SAVONIA

IMPROVING THE PERFORMANCE AND EFFICIENCY OF WRAP AROUND MACHINE

Case: Famifarm Oy, Joroinen Finland

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Bachelor' Thesis

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Accepted

SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS**
Abstract

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Abstract

Throughout Finland's independence, industrial production has been a vital generator of economic growth in the country hence the need to constantly improve Finnish industrial machines.

The objective of the study was to improve the performance and efficiency of Wrap Around Packaging Machine in Famifarm Oy, Finland. The study ascertained the current performance and efficiency of the machine and proposed strategic means of improving on its operation.

The research was carried out using qualitative research methodology. This included several research tools such as Active Participating and Observation Interviewing, Audios, Videos and Pictures, Emails, Primary and Secondary Data Collection, Review of Literature, Documents and Materials Analysis. Qualitative research was adopted to make the analysis of the study more feasible.

The study ascertained that some factors such as intermittent failure barcode reading, long packaging waiting time, and improper quality packaging cases were some of the problems that affected the performance and efficiency of the machine. The production output was also determined to have reduced to a larger amount.

Consequently the study seeks to provide stepwise recommendations to solve most of the problems affecting the efficiency and performance of the Wrap Around Packaging Machine. The study also recommended that the glue-drying waiting time should be decreased to help increase production speed. A model was also proposed to help conserve energy in Famifarm Oy. The third chapter of the study provides an exhaustive analysis of the main failures affecting the performance and efficiency of the Wrap Around Machine.

Keywords:
Wrap Around Machine, Packaging Machine, Automation, Machine Improvement, Efficiency

Public

Definition of Terms and Abbreviations

Automation

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. [1]

Efficiency

Efficiency in general describes the extent to which time or effort is well used for the intended task or purpose. [2]

Packaging

Packaging is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the process of design, evaluation, and production of packages. Packaging can be described as a coordinated system of preparing goods for transport, warehousing, logistics, sale, and end use. Packaging contains, protects, preserves, transports, informs, and sells. [3]

Productivity

Productivity is a measure of the efficiency of production. [4]

Pneumatics

Pneumatics is a branch of technology, which deals with the study and application of use of pressurized gas to effect mechanical motion. Pneumatic systems are extensively used in industry, where factories are commonly plumbed with compressed air or compressed inert gases. This is because a centrally located and electrically powered compressor that powers cylinders and other pneumatic devices through solenoid valves is often able to provide motive power in a cheaper, safer, more flexible, and more reliable way than a large number of electric motors and actuators. [5]

WAM- Wrap-Around-Machine

WAP- Wrap-Around-Packaging

RHS - Right Hand Side

LHS- Left Hand Side

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Dedication

The researcher wholly dedicates this piece of educational paper to Jesus Christ, the Son of the Living God who died on the cross to save mankind from our sins. The Holy Spirit, Who is the Researcher's Comforter, cannot be forgotten in this part of the Research work.

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APPENDICES

INTRODUCTION

1.1 Research Background

The concept of automation has affected the output of services and products in firms since the industrialisation era in most developing countries. This consequently has lead to developing new automated machines and several control systems to drive the industrialisation vision. With advancements in technology, engineers daily try to develop, improve and invent new automated machines to make work much easier and efficient.

Famifarm Oy is one of the fastest growing green house businesses in Joroinen, Finland. The company has a lot of automated systems and machines that they use to run the firm. As a company, the need to maintain quality services and products are of great interest to the company. One of the means to maintain this standard of quality services is maintaining a reliable balance between the quality of their automated machines and control systems on production output.

The final production line in Famifarm Oy is the packaging unit hence the need for a quality mode of packaging for the company's products. In recent periods, several sophisticated, reliable and convenient machines and systems have been developed for industrial packaging and wrapping. Wrap-Around-Machine (WAM) is one of the major automated packaging machines in Famifarm Oy. The Wrap-Around-Machine packages most of the company's products for final delivery to end users and the company's potential customers. The machine was acquired by the company to increase the productivity process of the company.

Throughout Finland's independence, industrial production has been a vital generator of economic growth in the country. Between 1925 and 2006, Finland's industrial output went up by an average of five per cent per year despite the fact that the period contained the Second World War and the two economic recessions. Up to the beginning of the 2000s the country's industrial output grew considerably faster than its total output. The growth of Finland's industrial output has clearly exceeded the average respective growth in the industrialised countries. [6]

This exponential growth in Finland's industrial production output should encourage the Finnish economy to persistently improve on their industrial machines and technologies. But on what accounts and measures are surrounding Finnish industrial companies to maintain such magnificent and significant industrial growth?

However, there arise intermittent problems which slow down the performance and efficiency of the Wrap-Around-Machine in Famifarm Oy Joroinen, Finland. Most of these problems have direct impact on the quality of services of the company, the performance and the efficiency of the machine and on industrial production. These notable industrial blunder, could consequently affect the company's industrial production output on a larger scale; if not permanently dealt with.

One's ability to react to the market is crucial in a competitive world, and it often depends on packaging process. Nowadays standard machines may rapidly be outdated. A good solution must be designed for the future, through dynamic design of flexible solutions, bearing in mind that products and packaging patterns may change at any time. When competition gets tougher, you have to keep your productivity at the top level. Automatic packaging and palletizing solutions can provide the best efficiency for the production, helping to reach the maximum capacity and still lower costs by saving on labour, packaging material, and shipping costs. [7]

To bridge the gap therefore with regards to reacting to the market in a competitive world, how is an industrial production company like Famifarm Oy improving on the performance and efficiency of their industrial packaging machines?

1.2 **Objectives of Research Study**

The study was initiated with the main aim of finding possible solutions to improve the performance and efficiency of a Wrap-Around-Machine in Famifarm Oy Joroinen, Finland. The research therefore ascertained the current performance and efficiency of the Wrap-Around-Machine (WAM) and suggested possible solutions to improving the packaging machine.

It is also anticipated that the study will propose models and automating theories for improving some of the industrial automation machines in Finland, with special emphasis on the Wrap-Around-Machine. It is in this frame that the study seeks to provide findings on the packaging machine, that will help improve some of the automation vision in the Finnish society and the other automation oriented nations.

The study was again initiated as a result of the researcher's interests towards automation initiatives and technologies. The researcher developed a strong interest in automation equipment as a result of studies done in 'Manufacturing Automation lessons' taught by Tero Jankko during the researcher's Bachelor of Engineering Degree Programme.

Consequently, the study also seeks to provide a transformable mode of maintenance for the Wrap-Around-Machine. The study therefore will seek to strengthen the network between Famifarm Oy and the manufacturers of the Wrap-Around-Machine, Jomet Oy on the basis of efficient maintenance for the WAM.

1.3 **Research Problem**

The efficiency improvement and performance of Wrap-Around-Machine was the main subject area of the thesis. The objective of the paper was to study the performance of the WAM and its efficiency as it seeks to increase productivity in Famifarm Oy. Possible setbacks and inefficiencies arising from the operation of the packaging machine were identified and used as research work. The WAM has a greater effect on the production sector of Famifarm Oy hence the need to access its performance and efficiency to help boost the direct strong correlation between the WAM and the production outputs of the company.

The author’s interview with the manufacturers of WAM explored some dimensions of the research problem:

1. The packaging machine is originally designed for capacity of 14 cases/min. Nowadays it's running about 11-13 cases/min

2. Basic performance factors are the mechanical solutions that are used in the machine. Those are chosen to meet the demands of product, case type and capacity. Normally the simplest solutions are used to get the best possible performance and durability.

After the mechanical solutions are chosen, the mechanics needs to be controlled. Controls can be chosen from linear motors to air cylinders and there is major effect on performance and also on the price. When you are looking at the machine in Famifarm, those solution choices were done when the machine was built in 2004. Nowadays, when the specifications are clearer and there is less case sizes than in 2004, I think and I hope that some new mechanical and also controlling solutions will be found that can be updated to the machine. Without new updates to the machine, the efficiency improvements need to be found by increasing speed of existing equipment and minimizing the delays.

The researcher’s interview with the manufacturers of the packaging machine showed that, the actual efficiency (number of cases per minute) the WAM produces has decreased. The author’s research flair surrounding the need to identify a phase of the research problem, revealed that, the mechanical solutions and control performance of the WAM needed to be updated to help bridge the gap in this 21st century, concerning industrial automation setups.

The packaging machine, WAM intermittently produces some errors that affect the performance of the machine: inconsistent barcode reading, improper quality packaging, too much glue-drying waiting time at the packaging station and finally, the WAM's recipient conveyor which keeps on running when no products are heading towards the machine for final packaging. Consequently, products at times get stuck in the machine that leads to a manual stoppage of the inflow of products to the WAM. This manual stoppage eventually stops some of the other conveyors leading to separate packaging lines. Eventually, the study seeks to answer the research question: "What is the impact of the Wrap-Around-Machine on production with regards to its operation?"

It is in view of this that the study was scheduled to propose stepwise recommendations to improve the efficiency and performance of the WAM in Famifarm Oy.

1.4 Significance of the Study

There are various reasons why the impact of R&D merits discussion. Firstly, industrial Research and Development activity is linked to innovation and economic growth (observed at the national, regional and firm levels). However, over time these links have become more complex and difficult to elucidate as they have grown more competition-driven, market-oriented and globally dispersed. [8]

Secondly, industrial R&D generates new and improved products, processes and services, and develops firms' strategic capabilities. And thirdly, industrial R&D helps improve the well being of society, by offering solutions to social and environmental problems, and supporting the transition towards a knowledge-based society. [8]

The study is geared towards improving the efficiency and performance of a Wrap-Around-Machine in Famifarm Oy Joroinen, Finland. Wrap-Around-Machine (WAM) is one of the major automated packaging machines in Famifarm Oy. It is anticipated that the study will ascertain the current performance and efficiency of the machine which will help improve its operation.

The research paper also seeks to come out with findings that will contribute to the automation vision in this industrialization age. In the attempt to propose strategic recommendations to improve the efficiency and performance of the packaging machine, the thesis seeks to build a strong chain of partnership between the engineers of Famifarm Oy and Jomet Oy engineers. The study would also serve as a perspective for further research works that will enable researchers to build on existing knowledge, leading to diverse innovations and discoveries.

1.5 Methodology and Research Tools

Research Methodology refers to theories of how research proceeds, and includes, for instance, consideration of methods, of participants, but also what role the research has, ethics and so forth [9]. One of the major reasons for engaging in qualitative research is to more deeply understand a given phenomenon [10]. To provide a better understanding of the study, qualitative research method was used in conducting the research. Several research tools were administered during the research which included: active participating and observation, interviewing, audios, videos and pictures, emails, primary and secondary data collection, review of literature, documents and materials analysis.

Intermittent emails were used between the researcher and some respondents (Company supervisor and Jomet Oy) as part of the research data collection. The researcher also had the privilege to interview some respondents who happened to be workers of Famifarm Oy, to collect important information that aided the study.

A higher percentage of the study was carried out through active participation and observations. This aided the need to use audios, picture captions as well as videos to make understanding and accurate data more feasible. An example of a qualitative research cycle is shown below. (see Figure 1)

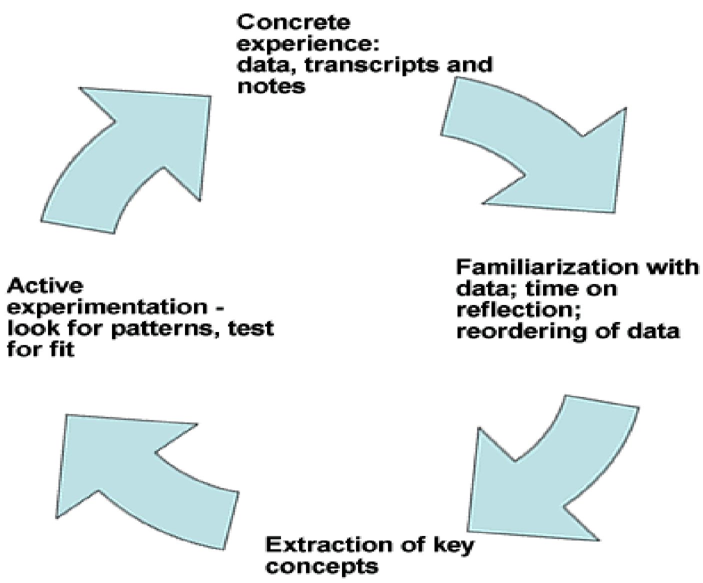

Figure 1 Qualitative Research [11]

The table below shows the researcher's input on the methodology adopted during the research process. (see Table 1). The researcher assigned specific number points for his input on the methodology.

Table 1 Chart Showing Researcher's Input on Methodology & Tools used.

Research Methodology & Tools	Marks (%)
Active Participating and Observation	40
Interviewing	10
Audios, Videos and Pictures	10
Emails	5
Primary and Secondary Data Collection	15
Review of Literature	10
Documents and Materials Analysis	10

Through some staff members of Famifarm Oy and student colleagues, the company was identified to begin the study. A scheduled meeting between the researchers' client (Researcher's Campus Supervisor Tero Jankko, Savonia University of Applied Sciences, Varkaus Finland) and Famifarm Oy immediately followed to hasten the research commencement (see Figure 2). A chain of collaboration among the researcher, Famifarm Oy and Jomet Oy made the salient information accessible.

Figure 2 Researcher's campus and Company's Supervisors at Famifarm Oy (Photo, Aduadjei 2011).

Consequently, since literature review helps understand your findings and also helps you to relate research to previous research (Leedy and Ormrod, 2001) [12], vital literatures were reviewed. The author's interview with the manufacturers of WAM explored some dimensions of the research problem. Critical analyses of all the interviews were also done.

1.6 Thesis Limitations

The study was subjected to certain factors which might significantly affect the research data precision. The researcher's irregularities in the data collection as a result of time constraints might affect the accuracy of the study results. The author had to attend to certain duties at the workplace which consequently might reduce the consistency of the research findings. Nonetheless, the results obtained depicted an undisputable strong level of correlation with regards to the research question.

Also, the study is limited to another sensitive factor like the research study time since the research was not conducted for all the various working shifts of Famifarm Oy. The research was conducted from six in the morning to half past one in the afternoon. The other production time of the days were neglected to the study. Time constraints limited the researcher's initiative in drawing a strategic maintenance programme for the WAM. Nonetheless the study has strengthened the relationship between Famifarm Oy and Jomet Oy because of data collection and clarification of other important questions.

Despite the limitations of the study, the findings obtained provided vital recommendations that could be used to improve the performance and efficiency of the Wrap-Around-Machine. The research did not only provide a stepwise deductions to improve the automation sect in Famifarm Oy but it also had a great impact on the researcher's own future prospects.

Consequently, regardless of the research limitations, the study will also serve as a perspective for further research works that will enable researchers to build on existing knowledge; leading to diverse innovations and improvement in Famifarm Oy, Finnish Industrial Companies and in this industrialization era.

1 OPERATION OF WAM IN FAMIFARM OY

1.1 Famifarm Oy

Famifarm is the market leader in salads grown in green houses in Finland. It has two green houses located in Joroinen, Juva and a contract grower Turakkala Oy located in Juva. The greenhouse located in Joroinen is the biggest (main) planting and production set up of the company. Famifarm Oy produces vegetables and herbs in the greenhouses and makes cut and boxed products. Products are sold under the Järvikylä brand, which is known as the market leader in the greenhouse farming in Finland. Customers of Järvikylä include household consumers, retail sector, HoReCa sector (Hotels, Restaurants and Catering) and industry. Most of the company products are sold in the domestic market and a small portion is exported to Estonia. [9]

There are about 100 (Production 84, Services 06, Management 10) people working in Joroinen (Järvikylä) green house. For the green house in Juva, there are staffs of 10 people both for production and services. Furthermore, the Marketing Division is located in Helsinki. The production capacity of the greenhouse in Joroinen is summarized in Table 2

Table 2 Summary of the production capacity in Joroinen.

Total Area of Greenhouse	4.9 hectors
Number of Production Houses	9
Number of Production Lines	20
Number of Gutters (Kourut)	15 516
Plants	1 250 290

The products produced at Turakkala Oy greenhouses on a subcontract basis include a variety of Herbs as Basilika, Sitruunabasilika, Thai-Basilika, Kanelibasilika, Punainen Basilika, Herneenverso, Auringonkukanverso, Korianteri, Kynteli, Kirveli, Rosmariini, Rakuuna, Minttu, Vesikrassi, Salvia, Timjami, Meirami, Oregano, Sitruunamelissa, Lipstikka, Perilla, Vehnänoras, Mizuna Salaatti, Viinisuolaheinä, Lehtipersilja, Basilika Iso, Timjami Iso, Rosmariini Iso, Laventeli Iso, Viinisuolaheinä Iso, Sinappi and Lehtisinappi [9]. Some of the Järvikylä brand products are shown in Figure 3.

Salads

   

Jääsalaatti | Romaine | Lollo Rosso | Sinappi

   

Rucola | Tammenlehti | Frisee | Punainen Salanova

Herbs

   

Tilli | Basilika | Persilja | Timjami

   

Korianteri | Ruohosipuli | Kirveli | Kynteli

Figure 3 Järvikylä brand Products [9].

Figure 4 Famifarm Oy Salad, Viinisuolaheinä (Photo, Aduadjei 2011)

2.2 Jomet Oy

Jomet Oy is the manufacturer of the Wrap-Around-Machine. The company has established a long lasting relationship with their client Famifarm Oy. The network established since the purchasing of the packaging machine has brought a level of commitment between the manufacturer's of the packaging machine WAM and their buyers Famifarm Oy. Partnership, innovativeness, productivity and flexibility are some of the vital ingredients that identify the company. Jomet Oy improves its customer's competitiveness with innovativeness, cost efficient and flexible automatic packing and palletizing systems. [7]

Jomet Oy provides new automatic packing solutions for the client's products and innovative solutions for the client's existing products. New packaging materials, new packaging process and new packing configurations can help the client make a difference on the market. Jomet Oy is used to designing confidential packaging development projects for their customers to help them innovate. [7]

Jomet Oy stands to prove that, when competition gets tougher, productivity should be kept at the top level. The company's packaging and palletizing solutions provide the best efficiency for production that helps to reach the maximum capacity and still lower costs by saving on labor, packaging material and shipping costs. The company improves productivity together with their customers. [7]

A company's ability to react to the market is crucial in a competitive world, and it often depends on the packaging process. Nowadays, standard machines may rapidly be outdated. Jomet Oy believes that, a good solution must be designed for the future. This is why the company seeks to design flexible solutions, bearing in mind that products and packaging patterns may change at any time. [7] A relationship chart among the researcher, Jomet Oy and Famifarm Oy was drawn to show the manner in which the researcher worked along with these partners (see Figure 5).

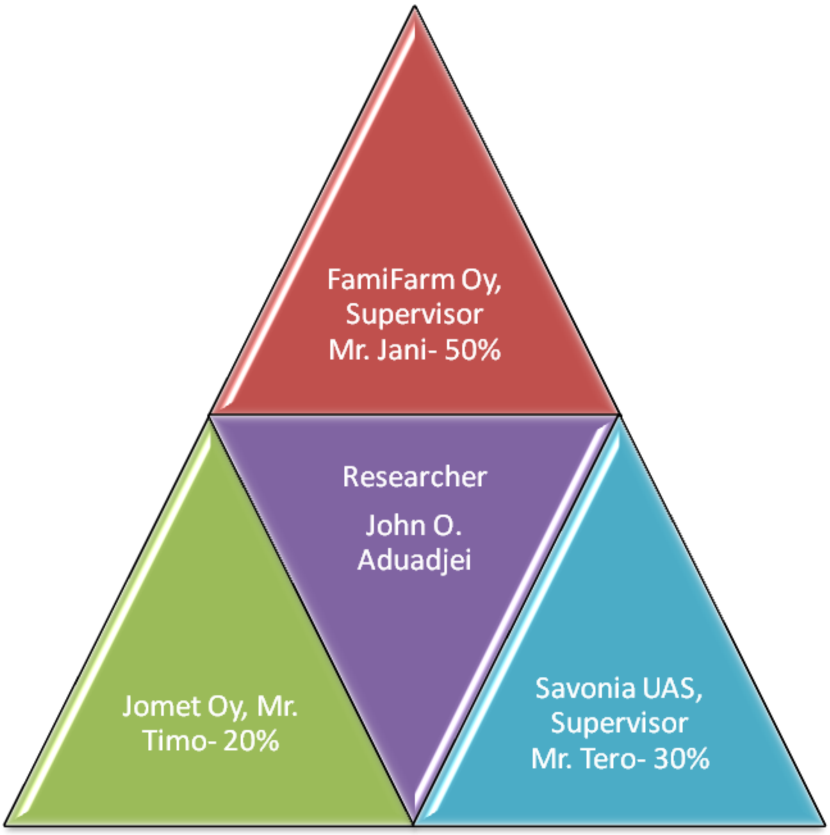

Figure 5 Researchers Thesis Relationship Chart.

2.3 Operation of Wrap-Around-Machine (Packaging Machine)

By Observation

The Wrap-Around-Machine (WAM) is one of the major packaging machines used in Famifarm Oy Joroinen, Finland. This section of the thesis provides a stepwise documentation of the operation of the Wrap-Around-Machine (WAM) by the researcher. The operation of the machine is documented as follows:

Recipient Conveyor

Products coming to the Wrap-Around-Machine are first received by the WAM's conveyor. This conveyor is what the researcher calls recipient conveyor. The production site conveyor transports the products to the WAM's conveyor (see Figure 6).

The recipient conveyor is the main conveyor that transports the various incoming products to the packaging machine (see Figure 7 and appendix 1).

Figure 6 Production Conveyor transporting packed product group to the Recipient Conveyor (Photo, Aduadjei 2011)

Figure 7 The recipient conveyor transporting a product group to the WAM (Photo, Aduadjei 2011)

Usually, the following distance between products on the conveyors depends on:

- The production speed
- The number of people in the production line
- Speed of the conveyor belts
- Avoidance of product stuck on the conveyors

The production conveyor plays a major role of efficiency in transporting the products to the recipient conveyor. Products that get stuck on the production conveyor delay the time it takes for the recipient conveyor to receive the products so as to transport them to the WAM. This problem also affects the following distances between products.

Barcode Reading

The recipient conveyor eventually transports the products to the entrance of the WAM. The barcode printed on each product package are read by a barcode reader as the packed products enter the packaging machine. Subsequent products are stopped by two pistons at the entrance of the WAM if:

- Products are too close to each other
- Distance between packaging product (product undergoing packaging) and the subsequent products are too close

An observer can easily see a red beam of light that shows within a second as the barcode reader reads the barcode on the various packed products entering the packaging machine. The Wrap-Around-Machine can package six (6) different kinds of product groups at the time the research work was conducted. Basilika, Korianteri, Timjami, Tilli, Persilja and Ruohosipuli are the various product groups that the WAM can package. Each of these different kinds of products has different barcode calibrations that the barcode reader reads, as the products enter the packaging machine (see Figure 8).

Figure 8 Barcode Calibrations on products rubber cases (Photo, Aduadjei 2011).

U-Shaped Versus Packed Products

Skeletal box papers loaded at the back of the WAM (see appendix 2) are pulled off in succession by the WAM's gripper and the skeletal paper opens into a U-shape. The skeletal U-shaped box paper is been held on the flight chains opposed by four green pillars holding the base of the U-shaped skeletal box in position (see Figure 9). The erected U-shaped skeletal box is now passed on to a phase where it awaits for a group of incoming packed products (see appendix 3). The skeletal box by this phase of the packaging process is now folded in a way reader to receive the incoming packed products. Consequently the product group that has been read by the barcode is received by the skeletal box closed at four (4) ends of the box.

Figure 9 Skeletal Paper carton pulled onto the flight chains by the gripper (LHS photo) (Photo, Aduadjei 2011).

Packaging Station

The product group received into the four-closed erected skeletal paper box is then forwarded to the final packaging station (see Figure 10). The housed products get to the final packaging station with five (5) ends of the packaging case closed. Final glueing and packaging of the product is done. The glue, used to seal the ends of the packaging case is called technomelt glue. The drying time for the glue is at most five (5) seconds. The finished packaged product is then forwarded to the barcode printer where the printer head prints the name of the product group on the packaging case (see Appendix 4).

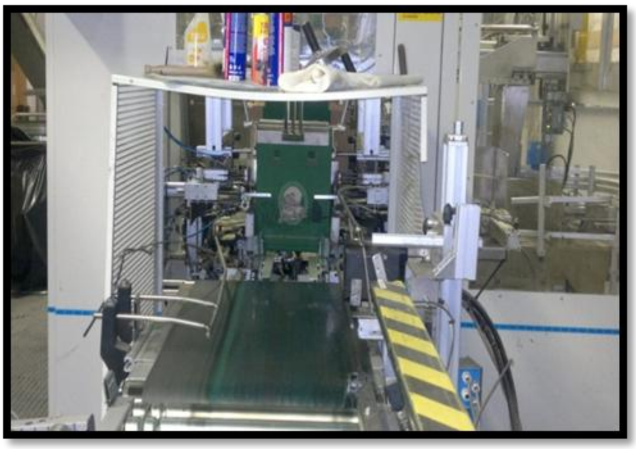

Figure 10 Packaged product at the Packaging Station waiting to be received by the Primary Delivery Conveyor (Photo, Aduadjei 2011)

Delivery Conveyor

The delivery conveyor is the conveyor that receives the final packaged products. The delivery conveyor is in two folds: the primary delivery conveyor and the secondary delivery roller-conveyor. The primary delivery conveyor is the immediate green conveyor that receives the final packaged products. The primary delivery conveyor transports the finished packaged products to the secondary delivery roller-conveyor. The secondary delivery-roller conveyor receives the final packaged products. Both the recipient conveyor and the secondary delivery roller-conveyor are positioned at the same sides of the WAM (see Figure 11).

Figure 11 Secondary Delivery Roller-Conveyor (L.H.S) and the Recipient Conveyor (R.H.S) (Photo, Aduadjei 2011).

2.4 Performance and Efficiency of WAM

The packaging machine was originally manufactured to package 14 cases per minute since the manufacturing year 2004. The machine usually operates during all the working days of Famifarm Oy. The operation period for the morning shift starts by 10:30 in the morning until half past one in the afternoon. The afternoon shift also starts from 30 minutes past ten in the morning until six in the evening. The packaging machine usually operates during all these working times in Famifarm Oy. The amount of products the packaging machine packages per day varies with respect to the amount of order the company receives. The WAM packages 20 000 products and 15 000 products cases weekly, during summer and winter respectively. These orders are interrupted daily because of some sensitive problems affecting the performance of the packaging machine. The production output of 14 cases per minute the WAM packages have reduced significantly. This will be analyzed further in the thesis. Some errors the machine produces during packaging processes might not affect the efficiency but rather affect the performance of the machine which also affects the company’s production rate. The efficiency and performance analysis of the Wrap-Around-Machine will be analyzed further in the next chapter.

2.5 Brief Comparison of Principles and Theory of Automation with the Operation of WAM

The early developments and modern developments of automation have provided the three basic building blocks of automation:

- A source of power to perform some action
- Feedback controls and
- Machine programming.

Almost without exception, an automated system will exhibit all these elements [13].

The actions and processes carried out by the Wrap-Around Packaging machine are driven by an electrical source of power. Famifarm Oy uses electric source of power which is consequently converted to pneumatic power used in driving the operation of the Wrap-Around-Machine.

The six main products (Basilika, Korianteri, Timjami, Tilli, Persilja and Ruohosipuli) that the Wrap-Around-Machine packages are the basic inputs to the machine. These product inputs are put into rubber cases with each marked with barcode calibrations. The packed product in the calibrated rubber cases are then put on rectangular plastic kernels having round holes created in them. These holes hold the packed products on the rectangular plastic kernels so the products can be transported ‘safely’ from the production site to the recipient conveyor. The arrow in the picture below shows the rectangular plastic kernel.

Figure 12 Yellow-arrow pointing to the plastic kernel (Photo, Aduadjei 2011).

The input products packed are transported to the recipient conveyor and consequently come out of the packaging machine as the final packaged products (see Figure 13)

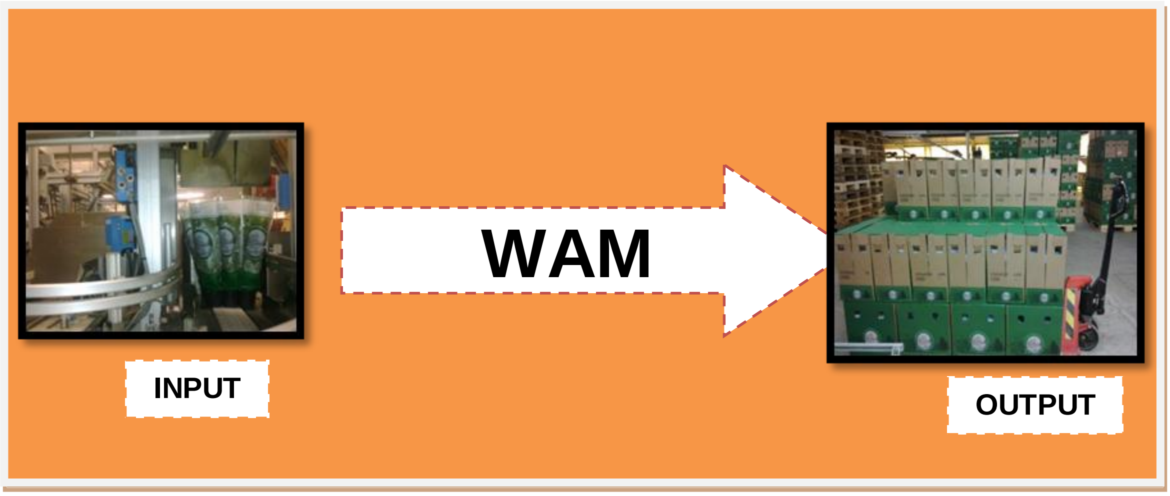

Figure 13: The final output of products that are input to the WAM.

The basic performance factors for the Wrap-Around-Packaging machine are the mechanical solutions that are used in the machine. Those are chosen to meet the demands of product, case type and capacity. Normally the simplest solutions are used to get the best possible performance and durability. By the 'Principles and Theory of Automation Principle', the controller and the actuator of the system are the mechanisms by which changes in the process are accomplished to influence the output variable. These mechanisms are usually designed specifically for the system and consist of devices such as motors, valves, solenoid, switches, piston cylinders, gears, power screws, pulley systems, chain drives, and other mechanical and electrical components. [13] The pistons that do the final closure of the packaging cases intermittently fail to make quality final closure. This result in deformation of the final packaging cases and opens the final packaging cases (see appendix 5).

After the mechanical solutions are chosen, the mechanics needs to be controlled. Controls can be chosen from linear motors to air cylinders and there is major affect to performance and also to the price. The Wrap-Around-Machine is also controlled by Programmable Logic Controller (PLC) - Omron CJ1M-series PLC (see Appendix 6) [14]. The WAM as well as new machines manufactured by Jomet Oy use PLC systems. With systems that need higher capacities Jomet Oy is using PLC with motion control unit. That means networked servo controllers communicating with PLC. With this integration all needed efficiency is achieved what comes to controlling the system. The rest is mechanics, which need to be light enough to be controlled with servo systems which can be adjusted in micro seconds. Mechanics is also facing the limits of the products which can be very sensitive for mechanical forces as in Famifarm Oy.

This principle and theory of automation is very significant to the operation and performance of the packaging machine. Some errors like inconsistent barcode reading and printing are detected by the Wrap-Around-Machine. Nonetheless these malfunctions are corrected manually. These errors can be programmed so that after the error detections, the WAM can correct these malfunctions nevertheless since automation costs, manual corrections are usually used to solve these problems. Products that also get stuck inside the WAM are signaled by the WAM's alarm which eventually also calls for human corrections.

3 Performance and Efficiency Analysis

It is essential to understand that the measurements to be used depend on the scope of interest when choosing from the wide range of available productivity measures. To understand changes in the efficiency of manufacturing establishments several factors must be included in the analysis. Total factor measures of productivity typically include human labour, energy, material, and capital. In many industries, standardisation of inputs and outputs are necessary because of the complex relationships between factor prices and consumer demand in a competitive economy [15].

This section of the study provides a systematic analysis of the performance and efficiency of the packaging machine. The researcher identifies some of the problems that occurred intermittently during the packaging processes by observation. The concept of efficiency and performance used in this study provides an analysis of how best the machine runs during packaging process.

Productive efficiency is defined as the least-cost combination for a given output. Efficiency measurement of companies and industries can address either cost efficiency (that is, minimizing inputs for a given output) or value efficiency (that is to maximize the value on the market with given inputs) [15].

The measurement variables used in analyzing the performance and efficiency of the Wrap-Around-Machine (WAM) were Machine, Energy, Quality and Staff Know-how. These variables correlate to Hages total factor measures of productivity as described above. A greater part of the analysis was made with regards to the machine- WAM. The Figure 14 shows the performance and efficiency diagram for the analysis.

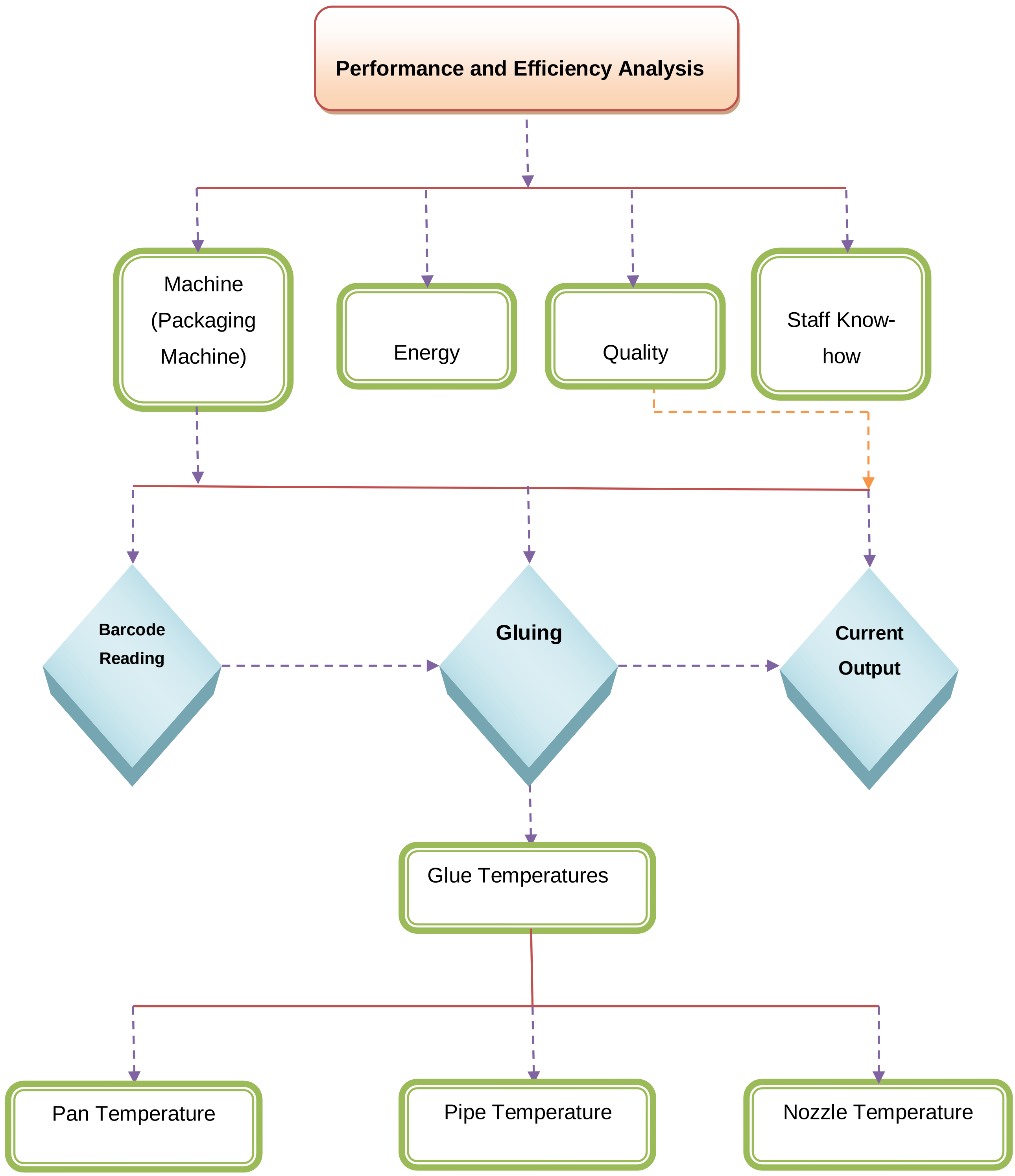

Figure 14: Analysis Chart for WAM

3.1 SWOT Analysis of Manufacturing Engineering in Finland

The study also provided the SWOT analysis of the manufacturing engineering in Finland (see Tables 3 and 4). The analysis clearly reveals the areas that needed to be improved and strengthened in the Finnish economy. The engineers in the Finnish community should work earnestly to improve on the efficiencies and performances of their manufacturing machinery since industrial growth is one of the main factors to their economic upswings.

Table 3. Analysis of Manufacturing Engineering in Finland [16].

Strengths	Weaknesses
• Good infrastructure • Good public administration • Stable environment/society • Good education system • High level of education • Competent labor force • Strong emphasis on basic skills before Specialization in engineering studies • Strong engineering culture • Strong world leading companies • Strong clusters • Strong cooperation between industry and education and research organizations • Good productivity • Strong projecting companies in Finland; they need manufacturing also in Finland.	• High labor costs • Small home markets • The situation (far from the growing markets) • Mathematics, physics and chemistry are not popular among high school students → not enough students to recruit for higher technical studies • Not enough technical workers in some areas • Energy intensiveness of manufacturing

Table 4. Analysis of Manufacturing Engineering in Finland [16].

Opportunities	Threats

• Productivity improvement
• Usage of ICT in process performance improvement
• Combination of different technologies→ New concepts and products
• Transfer from product orientation to market orientation
• Design
• Competing in global markets possible via developing manufacturing process
• Developing environmental-friendly technologies and products
• The opportunity of environmental technology for growth and specialization
• Globalization, maintaining technology
	• Too high costs of :
	  ○ labor
	  ○ services
	  ○ materials and energy
	• Energy efficiency requirements
	• Global economics slow-down
	• Wrong selection or definition of products
	• Neglecting the decreasing sectors that could be profitable in the long run
	• Globalization, especially technological advancements in developing countries
	• Labor shortage in some areas

3.2 **Barcode Reading Analysis**

The Wrap-Around-Machine packages six (6) different kinds of product groups at the time the research work was conducted. Basilika, Korianteri, Timjami, Tilli, Persilja and Ruohosipuli are the various product groups that the WAM packages.

The barcode reader (blue in color; Figure 15) is positioned at an angle of about 45^o close to the entrance of the Wrap Around packaging machine. This current angle makes the barcode occasionally unable to read the barcode calibrations on the product package.

Figure 15 Barcode at Entrance of WAM (LHS) & Side View of Barcode Reader (RHS) (Photo, Aduadjei 2011).

The researcher's careful observations deduced that the current barcode angle could be changed to 90^o. This can make the barcode more accessible to read the various calibrations on the different kinds of product group. The researcher's alternative solution to the problem of the barcode, unable to read the barcode calibrations on the product packed case, was to get two barcodes at the entrance of the WAM (LHS & RHS in opposite direction).

Packaged products that are unable to be read by the barcode reader eventually result in the product name not to be printed on the packaging cases. This results in failure in the output terminal- WAM's printer (see Appendix 7) failing to print the names of the product on the packaging cases. This consequently results in a manual fixing of the product category name on the packaged cases (see Appendix 8). Figure 16 shows an example of the barcode reader, reading a specific product group as it enters the WAP machine. Table 5 also provides a summary of the analysis of the barcode reader.

Figure 16. Barcode reader, reading a product group (Tilli) (Photo, Aduadjei 2011).

Table 5. Summary of the barcode reader analysis

Problem	Proposed Solution
Intermittent barcode reader failures	• Change current barcode angle to 90^o • Get two barcode readers at the entrance of the WAM

3.3 **Gluing Analysis**

The gluing phase of the packaging process helps to improve the quality of the final packaging. Technomelt glue is the main glue used for the packaging cases. The manufacturer of the Wrap-Around-Packaging machine Jomet Oy provided a data sheet for the technomelt glue analysis. A picture showing the granules of the technomelt glue is shown below (see Figure 17).

Figure 17. Granules of the Technomelt glue [17]

The name of the glue is Technomelt Supra 100. Technomelt Supra is a versatile product for gluing of wrap-around cases. The recommended working temperature ranges from 160 - 190 °C. Due to the variety of substrates available, gluability of materials can be very different therefore the need for pre-tests to be carried out. The innovative adhesive is more efficient than conventional hotmelts; it also increases productivity through better machinability. Technomelt Supra provides excellent compatibility for a variety of applications in the food industry. [18]

Detailed tables are provided for thorough properties and special features of the technomelt glue used in the packaging machine in see Appendixes 9 and 10 [18].

3.3.1 Glue Temperature

The temperature of the Technomelt Supra 100 glue was determined from three different material sources. The study provides the various different sources of temperature measurement for the glue. The glue is heated between a temperature range of about 150 ^{o}C to 160 ^{o}C by the glue heater (see Figure 18). The glue temperature in the technomelt can was determined to be 137 ^{0}C, that of the glue pipes measured 155 ^{o}C and the glue in the glue nozzle also recorded a temperature reading of 160 ^{o}C.

The nozzle glue temperature that is eventually used for the final closure of the sides of the packaging boxes correlates with the recommended working temperature of about 160 - 190 °C. This stands to reason that the nozzle temperature for the glue is good for the packaging processes. Nonetheless, there arises intermittent poor packaging during the final closure of the packaging cases.

Figure 18 Views of the Glue heater situated in the WAM (Photo, Aduadjei 2011).

The researcher had to find out why the temperature range was good but the final packaging yielded some poor packaging cases. The paper provided answers to this problem in the process of the research findings. The figures below show the three different sources of the glue temperature measurements (see Figures 19, 20 and 21).

Figure 19. Glue (granules) in the can (Photo, Aduadjei 2011)

Figure 20 Glue pipe (black) running from the glue heater to the glue nozzle (Photo, Aduadjei 2011)

Figure 21. Glue nozzle that sprays the glue (Photo, Aduadjei 2011)

3.4 Quality and Output Analysis

The packaging machine was originally manufactured to package 14 cases per minute since the manufacturing year in 2004. The amount of products the packaging machine packages per day varies with respect to the amount of order the company receives. The WAM packages 20 000 products and 15 000 product cases weekly, during summer and winter respectively. These production figures reflect the demand on the company's target markets. The original and current production output of the packaging machine, has been analyzed in the table below (see Table 6).

Table 6. Analysis of Current Production Output of WAM

	Cases Per Minute	Efficiency	Summer Production per Week	Winter Production per Week
Original	14	99.90 %	20 000	15 000
Current	9	60.65 %	12 130	9 098

The original packaging cases the packaging machine could package under a minute were 14 cases. Currently the machine packages 8 to 9 cases per minute which could be attributed to a lot of factors. The average of the current cases gives approximately 9 cases per minute.

Assumed original Efficiency of WAM from the table was taken to be 99.90 % which was calculated as 14/14 * 99.90 % = 99.90 %. The current efficiency of the WAM also gave a value of about 66.70 % which was also calculated as: Current Efficiency = (8.50/14) * 99.90 % = 60.65 %. Clearly there appeared to be a great loss of about 39.30 % and that was also derived as: amount of Lost Efficiency = 99.90 % - 60.65 % = 39.25 %. Hence knowing the amount of summer and winter weekly production, the amount of production losses were also calculated as: Original automated summer Production per week = 20 000 will be reduced to 20 000 * 60.65 % = 12 130 per week and the Original winter automated production per week = 15 000 will also be reduced to 15 000 * 60.65 % = 9 098 per week.

Hence Summer Production Loss (by WAM) = 20 000 * 39.25 % = 9 098

And Winter Production Loss (by WAM) = 15 000 * 39.25 % = 5 888

Productivity is a measure of the efficiency of production. Productivity growth is important to a firm because it shows that the firm can meet its (perhaps growing) obligations to customers, suppliers, workers, shareholders, governments (taxes and regulation), and still remain competitive or even improve its competitiveness in the market place. [4]

The large decrease in productivity will affect Famifarm Oy meeting its customers' demands if the company is to rely on the WAM solely. This will result in customer dissatisfaction which can eventually decrease their customers' loyalty to the company. The company might not be able to stand out when competition gets tougher with low productivity efficiency. To meet demands and orders, using the WAM might require extra manual work, manual packaging.

The next issue of great concern also had to do with the final gluing process. As mentioned earlier on, the study found out that the gluing temperature fell within the recommended gluing temperature range. Nonetheless, there arises intermittent poor packaging during the final closure of the packaging cases (see Figure 22).

Figure 22. Glue failure after final packaging by WAM (Photo, Aduadjei 2011)

The kind of salads packaged by the WAM was a minor factor that affected the final closure of the packaging cases. Originally, the Wrap-Around-Machine was mainly used to package a particular kind of Famifarm Oy product called Basilika. The other products the machine packages currently have different features from Basilika. This makes it at times difficult for the pistons to do quality box closure.

Famifarm Oy uses two different kinds of skeletal box papers for the WAM during packaging process. These two main paper cartons are purchased from Finland, Estonia and Russia. The Finnish cartons are marked with white strips whilst the Estonian and Russian paper cartons are marked with red strips (see Figure 23). Careful study revealed that the major factor that yielded intermittent poor final packaging closure had to do with the pistons that did the final closure.

The Finnish paper cartons are thicker than the Estonian and Russian cartons. These two different types of skeletal cases use the same gluing temperature (160 ^{o}C) for sealing the packaging cases. The two different skeletal paper cartons are loaded manually at the back of the Wrap-Around-Machine; the machine signals (alarm alerted) that the cartons are about to finish.

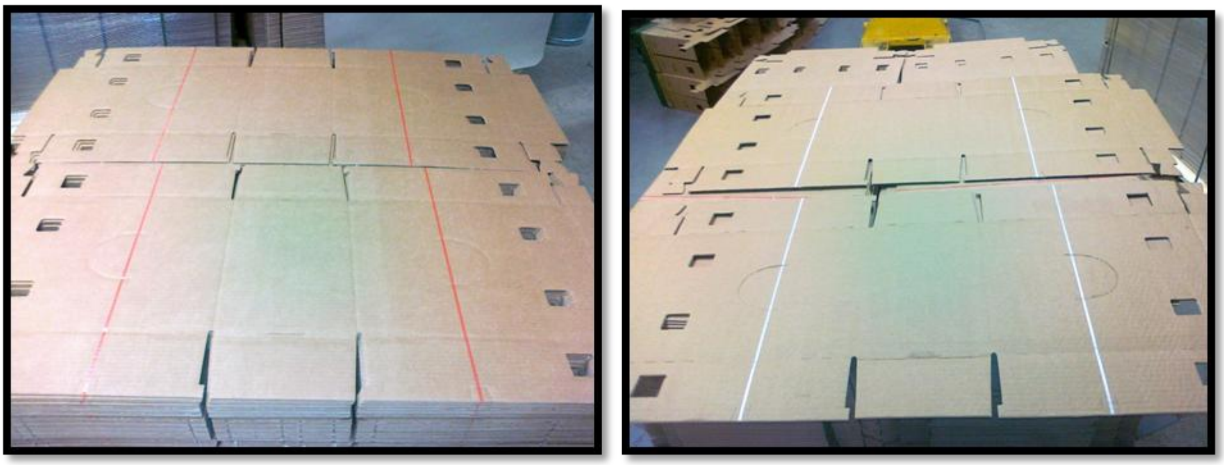

Figure. 23 Finnish skeletal paper cartons (RHS) and Russian and Estonian Cartons (LHS) (Photo, Aduadjei 2011)

The current pistons (A) carrying out the final process of closing the packaging case, work better with the Estonian and Russian paper cartons than the Finnish cartons. This problem resulted in poor final packaging with the Finnish cartons. The researcher observations and reports to the researcher's company supervisor made the company change the existing pistons to a new type of pistons (B). The arrow in the picture below shows the former pistons (A) used in the machine (see Figure 24).

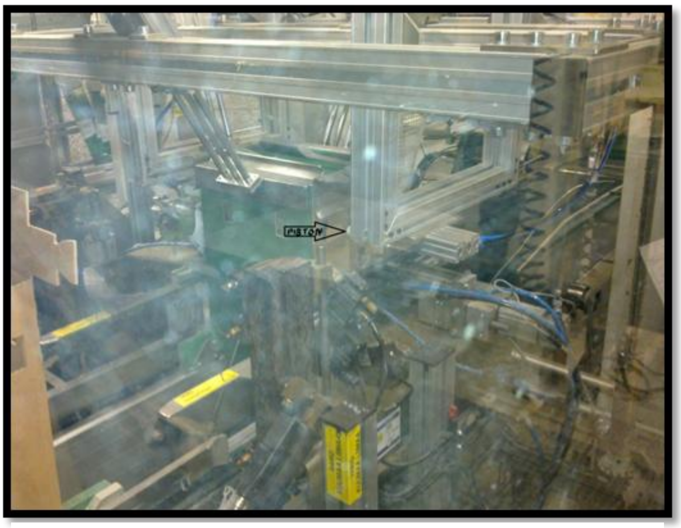

Figure 24. Piston A (Photo, Aduadjei 2011)

The researcher's findings contributed to the company's decision for getting new pistons (B). These pistons (B) produce better packaging cases for both the Finnish paper cartons and the Estonian and Russian paper cartons hence making quality final packaging cases. The study did not provide the different company names where pistons A and B were purchased. This was done in order not to put the company's image into disrepute.

3.5 Energy Overview

An automated system is designed to accomplish some useful action, and that action requires power. [13] The actions and processes carried out by the Wrap-Around Packaging machine are driven by an electrical source of power. Famifarm Oy uses electric source of power which is consequently converted to pneumatic power used in driving the operation of the Wrap-Around-Machine.

The study reveals that, the recipient conveyor of the Wrap-Around-Packaging (WAP) machine keeps on running when no product groups are been conveyed to the machine. Stopping the conveyor line leading to the WAM, meant stopping the other production lines leading to separate packaging places. This meant that anytime the WAM is stopped, the other packaging lines are affected. The researcher therefore proposed a model (see Figure 25) for automating the process of stopping the recipient conveyor and the WAM whenever no production process is going on within a time frame (say 15 minutes) and also running processes again when production resumes.

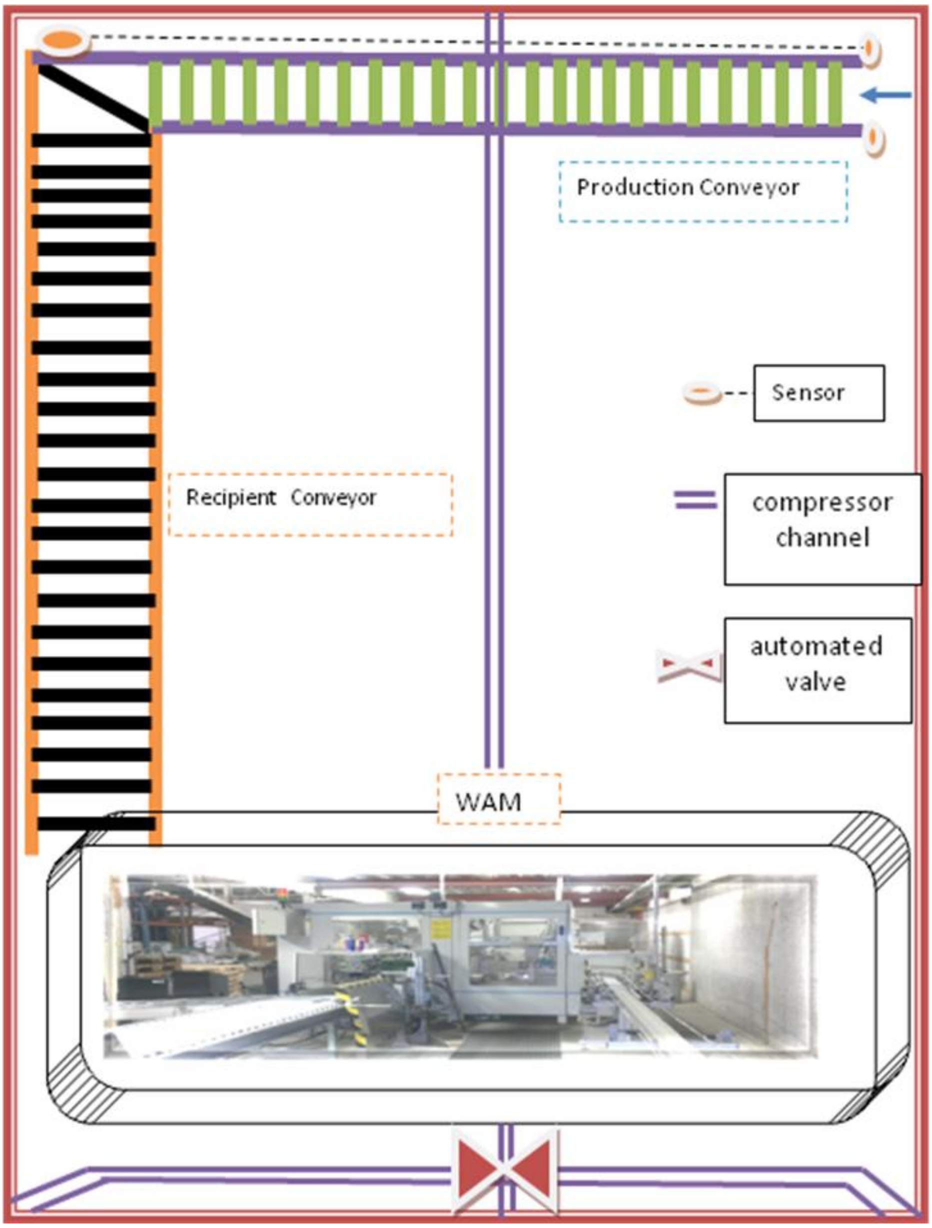

Figure 25. Automation Model for Saving Energy.

The layout is automated to detect incoming products. Products are detected by sensors on reaching the production conveyor. This automatically signals the recipient conveyor to start running. The recipient conveyor then receives the products from the production conveyor and then transports them to the WAM. The layout automatically stops to save energy (money) whenever there are no incoming products.

Another factor to consider in order to save energy was the compressor that pumps air to operate the conveyor lines. The study again proposed that the airflow from the compressor should be automatically stopped to reduce the compressed air consumption. This mechanism is initiated when no production process is going on within a time frame. The model will only be applicable to the operation of the WAM whilst the other conveyor lines will still continue to work. The technical idea was proposed by using an automated control valve that will stop the airflow from the compressor automatically when no production is taking place in the WAM. This model is connected to the layout in Appendix 11.

3.6 Efficiency Increase in the WAM

In computer science, program optimization or software optimization is the process of modifying a software system to make some aspect of it work more efficiently or use fewer resources. In general, a computer program may be optimized so that it executes more rapidly, or is capable of operating with less memory storage or other resources, or draw less power. [20]

A careful study of the packaging processes in the Wrap-Around-Packaging machine shows that the packaging station takes a longer time. The housed products get to the final packaging station with five (5) ends of the packaging case closed. Final gluing and packaging of the product is done here at the packaging station. Technomelt glue sprayed from the glue nozzle is used to seal the ends of the packaging case. The drying time for the glue is five (5) seconds at most. The picture below shows the final packaging process at the packaging station (see Figure 26).

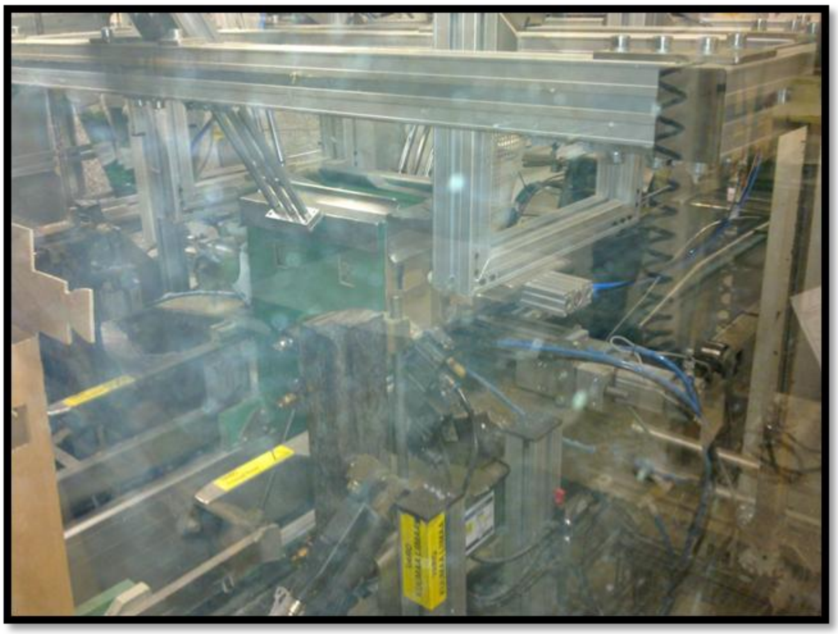

Figure 26. Final Packaging at the Packaging Station.

The glue drying time which takes 5 seconds at most, needed to be optimized in order to get a higher efficient production output for Famifarm Oy. Optimization of the gluing drying time needs a modification of the program used in the Wrap-Around-Machine (WAM). The study recommends that the glue should have an optimal value for the glue temperature that could be regulated to produce the best efficiency and performance of the WAM. The time frame of at most 5 seconds could be programmed to a short drying time. This time frame for the glue should also stick and dry perfectly when applied on the packaging cases. This could maximize the efficiency and the speed of the packaging processes. According to the ‘Principles and Theory of Automation’, the need for optimization occurs most commonly in processes in which there is an economic performance criterion whose optimization is desirable. For example, minimizing cost is usually an important objective in manufacturing. The automated system might use adaptive control to receive appropriate sensor signals and other inputs and make decisions to drive the process toward the optimal state. [13]

Consequently getting new mechanical and also controlling solutions that can be updated to the machine would contribute to improving the performance and efficiency of the WAM. Without new updates to the machine, the efficiency improvements need to be found by increasing speed of existing equipment and minimizing the delays. The study recommends that the glue temperature must have an optimal value that could be regulated to produce the best efficiency and performance of the WAM. The time frame of 5 seconds at most must be shortened and tested to yield a faster drying time. This time frame for the glue should also stick better and dry perfectly when applied on the packaging cases. This could maximize the efficiency and the speed of the packaging processes.

4 Conclusion

The Wrap-Around-Machine or the Wrap-Around-Packaging Machine was the main research object in the study. The research paper was initiated to observe carefully how efficient the packaging machine works in Famifarm Oy and to suggest possible ways of improving it hence the aim of the study: “Improving the Performance and Efficiency of Wrap-Around-Machine” in Famifarm Oy, Finland. The operation of the WAM has a larger effect on the production output of Famifarm Oy hence the need to critically examine the performance and efficiency of the packaging machine, to be able to maintain the automated production outputs.

The study was initiated with the main aim of finding possible solutions to improve the performance and efficiency of a Wrap-Around-Machine in Famifarm Oy Joroinen, Finland. The research therefore ascertained the current performance and efficiency of the Wrap-Around-Machine (WAM) and suggested possible solutions to improving the packaging machine WAM.

The study was again initiated as a result of the researcher’s interests towards automation initiatives and technologies. The researcher developed a strong interest in automation equipment as a result of studies done in ‘Manufacturing Automation lessons’ taught by Tero Jankko during the researcher’s Bachelor of Engineering Degree Programme.

The idea behind the study was to study the performance of the WAM and its efficiency as it seeks to increase productivity in Famifarm Oy. Possible setbacks and inefficiencies arising from the operation of the packaging machine were identified and used as research work. This chapter of the research paper also provides stepwise recommendations for improving the performance and efficiency of the Wrap-Around-Packaging Machine.

4.1 Main Findings of the Research Paper

The researcher’s critical observations of the Wrap-Around-Packaging Machine provided a stepwise documentation of how the machine operates. This made possible error detections accessible for evaluation and analysis. The analysis strategy used by the researcher was found to correlate with Hages total factor measures of productivity.

The current barcode reader angle is positioned at an angle of about 45^o. This angle makes the barcode occasionally unable to read the barcode calibrations on the product package. The nozzle glue temperature that is eventually used for the final closure of the sides of the packaging boxes, correlates with the recommended working temperature of about 160 - 190 ^oC. This stands to reason that the nozzle temperature for the glue is good for the packaging processes.

The original number of packaging cases the packaging machine could package per minute were 14 cases. Currently the machine packages 9 cases per minute which could be attributed to a lot of factors.

The study also found out that, the pistons used to close the packaging cases at the final packaging station, produced poor quality boxes. These pistons could at times destroy the packaging cases which also delayed the packaging processes.

The study reveals that, the recipient conveyor of the Wrap-Around-Packaging (WAP) machine keeps on running when no product groups are going to the machine. This causes energy wastage to the company. Also anytime the WAM is stopped when products get stuck in the WAM; the other packaging lines are also affected. Again, the amount of time spent at the gluing station was also found to be too much. Final gluing time was found to be so much since products have to wait for the glue to dry. This drying time of 5 seconds at most was too much. This also delayed the production speed of the packaging machine.

4.2 Evaluation and Recommendations

To provide a better understanding of the study, qualitative research method was used in conducting the research. Several research tools were administered during the research which included: active participating and observation, interviewing, audios, videos and pictures, emails, primary and secondary data collection, review of literature, documents and materials analyses.

A higher percentage of the study was carried out through active participation and observations. This aided the need to use audios, picture captions as well as videos to make understanding and accurate data more feasible.

Regardless of the research limitations, the study will also serve as a perspective for further research work that will enable researchers to build on existing knowledge and leading to diverse innovations and improvement in Famifarm Oy, Finnish industrial companies and in this industrialization era.

The researcher’s careful observations deduced that the current barcode angle could be changed to a different angle that will make products easily read by the barcode. This will make the barcode more accessible to read the various calibrations on the different kind of product groups.

The study also discovered that, about 39.30% production efficiency (WAM) was lost which has affected the automated production output of Famifarm Oy. Consequently, the total weekly automated production for summer and winter has been decreased by 9 098 cases and 5 888 cases respectively.

The barcode angle positioned at an angle of about 45^o should be changed to 90^o. Alternatively, the research also recommended that two barcodes should be set at the opposite sides of the entrance of the WAM. This can make the product barcode calibrations easily to be read by the barcode reader.

The researcher observations and reports to the researcher's company supervisor made the company change the existing pistons to new type of pistons (B). These pistons (B) produce better packaging cases for both the Finnish paper cartons and the Estonian and Russian paper cartons hence making quality final packaged cases

To conserve energy during the packaging processes by the WAM, the researcher proposed a model (see Appendix 11) for automating the process of stopping the recipient conveyor and the WAM whenever no production process is going on within a time frame and also running processes again when production resumes.

Another factor to consider in order to saving energy was the compressor that pumps air to operate the conveyor lines. The study again proposed that the airflow from the compressor should be automatically stopped to reduce the compressed air consumption. This mechanism is initiated when no production process is going on within a time frame. The model will only be applicable to the operation of the WAM whilst the other conveyor lines will still continue to work. The technical idea was proposed by using an automated control valve that will stop the airflow from the compressor automatically when no production is taking place in the WAM. This model can also be seen in Appendix 11.

The study recommends that the glue temperature must have an optimal value that could be regulated to produce the best efficiency and performance of the WAM. The time frame of 5 seconds at most must be shortened and tested to yield a faster drying time. This time frame for the glue should also stick better and dry perfectly when applied on the packaging cases. This could maximize the efficiency and the speed of the packaging processes.

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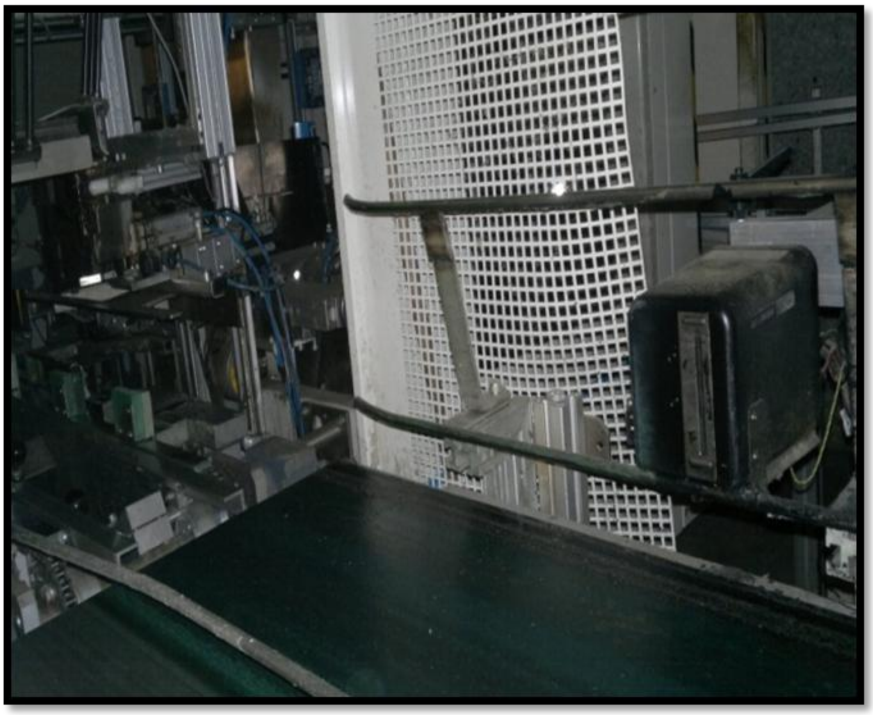
List of Some Figures

Appendix 1 The Recipient Conveyor leading to the entrance of the WAM (Photo, Aduadjei 2011)

Appendix 2- Skeletal Paper cartons loaded at the back of the WAM (Photo, Aduadjei 2011)

Appendix 3 Folded Skeletal Case Waiting for Incoming Product Group (Photo, Aduadjei 2011)

Appendix 4 Views of the Printer Head (Photo, Aduadjei 2011)



Appendix 5 Results of old pistons trying to close the cases (Photo, Aduadjei 2011)

Appendix 6 PLC-CJ1M Omron Industrial Automation (Photo, Aduadjei 2011)

Appendix 7 Views of the WAM's Printer (Photo, Aduadjei 2011)

Appendix 8 Manual Fixing of product names on Final Packaged cases (Photo, Aduadjei 2011)

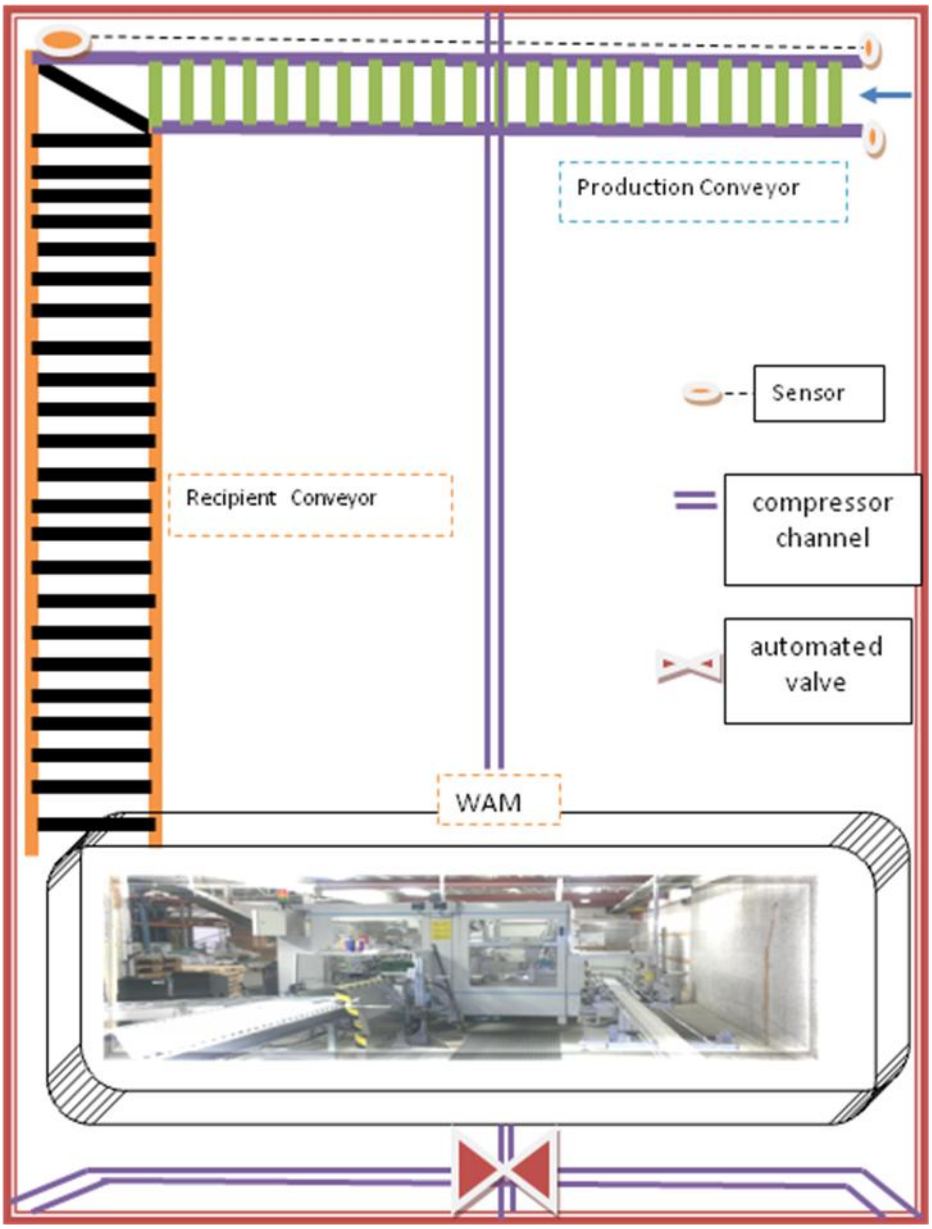
Appendix 9 Technomelt Glue Features

Characteristics	Fields of application
• High-quality synthetic hotmelt adhesive • High processing and bonding quality • Very high adhesion • Extremely thermostable • Very high mileage characteristics • Excellent cold flexibility • High heat resistance	• Versatile product for gluing of wrap-around cases, tray forming, folding boxes • Bonding paper and carton – including printed and lacquered surfaces • Permits high machine speeds • Suitable for deep-freeze packaging
Technical Data • Color: *white* • Softening point (Ring & Ball): *100 - 110 °C* • Viscosity (Brookfield): *1200 - 1600mPa·s / 160 °C* • Open time: *short* • Setting time: *short* Delivery form: Granules in 25 kg PE-bags Shelf life and Storage conditions In closed original packaging and under normal dry storage conditions, at least 2 years without negative impact on quality. Increased Mileage • Excellent bonding to a wide variety of substrates • Lower density and excellent flow behavior reduce adhesive usage • Mileage increases Less Maintenance • Longer life for equipment like pumps, hoses, filters and nozzles • Longer intervals between maintenance • Reduced costs for spare	Instructions for use • Application method: *nozzle, wheel, plunger* • Recommended working temperature: *160 - 190 °C* Due to the variety of substrates available, gluability of materials can be very different. Therefore pre-tests should be carried out Decrease expenses - Increase performance Substantial savings and higher productivity are important advantages of using supra. The innovative adhesive is more efficient than conventional hotmelts; it also increases productivity through better machinability. Clean Production • High thermal stability prevents gelling, charring and coking • Self-cleaning properties • No stringing and cob webbing

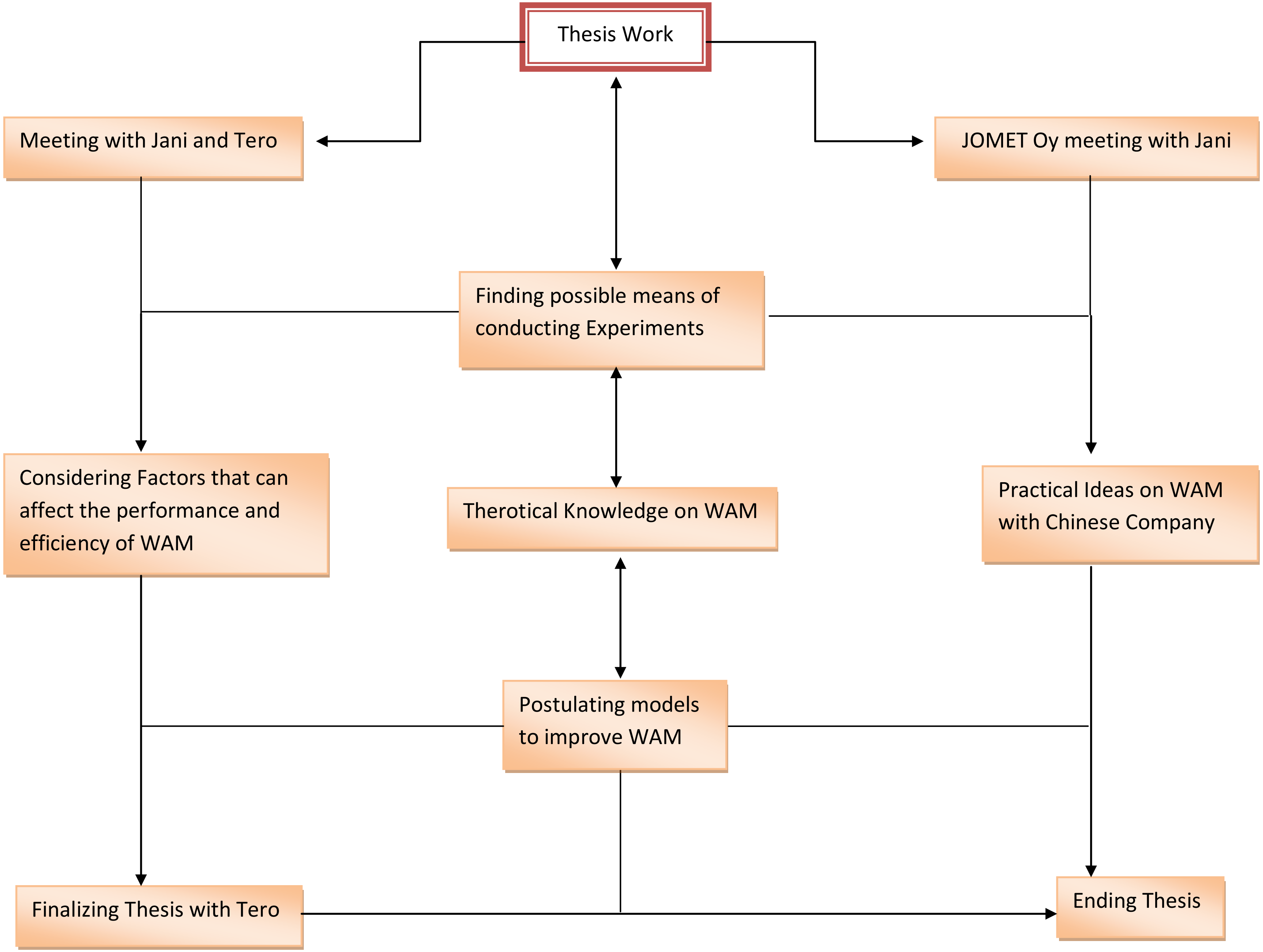
Appendix 10 Features of the Technomelt Glue

Reduced Downtime • Trouble-free performance • Lower rate of line shut-down • Reduced downtime for cleaning and maintenance Low Complexity • Broad field of application through wide adhesion range • Reduction of number of adhesives in storage • Less work in production, inventory, purchasing and warehousing • Reduced risk of mixing up adhesives • No necessity for frequent changes of adhesives in production • Simplified warehouse management Attractive Package Appearance • Appealing color: crystal clear when molten, white when hardened • Precise, even and economical application • Clean cut-off Good Working Conditions • Nearly odorless • No solvents • Very low emissions Direct Food Contact • Approved for direct food contact • Suitable for use in the food industry	Less Scrap • High thermal stability dramatically reduces production problems • Significant reduction of scrap rate • Minimized costs for waste disposal and repackaging due to packaging errors High Bonding Quality • Suited for a large variety of substrates and packages (including trays, wraparound cartons, and paper and cardboard with coated, varnished or printed surfaces) • Excellent machinability with no stringing or tailing • Suitable for difficult applications, including those involving high memory forces or low counter pressure • Excellent flow behavior supports effective wetting of the substrates Broad Service Temperature Range • Suitable for warm filling • Heat resistance and cold flexibility in one and the same adhesive allow freezer-to-oven packaging Environment Friendly • Reduced adhesive usage overall • Easier recycling of cardboard packaging due to less adhesive

Appendix 11 Automated Valve inserted in the Energy Saving Model



Appendix 12 John Thesis Mind Map, 8.5.2011: 20:30 - 22:12



Appendix 13 John Thesis Project Schedule

Number	Task	Resource	Start	End	Duration	% Completed
1	Meeting with Jani and Tero	Tero	9th May 2011	19th May 2011	10days	100
2	JOMET Oy meeting with Jani	Jani	May 2011	May 2011	5days	100
Summer Break	Summer Break	Summer Break	Summer Break	Summer Break	Summer Break	Summer Break
3	Starting Documentations for Thesis	John	Autumn Term, Sept week 1	Sept Week 1, 2011	1 Week	100
4	Therotical Knowledge on WAM	John & Jani(JOMET Oy)	Sept week 2, 2011	Sept Week 2, 2011	1 Week	100
5	Finding possible means of conducting Experiments	John	Sept week 3, 2011	25.9.2011	12 Days	100
6	Gathering various data collections	John				100
7	Considering Factors that can affect the performance and efficiency of WAM	John	Sept week 4 to (+ 1 or 2wks in Oct 2011)		2 or 3 wks	100
8	More Practical Ideas on WAM with Chinese Company	Tero	October 2011 (Either 2 or 3 weeks)		2 or 3 wks	
9	Postulating models to improve WAM	John	November week 1,2 & 3, 2011		3 Weeks	100
10	Finalizing Thesis with Tero	John & Tero				100
11	Ending Thesis	John & Tero	**December 2011-January 2012**		Two Months	100

SAVONIA