THE AUTOMATION OF THE MATERIAL HANDLING PROCESS AT COMPANY X

Industrial Engineering and Management Bachelor thesis

Abstract

This document contains a summary of the thesis written at Company X

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Contents

Introduction of the company

Company X is a company specialised in the coating of products. These products are delivered by their customers, as Company X only adjusts products and does not produce them. These products are processed in the production lines using a barrel or racks. The filling of the racks is a labour-intensive process, which leads to low usage of the available capacity of the production lines. To enhance usage of the available capacity, the goal of this research was to analyse the feasibility of automation of this process. Therefore this thesis aims to answer the following research question: "To what extent is automation of the material handling process at Company X feasible?" The goal of the automation is to be more efficient and less dependent on human labour, as production may improve and shortage on the labour-market may endure. This means that an automated process with a higher throughput but with higher costs is beneficial, as well as a process with only lower costs. The main goal is to achieve maximum efficiency and a reduced dependence on human labour.

Purpose of the thesis

This thesis has been written in light of my bachelor Industrial Engineering and Management at the University of Twente. This research has been conducted from April 2020 to the end of June 2020, while writing this report. I have worked 5 days per week at Company X, despite the special circumstances due to Covid-19. The purpose of this thesis was to conduct research about the possibilities of automation of the material handling process. By analysing the current process, solutions for a future state could be created. This future state should deal with the bottlenecks Company X has to deal with in the current process. The first intention was to deliver an implemented solution, but due to various constraints this changed to an overview of the available solutions and the feasibility of implementation at Company X.

Research design

Since the problems have already been identified by Company X, it is desired to create a problem approach in which will be explained how the problem will be tackled. First, the current process has been explained and every step has been analysed by using the level of automation. Thereafter, data about the previous processes was analysed to make clear which products fulfilled the requirements for automation. For example, if a product has a batch size of 1000 per year and the time for putting the parts on the racks is negligible it is not beneficial to automize the process with taking the requirements for that product into account.

This analysis aimed to give a clear overview of which products are suitable for automation and which are not. This resulted in a list of products that could be categorised as "large batches". These large batches thereafter have been analysed with regards to their size and shape. By doing this, categories were created which offered the opportunity to automate more than type of product at a time. This analysis was part of an analysis of the current state, which consisted of much more than only the products. The KPIs of the current process have been analysed with the aim to get an overview of the achieved efficiency of the process. The time it takes to execute this material handling process has been measured to gain insight in the size of this bottleneck. The capacity was calculated to see if this would potentially be a bottleneck after improving the hanging process. The way the products are supplied to Company X has been analysed as well, as this has influence on the repeatability of the process. This analysis thereafter has been summarized to get an overview of the bottlenecks that needed to be dealt with before an implementation of a robot or cobot could take place.

After the analysis of all the products and the current state was done, a research has been conducted on which requirements the machines needed to have to handle the chosen products. Since Company

X does not produce the products but only processes them, the requirements of the products themselves could not be influenced that easy. If Company X would do this, customers might go to other companies since they do not want to change anything. Customers could be persuaded to make small adjustments to their products if it would lead to great benefits for the customers. Due to the fact that this is an uncertain factor, this research has focussed on finding the right machines or robots for the current products, instead of adjusting the products to the best machine. But it needs to be stated, that if a small adjustment of the products could lead to benefits for the customer, the products could be adjusted if no other solution is found. Another thing that has been analysed is the way products arrive at the factory, as it differs per customer how the products are delivered. This can have substantial influence on the material handling-time, and the specifications for automation.

Thereafter, a choice has been made on which machines are capable of handling the products processed by Company X. By conducting research, a list of suitable machines has been created, with specifications to see which machines suited Company X best. This choice also consisted of choosing an implementation plan that suits the existing company structure best.

Last, a cost-benefit analysis has been made to see whether the machine is suitable for usage in the factory. During the last few weeks of the research suppliers have visited the company with the goal of validating the first conclusions of the research and delivering feasible solutions for the current process at Company X.

Research questions

By implementing this research design most of the research questions logically followed. The main research question of this thesis was: “To what extent is automation of the material handling process at company X feasible?”

This research question has been answered using the following sub-questions:

1 What is the current process-flow?
   - What are the differences between the production lines?
   - Which steps are used in the current process?
   - What is the level of automation of these steps?
   - What KPIs are currently used by Company X?
   - How does Company X score on these KPIs?
   - What is the capacity of the production lines?
   - How long does the material handling process take?
   - What are the costs of these processes?
   - How are the products supplied?
   - What is the transportation time of the carts?

2 Which requirements should a product have to be automated?
   - Which production lines are used for the research?
   - What is the diversity of the products and the volume of the different products?
   - What is the frequency of large batches?
   - What is the shape and volume of these large batches?
   - What types of racks are used in the current process?
   - Which product groups processed by Company X could be automated?

3 Which machines are suitable for the company structure of Company X?
   - Which requirements are needed for the machines?
   - Which machines fulfil the given requirements?
   - What are the implementation costs of these machines?
   - What is the best solution of the given options?
   - What will the new process look like?

Literature review

As some parts of the research had to be dealt with through theory rather than practice, the first question answered after literature research was: “What is the level of automation of these steps?. By using various academic this question is answered as follows. The right level of automation has to be chosen as it has consequences for the results of the implementation. Although it is said that automation is done in one step, from manual workers to fully-automated, there are multiple small steps that can be taken (J. Frohm, 2008). As manual operation is described as “by human labour rather than automatic or computer aided means” (Manual Operation, 2020), giving an employee a tool is a small step to automation. This is a trivial example, but it indicates that choosing a different level of automation can lead to different consequences. Therefore, Frohm has divided the LoA into Physical (Mechanical & Equipment) and Cognitive tasks (Information & Control) while still acknowledging the co-operation between human and technology, to create a better scale (J. Frohm, 2008). This offers the opportunity to vary the implementation for automation for physical and cognitive automation depending on the needs of the production line. This segregation is necessary due to the fact that at Company X some parts of the material handling process have a different level of automation when looking at the physical part compared with the cognitive part. These different levels of automation are given in Table Y, where every level is explained in short. The level of automation is a more

elaborated scheme of soft and hard automation. To give a clear example of the consequences of LoA, soft and hard automation will be used. Soft automation is when the machine monitors the actions of the operator and gives warnings and signals in case of wrongdoing. Hard automation is whenever the machine corrects the action of the operator by doing the task himself (Mark S. Young, 2007). Soft automation starts at level 4 or 5 of the scale of Frohm, where hard automation is level 6 on this scale. This means that giving the machine a bit more control the work situation can differ more than anticipated. This explanation can insinuate that more automation is always better, but this is not always the case. Hard automation can lead to false security, the employee trusts the computer more than his own observation. This can lead to non-conformities in the products when the machine makes mistakes (Klaus Christoffersen, 2002).

The second research question that has been answered through literature research was: "Which requirements should a product have to be automated?" Various scientific sources have been used, where after two main requirements have been concluded for automation. The first and most logical requirement is high and secure volume. This means that the number of products processed by Company X should be significant and the volume does not fluctuate per month (Mats Jackson, 2011). Automation functions best when repetitive tasks are carried out by a robot because this results in less changeover time. A second requirement could be a maximum amount of weight a machine is able to handle. According to Agrawal & Heragu, Automated Material Handling machines are used for products or parts that are too heavy or when vibration has to be minimized (G.K. Agrawal, 2006). During the selection process of the product portfolio of Company X, weight will be used as a criteria as different robots have a different maximum payload.

To make sure that the automation is fully integrated into the manufacturing system, there has to be development in multiple areas. First, ease-of-use is one of the pillars for a robot as the operator should be able to use the data given by the robot to measure its performance. The robot should harvest information and present in an understandable way (M. Hedelind, 2009). Second, all the machines in the factory should be standardized. Another requirement is that a systematic method for how to work with maintenance should be in place to ensure high availability of the system (M. Hedelind, 2009). Furthermore, the robot should give a clear overview of what product is currently worked on. This ensures that all the employees working with the robot can adapt to progress achieved by the robot. Last, the right level of automation should be chosen, as it has a major impact on the lay-out and performance of the new process.

Solution Design

As the aim of this research was to investigate the feasibility of automation, collaborative robots (cobots) offered the best solutions for Company X. The current situation has been analysed with the aim to formulate the requirements necessary for the selection procedure of the cobots. During the analysis of the current situation it became clear that there were several constraints regarding automation. One of them was great variety in almost every aspect of the process. There is a big variety in racks, shapes of products, size of batches and way of delivery. Therefore, a list of products has been created that are ordered more than 5 times per year and at least 400 products per order. This threshold was chosen as Company X charges an extra employee if more than 400 products have to be hanged. It was possible to standardise a part of these racks, which led to less variety. By categorizing the shapes of these large batches with a high frequency, it is possible to create an approach for automation. Furthermore, it became clear that the reach of the cobot would be the hardest constraint as the racks are bigger than most cobots can reach.

Methods used for validation

The research conducted is valid as it has been done with precision and according to the created approach. Although it is valid, there are some concerns as not all the parts of the research were as desired. The data used in this research is partially collected and administrated by hand which means it is subjective. During the observation research, it may be possible that the employees noticed that a research took place and that may have led to different results. My research was limited by the data available as not all data have been collected throughout the years, which meant not everything could be analysed. Due to the Covid-19 situation, it was harder than normal to visit companies or let companies visit Company X. This means that benchmarking was harder than normal and possible already existing solutions may have been missed. I suggest that Company X analyses their current portfolio in a different way than has been done during this research. By looking thoroughly at their portfolio, they are able to categorize their products even more and increase the number of products suitable for automation without being dependent on growth from outside the company.

Furthermore, the findings of this research have been created after consolidation with various suppliers of cobots. During the research, the whole production process, not only the material handling process, has been analysed and summarized before the suppliers visited Company X. This lead to the fact that the suppliers were able to answer most of the questions for the desired solutions. Two suppliers of cobots offered a lay-out of the future state, with an explanation about the choices made in this design. These choices were taken into account when coming up with different solutions, which means that the solutions that were proposed are feasible.

Results conclusions, or recommendations

The goal of this research was to answer the question to what extent it is possible to automate the material handling process at Company X. After a thorough research, I am convinced it is indeed possible to automate the material handling process. The analysis of the current situation showed that there are bottlenecks which must be dealt with first. But the capacity and lay-out of the whole factory of company X can deal with an improvement of the material handling process. By automating, the process becomes less dependent on human interaction. Second, it saves up to approximately €20,000 per year on employee costs. Furthermore, the throughput will be more stable which means that the planning of the machines can be done more efficiently. However, there are some constraints, the process will still depend on the employees as the cobot needs to be supplied with racks and products. Second, the success of this automation depends on the way of using the cobot as it needs to be

handled correctly. The cobot is not a fully automated machine but a collaborative robot which needs to be guided throughout its work. Last, the quality inspection of the products will be one of the hardest parts to carry out by the cobot as the result of the check depends on the circumstances and the climate the cobot is active in.

The findings of this thesis lead to a number of recommendations to improve the efficiency. First, I recommend Company X to make agreements with their customers about the way of delivering their products. At this moment it varies per article if and how they are structured, where it would be better for a cobot to have one or at least less different structures. Second, Company X needs to make agreements with their customers about when the products are delivered. As the customers decide when the products need to be processed it is possible that none of the suitable products are present or that most of them are present at once. By planning the deliveries of the customers, the throughput of the products is as stable as possible, which is beneficial for the cobot. Furthermore, I recommend Company X to standardise their racks and these racks should only be used by the cobot. As the hooks on one rack differ due to wrong usage, the human interaction should be kept to a minimum. Most important, I recommend Company X to use a cobot for a part of their portfolio. This cobot will be supplied by a supplier of Company X's choice by keeping my recommendations in mind. Last, Company X should make a choice in the way of using this cobot. They can be more cost-efficient by saving personnel costs or by increasing the capacity and the throughput. I recommend Company X to carry out these recommendations in the given order, to make sure the circumstances are adjusted to the needs of the cobot when the cobot is implemented.