7 it seems to level off somewhat and maintain that speed difference.

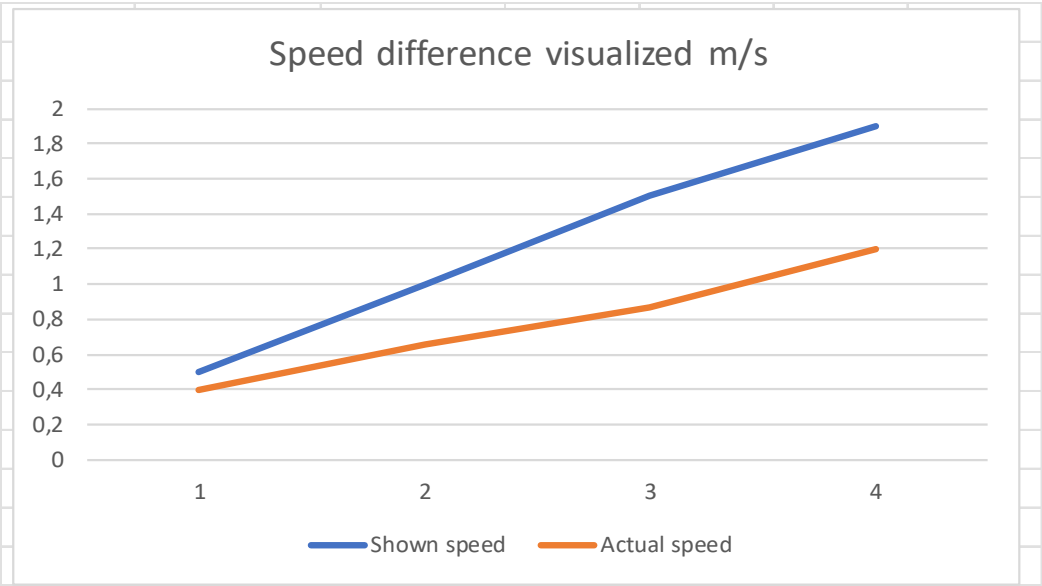

Figure 9. Speed difference visualized.

Therefore, it could be said that when shown speed and actual speed were compared together, the actual speed was somewhat linearly increasing

compared to the shown speed as can be observed from this table. However, when the first speed test was conducted in a shown speed of 1,9 m/min the actual speed was 1,2 m/min. This means that the actual speed is linearly increasing until it reaches around 1,5 m/min, after which the actual speed is the shown speed minus 0,7 m/min from the shown speed.

Moreover, it was noted that when starting the production line, the speed alignment of belt 1 and belt 2 was quite difficult. Even if one changes the setups that are saved into the production line it almost always needs some adjusting. The hypothesis is that there are too much of differences in the dough. These differences are things such as temperature, thickness, stickiness, flour to water mix, etc.

4.3 Shape cutters

After the dough has passed the rollers which level the dough into the right thickness, it is moved first into a brusher, which then swipe away the extra flour that lies on top of the dough. After the dough has passed the brusher, it moves into the shape cutting section. In this section the extra dough is shaved away from the edges of the dough. This section has two circular blades that cut away the excess material. The horizontal bar that holds the circular blades in specially designed holdouts for the blades. The line has a total of 4 different bars, which are used for different products. The difference between the 4 different bars lies in the number of blades that the bar has and the spacing between the blades.

This stage has two distinct functions. Firstly, it cuts the dough into the right shape by removing the excess material from the sides of the dough. Secondly, it makes the edges the same thickness as the middle part of the dough. The reason why this is important is that the dough sometimes gushes out from the sides of the two rollers in the levelling machine. This gushing is bad because if the dough is hanging out from the side of the roller, it stretches out the dough. Obviously, when dough is stretched it makes it so that the thickness of the dough overall is not the same anymore but also the stretching creates stress on

the dough. The stress and stretching of dough should be kept to a minimum because it affects the cutting of the dough as well as how it will react after cutting.

Figure 10. Gushing of dough inside the levelling machine.

The negative effects of the stretched dough can be observed when it is cut. A piece of stretched dough will rebound when cut. This means that when a production line has a time-based cutting, the timing between the two pieces can be messed up because of the rebounding effect on a stretched dough. In practice it means that the stretched pieces of the dough can be smaller than

their rested counterparts. Pieces that do not reach the weight limit on the lower side are detrimental to the effort to save material since those cannot be used again except for a product that is similar to bun y. With the pieces that are over the weight limit, the situation is not as bad since too big pieces can be simply chopped a bit to reach the tolerances. However, if all the pieces are significantly overweight it means that over time the material losses can get high. But in general, too heavy is always better than too light.

Regarding the guillotine, it has minor problems that are not its fault but faults that root from the levelling machine as well as from the workers. Because of the levelling machine, sometimes the dough enters the shape cutting blades so that it barely touches the blades. This has the problem of not creating an equal width of dough, as well as not providing equal thickness on every part of the dough. Additionally, sometimes the cutters cut one side significantly more than the other side.

Workers are sometimes the issue as well. The issue lies in the fact that it is possible to start making for example bun y, while having all the setups for bun x. Usually, because the mixes of the dough are quite close to each other they run with the same setups. However, adjusting is needed for achieving the optimum setups. Moreover, the blades need to be changed by hand so this can easily create a situation where bun y needs blade set for the bun y, but the user forgets to change the blade set, thus the width of the dough is wrong. This then creates problems at the tail end of the production since the wider the dough is, the heavier it is. This can lead to not reaching the desired weight tolerances, as well as cosmetical errors that make the products unusable.

4.4 Guillotine

The guillotine cuts the bun into strips or loafs. It is machine operated and it can be adjusted via the machine’s monitor. The guillotine has some problems associated with the day-to-day operating. One of these problems is the problem of when stopping or starting the machine affects the size of the strips by either

making the strips too wide or narrow. With one product this is not a problem since if the loaf that it cuts is too small, they can just add an overweight piece at the tail end of this product. However, this is an exception. With most products stopping the machine for any reason means that the next 3 to 5 products will have totally random weight that can be either too heavy or too low.

The guillotine has 3 ways that it can be set up. These set ups are mainly changed when the strips of bun are for example too heavy or light. Essentially this is currently the primary way of changing the weight of the strips. The adjustment settings are the following: the length adjustment, the blade position adjustment, and the blade speed.

It should also be noted that the conveyor belt lifts slightly upwards when coming up to the blade. This is to aid the cutting of the dough as well as provide a base for the blade to cut against. What the slight upward motion or a bump does is that it prevents the dough to have chance of merging again with the other half of the dough. This effect is worsened when cutting dough in a bowl for example since when the dough would be cut, it would begin to merge back together especially if the dough is sticky.

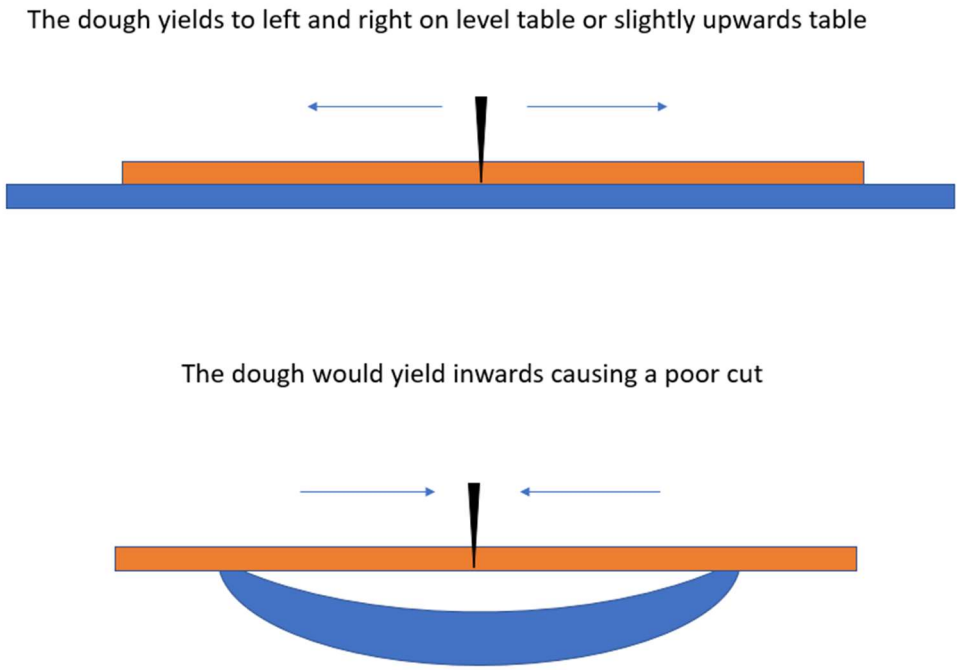

Figure 11. Difference between cutting in a level table versus uneven table.

If the dough were to be cut on a perfectly level table, some batches of the dough could remain stuck together, thus it would not be a straight cut but similar to shearing. In general, it makes cutting easier if the cutting board is elevated a bit.[56]

4.5 Workers and the final stage

This chapter is about the workers and the final stage, which is called the craftmanship step in this document. Currently the line is worked usually by 4 to 7 workers. Usually, they are not assigned to a specific role on the line, but they

[56] (workers, 2022)

change the roles when for example someone goes to a break or gets bored of doing the same thing repeatedly.

The number of workers can also change according to the stage where the whole production line is. When the line is being started, two workers are sufficient to get it running since one uses the roller machine and one puts filling into the filling feeding mechanism. Meanwhile, the other workers are usually helping others in the other parts of the production. Some of them are for example baking bread and others are bringing dough to the production line.

In the normal operational mode, one worker usually operates the roller machine which is the before the levelling/rolling machine. In addition, they also link up the end pieces of two dough mats. His work is the simplest among the workers. His work is usually the entry level position when coming in to work in the production line. It is to be noted that there are differences, and some begin their work in the final stage work their way from there.

The second worker is usually assigned as a roamer. His job is to do various tasks. These include things such as helping the first worker with the linking if the first worker is too busy. Moreover, his work is to feed filling into the filling machine as well as controlling the spreading of the filling when it hits the spreading irons. He is also responsible for adjusting the settings that affect the speed of the conveyor belts, rollers, filling feeding and guillotine.

If these are not setup correctly, he will focus on fixing the setting and an additional worker will help in the folding set which is just before guillotine. Normally, the second worker does this but if he is too busy then someone from the final stage will usually come to make the fold.

The fold is arguably one of the most important steps since if it is done poorly, the sides of the dough can get wavy which then increases the weight changes. This is because the part of the dough mat that is curved towards the center usually does not have as much of dough mass and vice versa when a part of the dough mat is curved outwards.

The rest of the workers are then usually at the final stage doing knots if it is the kind of bun that needs knots. If it is a roll then the roll is usually put into a box and then cut into smaller pieces. The number of workers needed depends on the complexity of the final product. If the product needs to be tied, then more workers are needed. A good estimate is around 4-6 workers if there is a hurry, and it is buns with knots that need to be made. However, with rolls three workers can work quite well if the line is running at a reduced speed.

5 Testing phase

This chapter describes the testing phase and some of the findings that were discovered. First, it was decided to gather data by testing all sorts of information from the machine. The emphasis was on random sample testing, meaning that the line would operate normally and suddenly a measurement would take place. The thought process here was to get as accurate data from normal operation and eliminate variables regarding people and machine set ups. The tests that were carried out were the following:

- Speed test (belt 1 and 2)
- Roller test (calibrating screw and second roller)
- Filling test (content measuring)
- Guillotine test (blade speed and accuracy)
- Dough test (thickness and width)

The majority of these test were conducted on different days. It should be noted that some of these days the dough and filling were slightly different compounds, thus it could have distorted the results a bit. However, the problems that have been described in the previous chapters occur regardless of the dough type or the type of filling being use. This means that it should have a minimum effect on the test results. Moreover, doing all the tests with one specific dough and filling would have been unrealistic since usually products were assigned a single day that they were being made. The optimum would have been to do all the measurements with bun x, but that would have not been possible more than once a week with some products. This was because some of the products were

so rarely made in comparison to other products that were almost made every other day.

5.1 Speed test on belt 1

For referring to this and tests after this, the following picture to point out exactly which part is meant in the production line. The pictures show the machine in 3D image presentation such as Solidworks or AutoCAD.

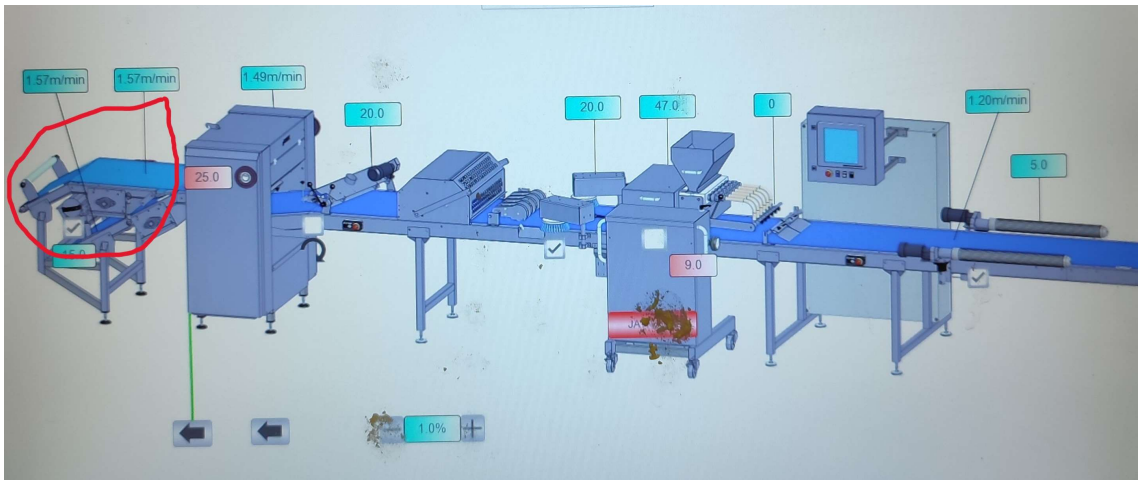

Figure 12. Belt 1 shown from the monitor. A ruler was used to determine the distance and stopwatch to determine the speed. Red circle will highlight the object area.

It was quickly found that the first conveyor belt does not run according to the speed that the monitor shows. The tests were with and without dough on top of the belt and the results were the same. The same test was conducted 3 times for each of the results to eliminate chance out from the equation.

Table 4. Speed test on belt 1

Shown speed	Actual speed

0,5 m/min	0,4 m/min
1 m/min	0,66 m/min
1,5 m/min	0,87 m/min

As can be seen from the chart, belt 1 was clearly slower than what the monitor showed. The effect was lessened on slower speeds and increased on higher speeds. However, the effect that this had on the dough and in the production remain minimal. In practise the speed difference meant that continuing forward it needs to be considered when adjusting the line.

5.2 Speed test on belt 2

When it was discovered that belt 1 was not running the speed that was shown, it immediately sprung up questions about belt 2 and whether it had the same problem or not. Fortunately, it was found that belt 2 worked perfectly regarding speed as can be seen from this table:

Table 5. Speed test on belt 2

Actual/shown speed: 2,5 m/min
2,43 m/min
2,48 m/min
2,46 m/min

As can be observed from this table the speeds were nearly the same. It must be noted that there are differences however, it was argued that those differences

are more the result of human errors on the stopwatch rather than actual differences in speed. The slightly lower speed can be explained by having the weight of the dough on top of the conveyor belt.

It is noteworthy that this same test was made with 1,2 m/min speed and in that case the speed was also the same, thus it can be safely stated that there are no speed problems with the second belt.

However, while conducting the tests, another problem popped up. This was an issue where the belt began for some strange reason to stutter. The belt had previously stuttered only when the line was being prepared for production but this time it stuttered in normal production. The stuttering movement was not significant, but it was noticeable. This could explain some of the issues in the guillotine machine. Even though, an intensive search was conducted to find the source of the stuttering it was not found on the belt nor the flywheel that connects the motor to the belt.

The second belt has also the tendency to shear small chips away which is an indication that the belt is running out of service life, and it needs to be changed or repaired as soon as possible.

5.3 Roller test

Since it was noted that the dough did not have a level surface but rather a wave like surface it was decided to do two tests on the rollers. The first one was to just run the dough through the rollers without the rollers touching the dough. The purpose was to do a control test but also to see if the rollers did in fact influence the weight of the dough. It was thought that this would also solve the problem where the dough began biassing towards the left side of the conveyor

belt after the rollers.

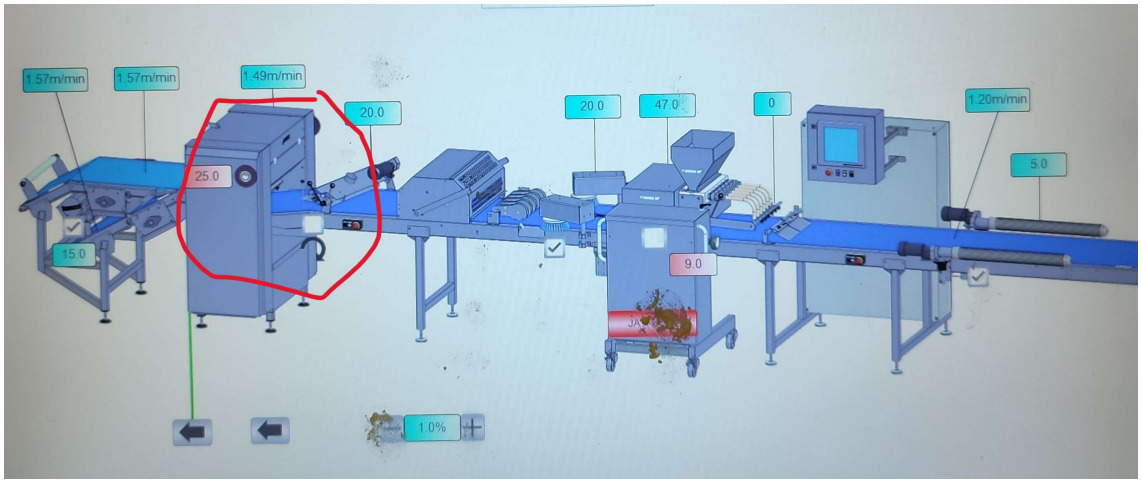

Figure 13. Levelling/rolling machine.

Naturally it was found that having no roller contact on the dough increases the weight dispersion. It also lessened the bias towards the left side, but it was so little that it was deemed to be possible of just getting lucky during this test. Nevertheless, having bad results regarding weight meant that even if this could have solved the left bias issue, it still would not be a viable fix.

After this the workers suggested another test where the machine settings were changed in a way that would allow to squeeze more of the dough through the rollers and as would be seen later again this was not a good idea since the rollers would get packed up with the dough and at some point, this packed up dough would then force its way through the rollers. This means that there would be a huge chunk in the dough, or the dough would tear itself apart to make room for the chunk to fit through.

Noticing how the two extremes did not work well, it was decided to try a more logical subtle option, which was to move the rollers closer together using a calibrating screw. This worked, meaning that the dough did get more level but only slightly. Importantly it did not have big enough impact to be noticeable at the scale. Thus, this test was ultimately declared to be a failed attempt to solve the problem by using a simple fix.

One idea that was tried also was to put a rolling pin between the folding part and the guillotine. The logic behind this move was to level the dough again and get more surface area to the dough. If the dough would have been more spread out it would help with in the guillotine, since more surface area would have meant that millimeters too much or little would have had a smaller difference in comparison to more packed up dough. Once again theory did not meet the test result and the same thing happened as with the earlier rolling machine, meaning that the dough would just pack up in front of the roller pin until the chunk was big enough and then it would force its way through the rolling pin. However, there was a slight positive effect with the rolling pin and it did indeed help with the weight a bit, but the chunks made the option unthinkable.

5.4 Filling test

This test was done by scooping the filling from the top of the dough and then measuring the contents of the filling. At first this test was done normally, as described in the previous sentence, but it was noted that while the levelling iron made sure that the top part of the filling was level, the part of the filling that was in contact with dough was not.

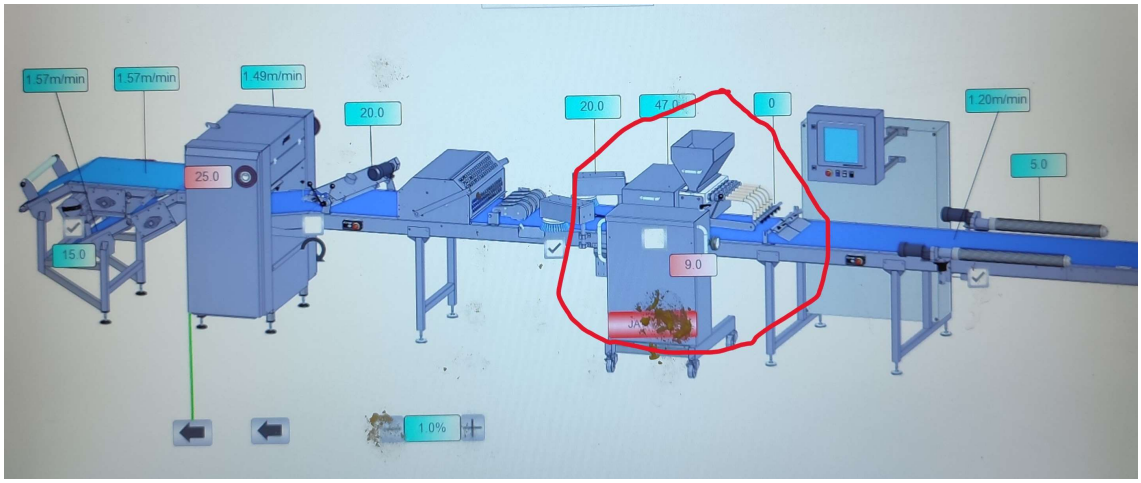

Figure 14. Filling machine.

This was because as described earlier the dough was not actually level, but more such as wave pattern in a millimeter scale. This, however, was enough to

cause imbalance in the amount of filling that there was at certain parts of the dough. Meaning that if the dough had a chunk, then the filling contents would be less than the amount deemed satisfactory. On the contrary if the filling test was done with a slot or a dent in the dough, then there would be too much filling to go with the dough.

The filling machine's operating mechanism was however quite good. Because the operating system was based on piston action and the levelling irons it was deemed that the filling machine was one of the best working parts in this machine. However, the workers were dissatisfied with it, since the cleaning was time consuming, and the adjustments of the levelling irons was deemed to be difficult and obnoxious. Essentially the worker had to adjust the levelling iron's screws individually, thus making the process of adjusting time consuming and difficult to get right.

5.5 Guillotine test

The thought process with this test was to test whether the guillotine was accurate regarding timing and blade speed or not. If the guillotine would be inaccurate, it could explain partly why the weight swings from being overweight to suddenly being underweight. The hypothesis was that a part of the overall problem was partly due to the dough and it being not level enough.

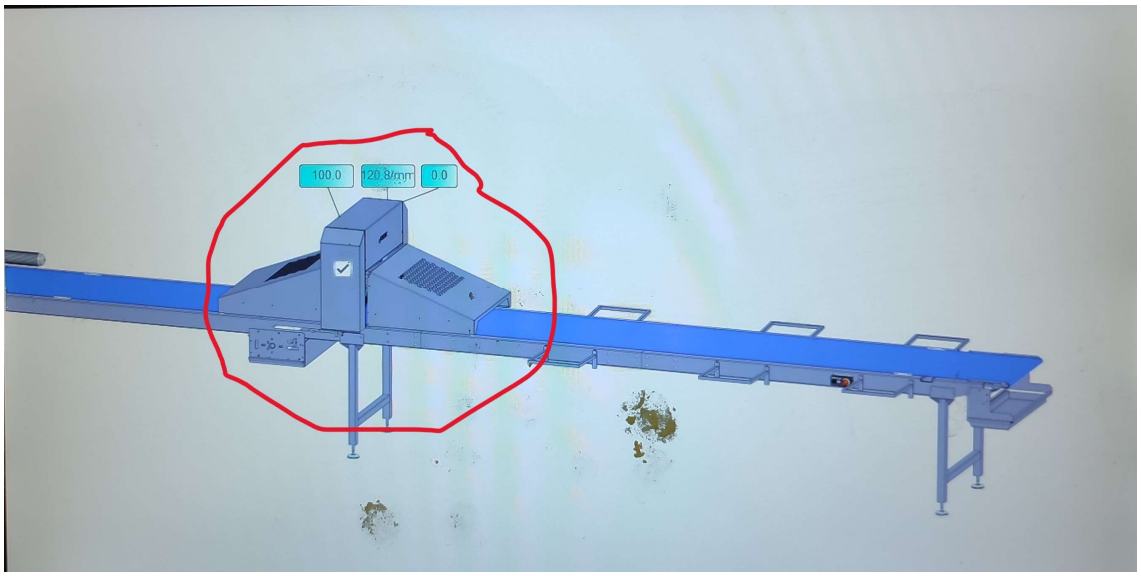

Figure 15. Guillotine

It was found that there is a huge difference between the cuts. In fact, there was as much as 8% difference with the dough strips. This means that the differences were more than the tolerances set for the products (7,35%). Also, the same test was done by having the rolling pin before the guillotine just as was described in the previous chapter.

Table 6. Dough strips and weight with and without rolling pin.

		Measurement:	millimeters	Weight:	grams
		Dough strips	Strips w/ rolling pin	No rolling pin	With rolling pin
		20,37	22,92	82	89
		22,55	21,43	85	84
		21,95	20,28	83	85
		24,08	22,01	88	89
		20,71	20,03	82	93
		22,46	24,28	84	80
		23,81	21,1	83	84
		21,29	21,15	95	73
		19,78	22,34	88	86
		21,38	21,08	90	83
		22,35	22,99	86	80
		22,34	22,12	82	86
		24,93	23,74	100	83
		25,54	23,19		
		18,65	22,38		
		21,14	20,02		
		23,47	22,67		
		19,9	19,86		
		24,93	22		
		22,1	20,82		
	Average	22,1865	21,8205	86,76923077	84,23076923
	Medium	22,22	22,005	85	84
	Standard d	1,817193647	1,244650453	5,293738626	4,758051414
	Percentag	8,19 %	5,70 %	6,10 %	5,65 %

These measurements were measured with a thrust gauge. Also, one notable pick in this Excel sheet is in the strips with rolling pin in millimeters. Even though the strips were closer to each other with the rolling pin these measurements were not reflected regarding weight.

5.6 Dough tests

The dough test was conducted in the part between rollers and the filling machine with the normal dough. This test was also done with a thrust gauge and two pieces of metal that were inserted on top and below the dough. Therefore, the measurements could be as accurate as possible.

Table 7. Dough thickness test with different temperatures

	Dough different (t)	Dough same (t)
	4,72	5,3
	4,51	5
	4,42	4
	4,42	5,4
	4,66	5,5
	4,53	5,7
	5,14	4,85
	4,67	5,7
	3,88	5,71
	3,4	5
	4,03	5,1
	5,17	6,03
	4,14	5,5
	4,6	5,7
	5,36	5,75
	4,35	5,45
	5,42	5,92
	5,65	5,62
	3,15	5,3
	5,02	5,68
Average	4,562	5,4105
Medium	4,565	5,5
Standard deviation	0,627579477	0,446961687
Percentage	13,76 %	8,26 %

The (t) in this instance means temperature. The reason why it has had different temperatures is because the workers made a mistake by bringing different temperature dough to the test without informing. Nevertheless, it provided the information that the different temperature in dough can make a huge difference in the properties of the dough.

However, even if the dough had the same temperature, it still has difference on its surface. Some parts are clearly higher than other. Therefore, it should be highlighted that the test results were taken from the exact same spot with random strips of dough.

It was also decided to do a test where the objective was to measure the dough's thickness on different parts of the dough. For example, left side versus right side and middle versus sides.

Table 8. Dispersion regarding weight on the width axis.

	Row 1	Row 2	Row 3	Row 4	Row 5
	92	84	x	88	99
	101	87	x	101	92
	89	88	x	97	105
	102	88	x	91	101
	99	89	x	91	113
	103	90	x	90	92
	92	88	x	95	107
	96	89	x	96	101
	94	86	x	89	103
	103	90	x	90	98
Standard deviation	4,908156	1,75784	x	3,994997	6,122908
Average	97,1	87,9	x	92,8	101,1

As can be observed from the Excel sheet, the sides were more prone to weight differences than the center. Also, there is a slight weight increase on the sides compared to the middle. Row 3 was not considered since it was known from previous tests that it is the most accurate and consistent one out of all the rows.

5.7 Working by hand

Nearing the end of the testing phase it was decided to try making the end products completely by hand as they were done previously. The idea came from the workers themselves since some of them were used to make the dough by hand. The test started off a bit poorly with the workers cutting a few pieces instantly over and under the weight limit. However, after they had done a few chunks of dough the cuts became more consistent and more importantly the weights became more consistent.

Table 9. Accuracy of cuts by hand and machine.

		By hand	Machine	
	Average	17,08	16,1	
	Mean	16,97	15,99	
	Standard deviation	1,69	1,57	
	Percentage	9,91 %	9,78 %	
	Biggest	21,35	19,74	
	Smallest	13,94	12,76	
	Difference	7,41	6,98	
	Chunk of dough	52	51	
	Material loss (kg)	26	44	

As can be observed in Table 9, even though the workers had trouble in getting the cuts and weights right, it seems that by making the buns by hand has around 40% reduction in the material loss category. This was a much bigger material loss than the workers said previously. Previously they said that when they conducted work by hand, they did not have almost any material that was reported as losses. This test therefore concludes that this claim is not right and cannot be taken as granted. A more realistic number would be probably something in between no losses and the given 26 kg of material loss by hand.

It should also be noted that the cuts were made without a proper measurement, meaning that the cuts were made by the judgement of the confectioner. There was not a proper measuring device available but if there were one, it is to be believed that the cuts would have been even better.

The confectioners made a total of 4 chunks of dough which does leave room for debate on whether they got lucky while making the products by hand, but it was argued that if the past data and experiences are to be believed then this method is significantly better than the machine cutting one when it comes to the material loss.

5.8 Aftermath

After the tests were completed, it was deemed that most of the differences come from the dough and guillotine. However, improving the temperature distribution within the dough as well as the within the different chunks of dough is out from the scope of this engineering work. It will not be researched more in this engineering work, although it is something that must be studied more thoroughly to make the dough become more level.

Also, the studies regarding dough rheology and viscosity should be taken into consideration, since it is known that if the dough is not in completely rested state, it is more difficult to work with. If there is a temperature change in the dough it also changes the properties of the pieces of dough.

Guillotine is something that is in the scope of this work. It has a big enough impact to make a change and it is easy enough to implement into the existing production line with minimal financial assets tied into it. Gateau Fazer had past data from the workers showing that before this production line, they were cutting by hand and the weight was almost always closer to the tolerances. Therefore, a conclusion can be made that a part of the problem is caused by the guillotine and fixing it should be a priority.

6 Proposed solution

Based on the measurements that were taken from the different parts of the production line it is impossible meet the quality tolerances regarding weight with these machines and these production methods. Therefore, to alleviate the huge

material losses that are coming daily with buns x and x it was suggested that the weight tolerances should be increased along with eliminating one of the variables in the production line.

Table 10. Ease and effect on repairing a part in the production line

	Deviation (%)	Repairability
Dough	8%	Difficult, many variables contribute
Filling	~2 - 4%	Possible but expensive with little effect
Guillotine	6%	Possible, relatively cheap

As can be observed from this table, although the dough has the largest deviation and therefore the largest contribution to the weight being over or under the desired limit, it has many variables that are out of the scope of this engineering work. These variables include things such as temperature, stretching and stickiness. For example, if the dough comes straight from the freezer, it has different properties compared to a dough that has been resting for a few hours in room temperature. Moreover, the dough can have different properties depending on the different temperatures on the different parts of the dough. It is safe to say that it gets complicated and more into the field of chemistry and rheology.

The filling machine is working quite well by itself. When considering that it must push through high viscosity filling, it performs well. The machine is not to be blamed here for the deviation. The problem lies in the dough. Precisely in the fact that it is so uneven makes it so that there will be more filling in certain parts

of the dough compared to others. This contributes to the weight difference. Certainly, the filling itself plays a part in the overall weight. For example, in a certain filling there are seeds in the filling itself and if by chance there is a part that is more concentrated with these seeds or less it has a small and barely noticeable change in the weight.

The guillotine is the one machine that has a big enough contribution to the weight and high enough repairability to make it viable for improvement. Essentially, the problem with guillotine is that it is not accurate enough to meet the set tolerances. The accuracy that the guillotine must meet is a few millimeters and it is impossible to meet this accuracy with it. Additionally, things such as stuttering of the conveyor belt, electronical inefficiencies and differences in dough construction influence the guillotine's accuracy. Electronical inefficiencies are things such as bugs or glitches, meaning that when the guillotine is given the command to cut it can have a slight delay before executing the command. In the time span of this delay the dough can move a few millimeters before the guillotine cuts. This can cause the strips to be too wide or too narrow.

The construction of the dough can also influence the cut. For example, if a dough is stretched from the top relaxed from the bottom, it creates an effect where the dough is rebounded from the top but stays still from the bottom. This then makes the cut seem to be offline. The dough stretching from the top can

be caused by poorly folding the dough prior to guillotine.

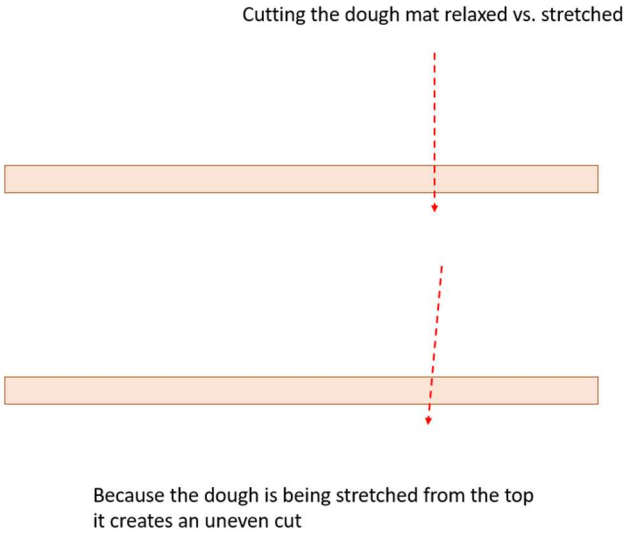

Figure 16. Stretching of the dough.

The stretching of the dough is quite difficult to negate since it is part of some of the products that the dough mat is folded. While folding, the dough mat will stretch regardless but if the stretching is too much then it influences the guillotine's cut.

There is also the factor of electronical bugs and lags that affect the guillotine machine the same way as other electronical devices. Essentially every electronical device has a slight delay from when one wants to perform an action to when the action is carried out. This exact thing was explained excellently by Mohammad Firoz Khan at ResearchGate.net:

> "Latency issues, from the user's perspective, are usually a perceived lag between an action and a response to it. In 3D simulation, for example, in describing a helmet that provides stereoscopic vision and head tracking,

> latency is the time between the computers detecting head motion to the time it displays the appropriate image." [57]

This means that the guillotine most likely has latency that varies from time to time. If for example there is a 0,1s delay on the guillotine then at the speed of 1,2 m/min the line would move 2 millimeters off the desired line. 2 millimeters is enough to make the strip being over or under weight. Therefore, it can be concluded that the guillotine delay together with the variables regarding dough can easily make the strips to be over or under weight.

6.1 Solution to the dough

Even though putting the dough to the freezer and fridge is not a part of this engineering work, a quick report on this matter should be touched on, since the proper fix to this production line problem is to get the dough tolerances smaller. Fixing the problem is simple to explain but harder to implement at least with regards to chemistry.

First the temperature of the dough needs to be controlled better. This includes both the individual chunks of dough as well as the temperature in the different parts of a single chunk of dough. A solution could be to better monitor and measure the temperatures. Additionally, the ideal temperature for all the different doughs should be found and then implemented.

Secondly there should be more caution when rolling and handling dough. Rolling should be done properly and should be done long enough to reach the desired thickness tolerance for the dough. This means that if now the average is 5,4 mm and the deviation is 8,2% we should have the deviation at least below 5% ideally more. This is because there needs to be a buffer in tolerance

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[57] (Khan, 2014)

counting to meet it enough. Moreover, in the tolerance calculations all the different variables need to be considered. This means that dough, filling, guillotine, and randomness should be considered, added together and then base the product tolerances on the result of these plus a buffer.

However, even though fixing this is the most helpful action it arguably the most difficult and most tedious fix out of all of them. A whole engineering work could be dedicated to just find the optimal temperature for each of the doughs and necessary steps that need to be taken to achieve. It was estimated that this is far more expensive than the guillotine which would already help significantly.

It was suggested that Gateau Fazer does an additional engineering work regarding the optimization on the characteristics of the dough. Everything regarding how long the dough is in the freezer and fridge to how long it should be in room temperature and so forth.

6.2 Solution to the guillotine

A solution to the guillotine can be found from the working methods three years ago. During this time all the current products were made by hand and while being significantly slower than the current production, there was not as much losses in material in comparison to present day. Thus, it was proposed that Gateau Fazer orders a multiple blade guillotine that is at least 1,5 meters long. This would have custom built blades that are 22 mm apart from each other or another desired length. This would mean that if the frame is considered giving the overall length of 1,3 m it would have 59 blades cutting.

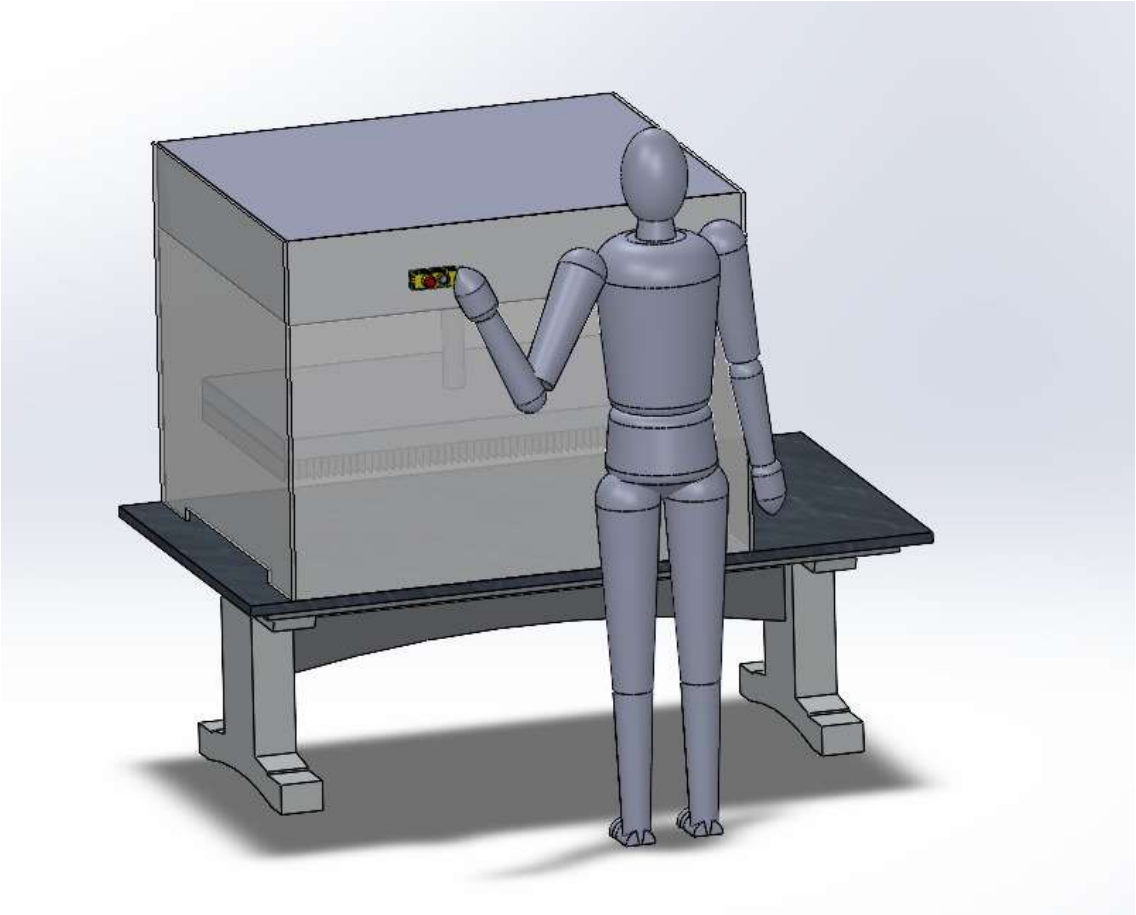

Figure 17. Proposal to replace guillotine with certain products

It would be semi-automatic meaning that it needs a human operator to operate the blade. This would eliminate the electronical bugs and lags from the equation. It would make sure that every piece other than the first piece is for example exactly 22 mm.

This would not however, completely replace the guillotine. The reason for this is that for products that are already successful enough in the line there is for no reason to change. This is because with certain products it is possible to repair if the product is too heavy or too light. For example, if bun y is too light a piece from an overweight bun can be cut and added to the lightweight bun therefore, making the overall piece the correct weight. However, this is a rare exception as most of the products are immediately designated as a loss since there is no viable way to make a lightweight bun the correct weight.

This semi-automatic multiple blade guillotine would be viable for the bun 1,2 and 3 where the product is strips of dough. However, if one could even half the losses that are coming now while only having a slight decrease in production, one could can call this improvement a resounding success.

How this semi-automatic blade would work in action is that the machine has a blade rack and this blade rack houses around 50 blades. When the operator then wants to cut, he simply pulls the whole blade contraction down from a handle. The blades then cut the dough into the desired width pieces it seems that the ideal width for most of the products lie in between 22 mm and 16 mm. With this device the advantage would be in the accuracy of the human hand but the efficiency of the machine when it comes to cutting.

The problem with this device comes in the form of calibration, since if the device is poorly calibrated or the blades bend while cutting or anything else then it loses all the effectiveness. In this sense it could be much worse than the guillotine that is operating currently. Safety is also one aspect that needs to be looked at before implementing and using this machinery. The good thing about the guillotine in a production line is that it is relatively easy to shield. But a hand operated machine such as this has its own risks associated with it.

Regarding costs this would be a relatively cheap fix if it works. At most a device such as this would cost most likely a couple thousands of euros, thus if it does not work as planned, the loss of capital is not huge but on the contrary if it works as planned and for example cuts the loss of material by 50% then it would relatively quickly pay itself back.

Table 11. Calculations regarding production cost and sales.

Cost of bun x	Weight	Gross margin	Production (kg)	Daily production	Material loss(kg)
€ 1,00	0,093	50 %	600	6451,612903	52,8
Cost of kg					
€ 10,75			Production cost	-€ 6 450,00	
			Material loss	-€ 567,60	
			Total	-€ 7 017,60	
			Batch value	€ 6 451,61	
			Total sales	€ 9 677,42	
			After tax	€ 7 804,37	
			Profit bun x	€ 786,77	
Cost of bun y	Weight	Gross margin	Production (kg)	Daily production	Material loss(kg)
€ 3,68	0,4	50 %	600	1500	36,96
Cost of kg					
€ 9,20			Production cost	-€ 5 520,00	
			Material loss	-€ 340,03	
			Total	-€ 5 860,03	
			Batch value	€ 5 520,00	
			Total sales	€ 8 280,00	
			After tax	€ 6 677,42	
			Profit bun y	€ 817,39	

As these calculations show bun y is more profitable than bun x. However, the reason behind that lies in the fact that bun x has almost 200€ more material loss when compared to bun y.

Table 12. Difference in profit when done by hand vs. by machine

			Machine		
			Production cost	-€	6 450,00
			Material loss	-€	567,60
			Total	-€	7 017,60
			Batch value	€	6 451,61
			Total sales	€	9 677,42
			After tax	€	7 804,37
			Profit bun x	€	786,77
	Material loss kg				
Making by	31,2				
Machine p	52,8		By hand		
			Production cost	-€	4 849,62
			Material loss	-€	335,40
			Total	-€	5 185,02
			Batch value	€	4 850,84
			Total sales	€	7 276,26
			After tax	€	5 867,95
			Profit bun x	€	682,92

Table 12 shows that by making bun x by hand it is possible to decrease the material losses by 40%. However, this decrease in material loss comes as a loss in the profit since making by hand is also 33% slower than machine production. Therefore, it would be optimal if one can combine the material loss statistic of hand making and have the production of machine.

Table 13. Profit increase from a semi-automatic guillotine.

Guillotine	70 %		Machine		
Cost	6 000,00 €		Production cost	-€	6 450,00
			Material loss	-€	567,60
			Total	-€	7 017,60
			Batch value	€	6 451,61
			Total sales	€	9 677,42
			After tax	€	7 804,37
			Profit bun x	€	786,77
			Guillotine		
			Production cost	-€	6 450,00
			Material loss	-€	170,28
			Total	-€	6 620,28
			Batch value	€	6 451,61
			Total sales	€	9 677,42
			After tax	€	7 804,37
			Profit bun x	€	1 184,09
			Profit increase		51 %

As can be observed, there is a tremendous increase in profit by just adding a semi-automatic guillotine for making the buns. But this is not the final solution. If bun y was made simultaneously with the current production line the numbers get even more interesting.

Table 14. Profit increase and return on investment.

Guillotine				Production line	
Production cost	-€	6 450,00		Production cost	-€ 5 520,00
Material loss	-€	170,28		Material loss	-€ 340,03
Total	-€	6 620,28		Total	-€ 5 860,03
Batch value	€	6 451,61		Batch value	€ 5 520,00
Total sales	€	9 677,42		Total sales	€ 8 280,00
After tax	€	7 804,37		After tax	€ 6 677,42
Profit bun x	€	1 184,09		Profit bun y	€ 817,39
	Overall profit				
	Guillotine/hand		Production line		
	bun x		bun y		
	€	1 184,09	€	817,39	
Combined total	€	2 001,48			
Profit increase		354 %			
	ROI				
Guillotine cost	€	6 000,00			
Combined increase	€	1 214,71			
ROI (days)		4,94			

The calculations show that if the semi-automatic guillotine would bring an improvement of 70% in material losses, then it would pay itself back in roughly 4 days. However, it should be noted that this was calculated for only one semi-automatic guillotine. The reason why the 70% improvement in material losses is a modest estimate is because in the past when the products were made by hand the loss of material was practically close to 0.

These calculations are based on the following assumptions:

- There are always 21 working days in month.

- Every product that is made is sold.
- 6000€ include hardware, installation, and training.
- Same product is made every day with the same production rate.
- Overproduction is not harmful for the operations.

It was estimated that the investment would be around 6000€ because guillotines at a hardware store can cost between 300 to 600 euros. This device needs to be both larger and custom made, thus a rough addition is rough tolerance is added to this price. Moreover, the 6000€ estimate is designed to account for errors made in the calculations. Realistically it was estimated that the price would be closer to 4000€ euros. However, the price is not the most important thing here since it is only an estimation. Should this be considered seriously, then there should be more thorough research made on the investment price.

Since the times that the products of the production line were done by hand the skill of making products by hand has degraded in 3 years that the production line has been operating. Thus, when initially the loss of material was measured to be around 40% less, it was not considered that if the workers were more skilful then the rate of rejection would have been significantly lower. Perhaps, the improvement by hand could have been closer to 70 or 80%.

Nevertheless, this proves that when it comes to products that end up as strips of dough, it is in fact more beneficial to cut them by hand or as it was proposed with a semi-automatic guillotine that would return the investment in less than 4 years. However, the proposed improvement does not fix all the problems, nor does it make the production line obsolete. For example, with the proposed improvement one can only do a single type of products and that is strips of dough. The production line will always be better at making certain products than a human making by hand or even with a semi-automatic guillotine.

Thus, it can be concluded that the proposal is not a fix but a tool. A tool that partly solves the issues for half the products that are ran on the production line. It is suggested that the production on the products that are made in strips

continues until the suggested tool can be implemented. When the semi-automatic guillotine can be fielded for working then the production of the strips in the production line shall end and production on products that flow through the line successful shall continue.

6.3 Secondary objectives

The secondary objectives that were briefly mentioned were the creation of a manual for the production line as well as a manual for the craftmanship stage of the production line. The manual for craftmanship was dropped from the objectives since at the end, the differences in the way that individual workers tie the knots for the cinnamon buns were minimal regarding to performance. It was quickly found that the reason why someone can make the buns faster than someone else simply lies in the fact that experience makes the worker faster not the way he ties a knot into a cinnamon bun.

Therefore, making a manual that illustrates the differences between some niche ways of tying a knot into a strip of dough is simply unreasonable. Also making a manual for a step that takes less than 2 seconds for a skilled worker is questionable at best. Most likely the end value of creating this kind of manual would be the workers who are on their first week working. After the second week or a few days the manual would have zero value.

However, a manual (in Finnish only) shown in Figure 18 was created for the overall production line that illustrates how to start the production line step by step as well as how to operate and clean after finishing with the production line. This was deemed quite important since it not only gives a basis for this engineering work, but it also helps seasoned veterans of the production line understand all the tricks and tips that were gathered from almost 10 people working in the line.

Työohje		Kaulaus		Versio 1	
Mika Ylikoski				Leipomo	
Nro	Työvaihe	Turvallisuus Laatu Vinkki		Kuva 1	Kuva 2
1	Operointi - Giljotiini		• Giljotiiniä operoidaan normaalisti yhdellä asetuksella (Kuvan keskimmäinen asetus) • Asetuksen pienentäminen vähentään taikina strippien leveyttä = pienentää painoa • Päinvastoin kun asetuksen arvoa kasvattaa → paino lisääntyy • Tärkeää olla säätämättä yksittäisten kappaleiden takia • Mielummin yläpäähän keskipaino		
2	Operointi - Painon mittaus		• Painon mittaus satunnaisten kappaleiden kohdalla noin minuutin välein		
3	Operointi - Käynti ja stop		• Käynti start nappulast • Stop pysäyttää • Hätäseis pitää kuitata tarvittaessa • Hätäseis tilan laittaa päälle turvaluukun avaaminen		

Figure 18. An example of the manual that was created.

Essentially, here is an example how the manual looks like. It is around 20 PowerPoint slides where there is every single detail and every niche information for the production line. Some pictures were added in some of the slides to clarify the things that were important. The ribbons at the top were added to bullet points that were important regarding:

- Worker and equipment safety.
- Steps that were critical regarding quality.
- Tips and tricks that eased workload or allowed more efficiency.

Every step and adjustment that a worker can do to a machine is included in this manual as well as different common scenarios that a worker can come up with while working in the line and the fixes to those problems. For example, if the dough is stretching too much or it is not flowing through the rollers in an efficient manner there are fixes that are listed to the manual.

The reason why the manual is in Finnish is because this was made for the workers at Gateau Fazer and most of them speak Finnish.

7 Summary

This engineering work was conducted at Gateau Fazer's factory at Sörnäinen. The objective of this engineering work was to optimize the production line that produces cinnamon buns for Fazer's artisan bakeries around the Helsinki area.

The engineering work started off by first doing measurements for the different products as well as the line itself. It was quickly noted that the line has some distinct problems, and these problems range from tiny issues such as belt 1 running slower than what the monitor shows to things such as the guillotine not cutting accurately enough and the uneven nature of every dough mat that is passed through the production line which together result in much of the losses in this production line.

Moreover, the knowledge of the production line itself was patchy at best, meaning that if the workers were not shown precisely how to act if for example the dough mat is too tight it resulted in unnecessary loss of material. A loss that could have been avoided if the workers were more educated on the principles of how the machine works and how to solve the most common issues.

After conducting a great number of interviews and countless hours watching the machinery operating it was deemed that a fix for the production line was necessary. Finding the target that should be fixed was valued and calculations on the effectiveness and cost were conducted to judge whether a fix was logical from the point of view of the worker as well as regarding productivity and cost.

Fixing the dough compound would have a slightly bigger effect than fixing the guillotine but fixing the dough would require much more capital. Thus, it was decided to fix the guillotine based on the minimum amount of capital that it would take as well as not really halting the normal production in any way, shape or form.

The product in the optimization of the production line is a semi-automatic guillotine that is more accurate than the current guillotine used by the

production line. The calculation concluded modestly that this solution will return the investment in approximately 5 days.

As for the manual, it will be used to teach new workers in a field that has quite high change rate among the workers. The manual allows for the explanations of common issues in the current production line and the fixes to them. It also educates the workers into applying tips and tricks that make work in the line more efficient.

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