

Analyzing Sorting and Packaging for automation and process improvement

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Abstract <p>Research-based study for checking the possibility of automating the sorting and packaging process by providing reasonable solutions was assigned by JR-Tools Oy and approved by the head of the department Tommi Fransila. The thesis client is a maker of unique cutting tools for a metal business located in Tikkakoski.</p> <p>During an observation, it was found that sorting and packaging was time consuming and requires lots of human efforts and has possibility of more error. So, major goal of the thesis was to analyze sorting and packaging process and check the possibility of automation for those processes which is followed by a minor goal to improve inbound and outbound process of the company. Qualitative research methodology was used to collect quantitative data and evaluation method was carried out by analyzing those collected data for intrinsic solutions for the company.</p> <p>Literature review part of the thesis was collected from the book and related articles. Literature review structure comprises inbound and outbound processes, automation and a brief explanation about sorting and packaging term in logistics. Research was started form studying and analyzing current state of the company. The research was also done in other companies which is manufacturing and sharpening cutting tools, to know about their performance on sorting and packaging. Based on this research possibility of an automation decision was proposed to the client.</p> <p>After analyzing the overall process (inbound transportation, receiving, manufacturing, sharpening, coating and dispatch) of the company, manual sorting and manual packaging with process improvement recommendation to the client was the conclusion of the research-based project.</p>		
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1 Introduction

This thesis was assigned by JR-Tools Oy, a Finnish company manufacturing, sharpening, and designing of cutting tools. The topic was chosen by the author after observing and working as a trainee in the respective department. The manager wants to optimize unwanted cost by improving the logistics processes using the best available modern trends.

The thesis starts with a simple introduction of the topic and research. In this section the reader will gain an overview of the assignor company, background of the project, research methodology and limitations.

All the information about the theoretical framework for the research project can be obtained from the second chapter. Inbound and outbound logistics processes in a company and its importance are thoroughly described in this part. Some logistics terms like sorting, packaging, automation is briefly described in this section.

Research works and results are presented in third part. In this segment company will get the complete solutions for their real time problems. This part is also called as analysis part which is followed by conclusion. Finally, suggestion for future is given to the company by the writer.

1.1 Introduction of the assignor company

JR-Tools as a company

JR-Tools Oy, a maker of unique cutting devices for the metal business, was established in 1973 in Muurame. Currently JR-Tools is situated in Tikkakoski, successfully running its task with 16 expert employees. JR-Tools is Finland's biggest and most adaptable firm in its field. (JR-Tools webpage; 2019)

JR-Tools Oy is owned by five Finnish private owners. The company has three business concerns: manufacturing new tools, re-sharpening and re-sale. JR-Tools's net sales in 2018 were EUR 2.3 million, where each business line had equal contributions i.e. 33% of the net sales respectively. USA, China, Germany and Austria are bigger suppliers of JR-Tools. (Ronn; 2019)

The tools are endmills, drills, reamers and some other special tools like rolling tools, punching tools and disc type milling cutters as shown in the picture below. Tools designing (customer oriented tool and application planning), PVD-coating (swiss

quality by Platit) and maintenance (guaranteed precision and performance for the tool) are major task of the company. (JR-Tools Brochure; 2019).



Figure 1 Some Tools (<https://www.jrtools.fi/en>)

1.2 Background of the project

Inbound and outbound processes have meaningful responsibility in JR-Tools daily task. Manual sorting and packaging occupying more working hours which was indirectly leading to unnecessary extra cost.

Incoming cutting tools from customer for sharpening are sometime large in number for example 100 - 200 or maybe more in one order of different sizes and materials. Company have several records, sorting for those huge numbers of tools consumes 3-5 hours or even whole day shift for one order. In a day order number is more than one. (Jukka, 2019)

Company have assigned only one employee for sorting, data entering to ERP, keeping records, packing and dispatching. Those who are experience for several years can easily recognize the names and sizes of tools, but for newcomers it's difficult for some months or even years. In some way inbound and outbound processes of the company is fully depending on one employee. Hard to get experience worker and hard to train new worker. After sorting, tools are kept in a box along sheet of paper with details like name of tools, machine names for re-sharpening and coating details. Major risk of losing paper and imbalances to the official operation if paper is lost or damage. We never know the tools of respective customer. (Ronn, 2019)

Therefore, the company wants to improve inbound and outbound processes mainly sorting and packaging task with automation or maybe any other solutions that really helps for efficient operations and reduce unwanted extra costs.

1.3 Objectives and scope of the project

Major goal of the thesis is to check the possibility of automating sorting and packaging processes of cutting tools to improve the logistics processes (inbound and outbound) of the company providing reasonable solutions to sorting and packaging. This research will provide the ability to increase the efficiency of work rate in respective department via utilization of modern technology.

Research and results of this project answers the following functional research questions.

Research Question 1:

JR-Tools Oy really needs to automate its sorting and packaging process?

Automating some process is not only buying some automating system and install. It needs research, cost should be feasible to the company. Automating one phase or process should not affect another phase. In JR-Tools sorting and packaging process really needs more human effort and is more time consuming. But there are also manufacturing process and sharpening process. So, all these should be considered for automating sorting and packaging process.

Research Question 2:

What action is required to recognize tools and speed up packaging if automation is not possible?

Automating any difficult task is a wise decision. Are there any robots or other automatic solutions that really recognize the name of the cutting tools or an easy manual process to sort and recognize them quickly with less or no error? Packaging of sharp cutting tools is time consuming and sensitive. It is taking a long time and more effort of the employee. So, is there any automatic solution for packaging or easy manual process which requires less effort and helps to make the process faster.

Research Question 3:

After analysis of the sorting and packaging process, does it help to improve inbound and outbound process?

Inbound and outbound processes in an organization are different, both have important roles in the development aspects. Each productive and profitable organizations should focus on to improve inbound and outbound logistics processes. Companies should re-evaluate their tasks either they have specific logistics objectives or not and know the work manner. A well-managed logistics processes in a company helps to increase efficiency, expand sales, enlarge supplier relationship, increasing productivity and customer satisfaction. In order to achieve these objectives, the company should implement definite rules and regulations, avoid mistakes and use the best possible management software applications. (GTG Technology, 2019)

Scope of the project is JR-Tools was recommended with the optimal solution on the sorting and packaging issues which help staff to perform their work process in a smooth and effective way resulting in low cost and less operational time. All in all, the company succeeded in reducing unwanted extra costs and somehow helped in productivity increasing. So, to achieve the entire goal of the project, scope of the research encourages:

- To introduce the company and its contemporary issues
- To perform a review on topic related theory
- To mingle the theory for real-time problems solving
- Finally, to get the proper improve in company's entire logistics processes.

2 Research

2.1 Methodology

As per background and objective of the project, first qualitative research methodology was used to collect quantitative data. Research was started by searching for similar companies as JR-Tools. After finding the company, questioning was done to the representative of the company about their sorting and packaging process to know whether they have used automation for the specific purpose or not. Qualitative research contributes perception to generate a plan or assumption for quantitative research. Also, qualitative data was achieved from observing the work process in the respective department during working period in the same place as a trainee. Quantitative data were collected from interviewing company representatives.

Finally, evaluation method was carried out by analyzing those gathered data for intrinsic solutions to the company.

2.2 Research limitations

The major limitations of the project were language. The writer does not speak and write Finnish and employee in packaging room does not speak English. Translator was required for the communication; Sales Coordinator translates all the word for me and from me.

Another limitation was choosing theory part for the project. The company was straightly looking automation for sorting and packaging, but writer was pulling off increasing inbound and outbound processes by managing sorting and packaging process maybe automatically or semi-automatically. Automating was a kind of wise decision but during training period writer seems to be in dilemma that is there any automation system for recognizing tools by its structure.

2.3 Theoretical infrastructure of JR-Tools

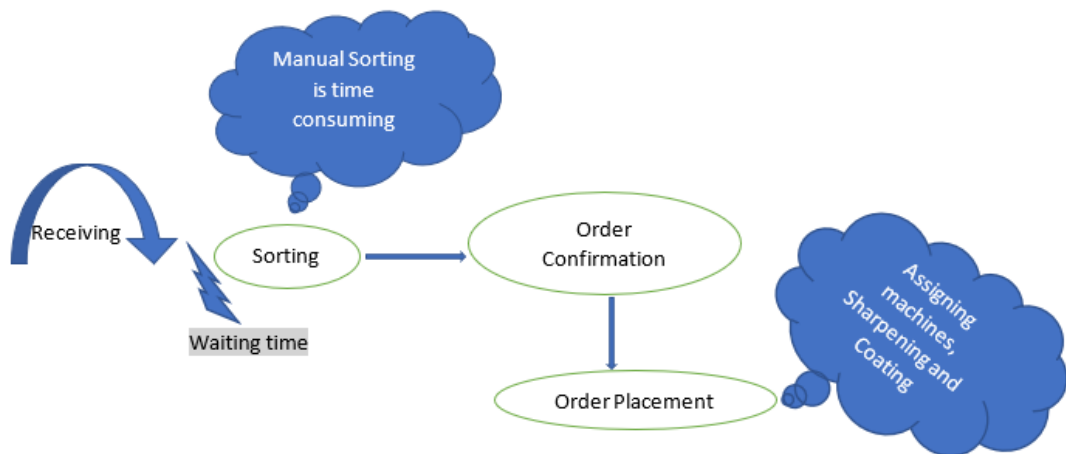


Figure 2 JR-Tools Oy Inbound process



Figure 3 JR-Tools Oy outbound process

3 Logistics Processes

3.1 Logistics Overview

Logistics is the arrangements of plans and policies for movement of stuff or data from the place of inception to the place of utilization, also ends up to the scrapping in some instances. The phrase logistics was initially related to the army however slowly scatter to the business sector. Logistics can also perceive as planning, management, and execution for the development of the firm. The list of some major activities of the logistics process are listed below and figure 4 is the pictorial representation:

- I. Forecasting
- II. Procurement
- III. Receiving, storing and handling
- IV. Production planning, executing and supervising
- V. Transportation
- VI. Information management

The systematic and successful accomplishment of these key activities leads to the reasonable profit, customer satisfaction and reputation of the company. (Grant, EU Ed, 3) According to the council of Logistics Management, United States in 1991 defines logistics as:

“the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of confirming to customer requirements.”

From the writer view, logistics is the study of management, planning, and implementation of ideas and ways for the growth of business with an efficient and effective connection to key elements of the logistics.

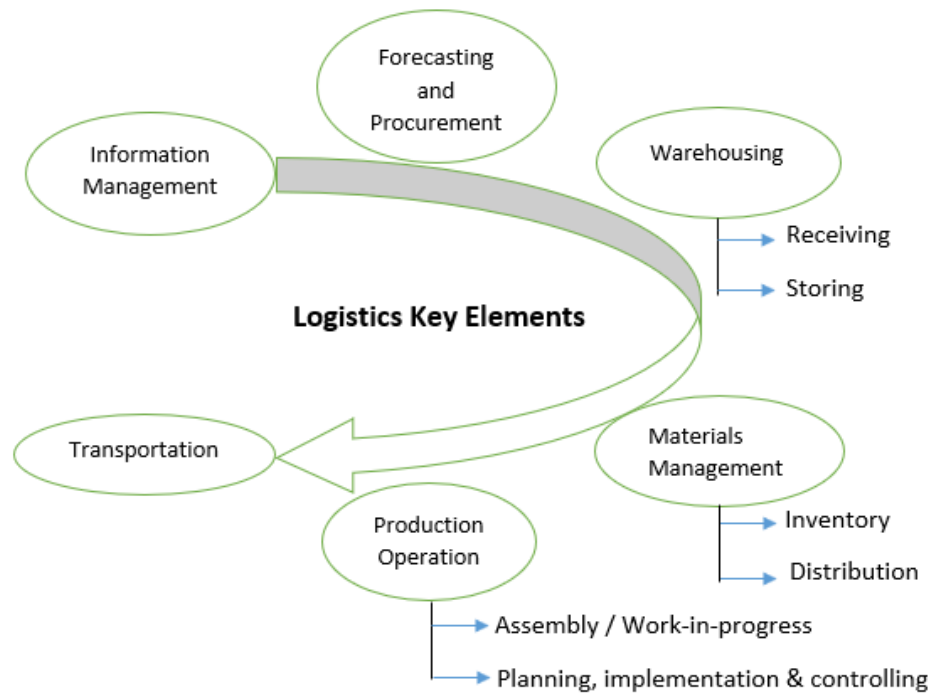


Figure 4 Logistics Key Elements

3.2 Inbound and Outbound logistics concept

Harvard Business School professor Michael Porter developed an idea about the value chain where the major focus was for key power of economic advantage to accomplish the aim or purpose of the company. Competitive advantage can be recognized from a separate task like manufacturing, scheming, transporting, marketing and sales of a company. All these tasks help to achieve profit according to their performance. Porter classified value chain activities into two groups: primary activities and support activities. (Christopher, Third Ed, 13-14)

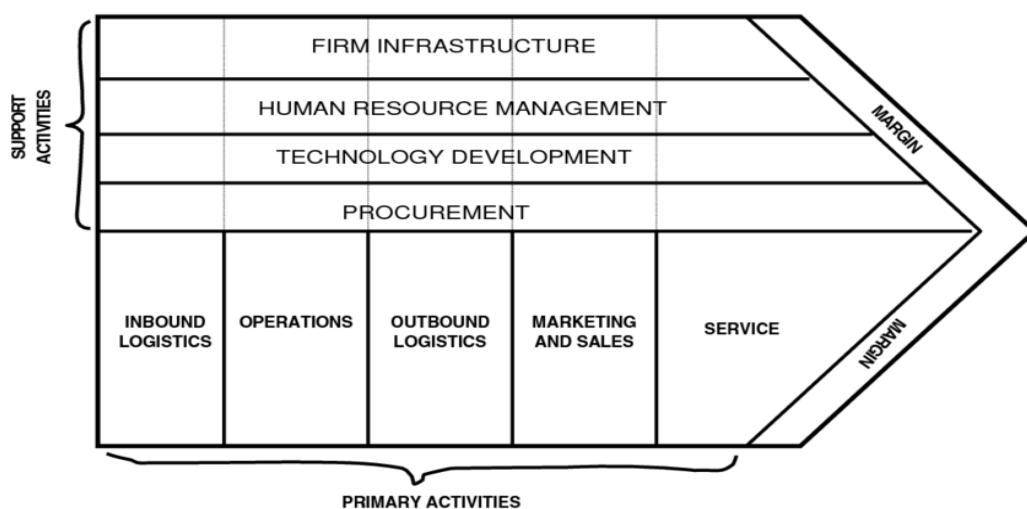


Figure 5 Porter's Value Chain Model [Source: Porter, M.E., Competitive Advantage, The Free Press, 1985]

M. Porter classifies the inbound logistics, operations, outbound logistics, marketing, and sales and services of any company as primary activities whereas supporting activities to obtain profit are firm infrastructure, human resource management, technology development and procurement. Each of these activities in any firm should execute effectively as compared to competitors and focus them on their value chain for competitive advantage. But if they could not maintain these activities for cost or value advantage, then possibly the company should think about outsourcing to those who can contribute a competitive advantage. The enlargement of the value chain exceeding the territory of the business is the result of outsourcing which can simply say supply chain becomes the value chain. So, competitive advantage is only gained by the well managed and systematic connection of these primary and support activities.

3.3 Inbound Logistics

The arrival or entry of goods or services to the company for assembly purposes or storage is known as inbound logistics. Inbound logistics concerns about the purchasing, receiving, sorting, storing and distribution of goods or parts coming to the company for production. Inbound logistics is the starting task which affects in overall operations of the company. Unmanaged and delayed inbound logistics function results in a discontinuity in assembly lines due to lack of raw materials which precisely affect profit. Significant inbound logistics functions are:

3.3.1 Receiving and Put-away

Receiving goods or raw materials and control them is the starting operation of inbound logistics work in any company or warehouse. Checking the received product is the right product in the right time with the right amount and the right quality is the high priority task. (Richards, 2011, P 44).

All the activities of the company are completely based on receiving. So, all those received at this starting point should be quickly processed that they can easily be accessible for further processing for example manufacturing, cross-docking. Receiving area and receiving processes of the company must be well planned and organized by experienced employees. The warehouse manager or receiver needs to know beforehand about the details of incoming materials and be ready to unload with the available resources. Products that require high attention should handle with care.

Then put-away can be done. Goods that are to be stored can be taken to the storage maybe using the warehouse management system. Cross-docking materials are to be taken to the respective area. Least handling and minimum delay in receiving is the actual clue to save extra cost and energy. This is all possible with a good relationship with suppliers, good communications within the employee. (Rushton, 2017, 369, 370)

3.3.2 Storage and handling

Storage and handling systems in a warehouse can be categorized as palletized and non-palletized. Wooden pallets are used for the palletized system whereas cardboard boxes, cases, tote bins are used for the non-palletized storage systems. Generally, goods or materials are received in pallets but in case they are not palletized and need to be placed in pallets, then the goods are possibly palletized in the receiving section and put-away to storage. There are different types of storage and handling ways are available for the palletized system in the warehouse. (Rushton, 2017, 301)

However, pallets are mostly used in storage procedure, the products which are too small, too long or too large like nuts and bolts, carpets, machines, papers, etc. requires a non-palletized system for storage. These products packed on cardboard boxes or cases or bins can be straightly kept on racks. The handling of those products can be done using the conveyor system. Research was done, and it is found that the non-palletized system is used to store half of the goods in the warehouse (figure 6). (Rushton, 2017, 327, 328)

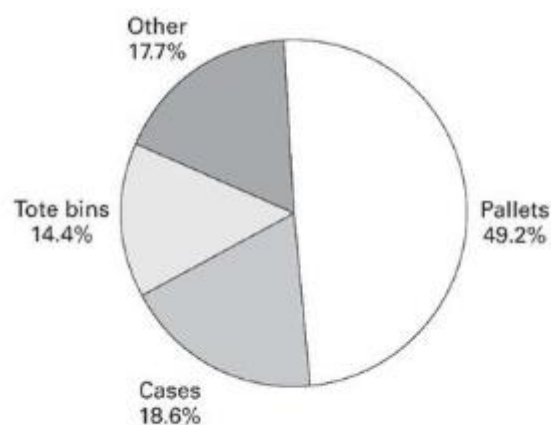


Figure 6 Warehouse area usage [Source: Baker and Perotti (2008)]

3.4 Outbound Logistics

The outgoing of finished goods from the firm to the customer is known as outbound logistics. Outbound logistics processes are picking, packing and transportation. In some cases reverse logistics like buyer returns, maintenance or warranty also comes on outbound logistics. As per supply chain management professionals, outbound logistics is defined as “the process related to the movement and storage of the products from the end of the production line to the end user”. Retailer’s fully decide supplier’s finished products either to stock or not based on outbound logistics behavior of the company. So, outbound logistics activities are key aspects of the management of supplier-customer relationship. (Tan and Matt, 2015)

The effective ways of management of the delivery of end products to the customers by the systematic performance of outbound logistics processes i.e. picking, packaging, distribution, transportation are the key factor to meet the customer requirements at the best cost.

3.4.1 Picking

Due to challenging automation, difficulties in planning and execution, picking is being expensive these days. And the fact is, picking is one of the most difficult and time-consuming tasks in warehouses or retailers. So, automating and a well plan is most necessary in picking tasks of the warehouse as it has a direct influence on customer service. Picking process is gradually changing from full case and pallet picking to just in time picking with automatic functions. (Richards, 2011, P 59).

Picking Methods are:

Order Picking: A traditional way of picking order one after another from starting to the end. For example, picking orders for production lines as per production lines.

Batch picking: In this case, picking list is prepared by combining several orders. One picking list may have a 40 – 60 order. Order picking can be changed to batch picking which can save time and cost.

Zone picking: Distribution centers or the warehouse are divided into different zones with limited employee in each zone. Zone picking is for a large warehouse or distribution center.

Picking technologies are:

Pick by paper: A traditional order picking process where list of orders is on paper and picked according to the list by marking the picked one.

Pick by the scanner: Barcodes or RFID are used in this kind of picking process. By scanning the bar codes on the products or by reading the tags of products order picking is done.

Pick by light: Light glows automatically in the position where order needs to be picked. After order is picked the signal is sent by picker the light goes off.

Pick by voice: In this case headphones and microphones are used. The system gives command or sent voice signal to the picker about the order to be picked.

Pick by CMD (Cart Mounted Display): Picking list is shown in the touch screen and based on the information provided on the screen order is picked.

Pick by vision: Pick by vision is now on the development stage nowadays. Research is going on this topic. Order is picked by vision on the glass or screen that the employee puts them on eye.

3.4.2 Packaging and Labelling

After success in selecting orders, it involves the packing task. The target of packing and labelling is to spot the product, simple handling, and safety of the product. The packaging materials used ought to be environmentally friendly. Labelling is completed to explain the packed materials like amount, delivery place and date, barcodes of the product and safety instruction. In some case orders square measure straight picked to the distribution space, during this scenario there might not have special packing and labelling operation. lately for straightforward packaging and labelling automation square measure getting used. when completion of the packing and labelling method, the prepared product is taken to the dispatch space for distribution. (Rushton, 2017, 367).

The main objectives, desires, and advantages of product packaging and labelling are:

Product Security: Packaging of the product protects the product from the utmost temperature, collision, vibration and harm throughout the time span of shipping product. During packaging anti-theft devices like RFID tags can be used to prevent the product from being lost.

Sales and Marketing promotion: Packaging can be used by the company for the product promotion which will help in sales and marketing of the product. This method of showing motivate buyers to buy the products.

Transportation: Palletized and non-palletized products are managed in such a way that they help in the easy transportation and no harm to the products. Standard pallets (1.2m*0.8m) are used for palletized products whereas cardboard boxes, cases, bins are used for non-palletized products. This also makes easy in handling

Identification: Labelling on the packaging helps to identify the products. Buyers will know the quantity and quality of the products. Most of the products own unique serial numbers and lot size which help the consumer to identify the product easily. This unique code helps in sorting, storage and handling for manufacturer, seller and buyer. (Langford 2nd Ed., 340-341).

3.5 Sortation

Sorting is the process of determining and arranging goods or materials coming into the warehouse or going out of the warehouse. So, from the definition it can be figure out that sorting is one of the most important tasks in both inbound and outbound processes. Sortation can be done both manually and automatically.

Goods or raw materials that are received are first sorted based on a lot size or manufacturing requirements or serial number or storage available and then put-away to the required destination. After sorting, the goods are sent to manufacturing or to the storage or cross-docking as per the requirements. This kind of sortation can be categorized as inbound sortation. Sorting can also be done instantly after picking of the goods to collect together for the relevant order packaging and dispatch. Mainly sorting is necessarily done for batch picking and zone picking. This sorting process on warehouse can be classified as outbound sortation.

Depending upon the shape and size (height, weight, length), urgency and limitations suitable sorters are selected for effective and efficient sorting. Effectively managed Sorting activities help in the manufacturing process, reduction of unwanted cost and time-saving. Sortation system should be chosen based on the requirements, product details, warehouse design etc. Some sortation systems are:

“Sliding shoe sorters”: For moving things, shoes are constantly positioned on the conveyor. Cartons and tote bins with uniform appearance are appropriate for this

sorter. Sliding shoe sorters can handle a wide range of materials as it has high peak rate (4000 – 6000 sorts per hour).

“Tilt-tray sorters”: During this sorters, tilting trays are hooked up to the moving conveyor perpetually. Those trays tilt left or the right to move goods into a sloping channel. Mainly for parcel handling and high-speed cross-docking tilt-tray sorters are used. As they provide the highest sorting rates (10,000 – 15,000 units per hour), they are one of the most expensive as compared to others.

“Bomb-bay sorters”: A high-speed automatic sorting for little and light-weight packages like books, medicines, cosmetics, jewelry etc. is known as Bomb-bay sorters. This type of sorter requires less space and has a rate of about 6000 sorts per hour.

“Cross-belt sorter”: like tilt-trays sorters, moving belt is mounted with moving conveyor at 90 degree. cross-belt sorter conveys the products into a slopping channel after passing to the sorting point.

“Pocket sorter”: Pockets are hanged on an overhead conveyor system on which products move after picking. RFID tags assigned recognize each pocket and automatically sorts the appropriate orders and make ready to dispatch. This kind of sorter can be applicable for hanging garments and other large-size products.

In addition to this, some other functions like counting the numbers, verifying equipment, recording information, checking damages can also be conducted automatically during or after sorting procedure. Bar codes, matrix codes, RFID tags, optical sensors could be the reasonable options for those automatic functions.

3.6 Automation approach to warehouse

Automation nowadays is extensively used in warehouse to decrease manual work, strengthen precision and to increase quality and production. Automating different tasks in the warehouse is taken as a wise decision for decreasing long term expenses. Some believe that automating warehouse is all about programming, whereas some consider automated storage and retrieval system’s execution as automating warehouse. But the fact is automating the various task i.e. sorting, packaging, picking etc. of warehouse for easy storage and most likely to reduce unwanted costs. As per Montage technology research in 2014, about 90% warehouse around world still entirely non-automatic or partly automated. (Nicole Pontius, 2017).

3.6.1 Robotics

The growth of technology is continual for the optimization of warehousing operations. Robotics are all-time solutions for today's busy and complex warehouse operations. It is believed that using robotics in daily jobs of logistics centers is making simple and effective. Robotics nowadays are integrated with the warehouse management system, which is improving efficiency, reducing labor costs (70-75%) directly helping the competitive advantages of the company. In past days magnetic tapes and hidden underground wires are used to map or read the activities of robots but in today's context optical sensors, RFID waves, IR sensors are used to navigate.

3.6.2 Conveyors

Normally conveyors are used to transferring goods or materials from one end to the right place at the right time without damage also with less human efforts. In these days' conveyors use in the warehouse are very necessary for maximum efficiency, less human effort. Totes, bottles, pallets, cartons or bulk materials all can be transferred using conveyors. Conveyor's types to be used depend upon materials to be transferred and mostly the layout and purpose of warehouse. The major conveyor's types commonly used in the warehouse are:

1. Powered warehouse conveyors: Belt or roller conveyors are normally powered conveyors relatively used for handling for small packages. Automation and the operation of the conveyors depend upon the shape and applications of the products.
2. Non-powered warehouse conveyors: stake wheels or roller conveyors can be non-powered warehouse conveyors. As the name, these types of conveyors use no power to transfer materials. Loading and unloading purpose non-powered conveyors are used. Roller conveyors are mostly used and best in practice.

3.6.3 Barcode and RFID

Barcodes and RFID both are used to store or collect data that can be recovered from the scanner. Both RFID (tags) and barcode (1D, 2D, QR) are used to track the products and workflow. Beyond this similarity, they do have some differences.

A research was done for 12 bottles to calculate the time between pen-paper traditional method, bar code and RFID on easy warehouse goods capture. It was calculated that the traditional method took 2 minutes and 16 seconds, bar code use took 37.9 seconds and the use of RFID scanner read all the 12 tags in just one scan i.e. one second. (<https://www.youtube.com/watch?v=EYJZbtXnBJM>).



S.N.	Bar Code	RFID
1.	Bar code is an optical representation of stored data that can be retrieved from scanner	RFID use tags attached to products which are also scanned for the identification and tracking of the products.
2.	Line of sight is required and reading distance is 1–12 inches.	Line of sight is not required and reading distance is up to 1.5m depending on tags used.
3.	Using the bar code is less expensive but slower compared to RFID	RFID tags are expensive compared to bar codes but are faster.
4.	Bar codes are less secured than RFID as they can be easily damaged and copied.	Tags used in RFID are highly secured as they are password protected, data can be encrypted and remove permanently.
5.	Implementation is simple and requires less time	Implementation is difficult and in some case its time consuming depending upon tags used
6.	 <p>Source: https://www.barcodere-source.com/images/EAN13Barcode.jpg</p>	 <p>Source: https://www.123rf.com/photo_27517580_rfid-sticker.html?vti=lev-zitvn67rsi91zyb-1-29</p>

Table 1 Bar code vs RFID

3.6.4 Machine Vision

Machine vision is an important technology in manufacturing for automatic observing and checking the progress or quality also optimizing production processes and related costs. Machine vision is also known as industrial image processing.

As per Automated Imaging Association (AIA), *"machine vision encompasses all industrial and non-industrial applications in which a combination of hardware and software provides operational guidance to devices in the execution of their functions based on the capture and processing of images"*.

The same algorithms and applications are also used in different sectors such as educational, governmental, military applications, etc. Some common operations of machine vision systems are:

1. Identification of object, to recognise dissimilar objects. It helps to check quality and quantity of the products
2. Identification of symbols, to detect bar codes, strings or specific characteristics.
3. Position detection, to correct the position of assembling products and set or organise materials in right place.
4. Geometrical parameters like shape, dimension can be known.

(Carsten Steger 2008, 1-2)

3.6.5 Laser Marking

Laser marking is the process of permanent marking of the logo, bar code, product code, etc. in the product of any materials and any shape which helps to recognize the specific product. These days laser marking is being flexible and multipurpose technology. The most common techniques used for marking these days are scanning optics and mask optics. Functional advantages of laser marking are:

- Highly flexible for any shapes, dimensions, and surfaces
- Any materials can be marked. (HSS, alloy, plastic)
- Marking is permanent. High heat, chemicals or erosion doesn't effect marking
- Cost-efficient and reliable product. Easy to handle.

(Trotech, 2019)

4 Current State analysis

4.1 Inbound logistics of JR-Tools Oy

Every company has its own specific inbound processes. So, do JR-Tools also has definite inbound processes for the systematic flow of its operations.

Inbound Transportation and Receiving: JR-Tools has a schedule of regular pickup for sharpening cutting tools. Every Wednesday in a week, company van goes to the customer premises around Jyvaskyla and picks up if they have tools for sharpening. Every third week of the month, company van goes to the southern part of Finland and if necessary a few other routes but they are irregular. Besides this, some customer drops tools to the company as their need for sharpening. Table 2 below shows an estimation number of tools collection from different parts of Finland.

Week	Area	No. of Tools (Pcs)
1 st	Jyvaskyla	100
2 nd	Jyvaskyla	100
3 rd	Jyvaskyla	100
3 rd	Southern	200
4 th	Jyvaskyla	100
4 th	Few other routes	300
Total		900 ≈ 1000

Table 2 Estimation of number of Tools

This is only regular pickup estimation, other regular customer drops tools in the company.

Sorting: After receiving tools, as per the schedule the employee in sorting and packaging room sorts the tools. In JR-Tools sorting means recognizing tools that go to the same sharpening machine. Sorting is done based on the dimensions of the tools, type of the tools and according to machines for sharpening. Mostly sorting is done based on machine names for sharpening. Those tools going to the same machine for sharpening having different sizes and materials types are kept in same box as shown in figure 10 assigning box numbers.

So, based on the observation approximately 100 – 150 tools are sorted per day. In an average counting 800 – 900 tools are to be sort in a week. The sorting process is described in the block diagram as shown in figure 7

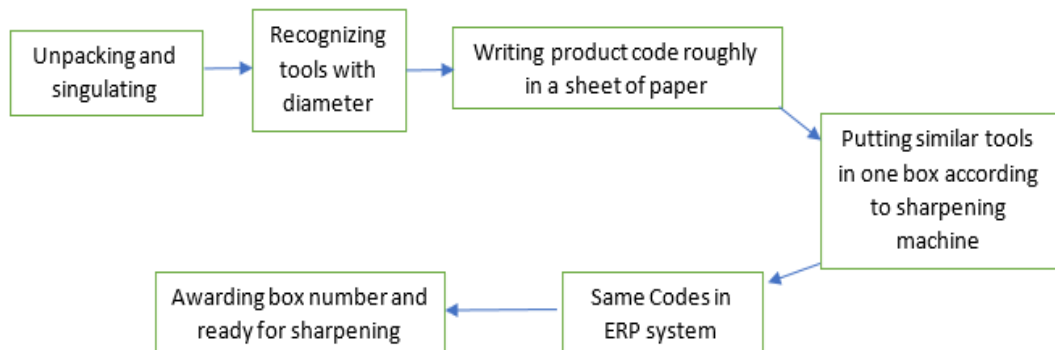


Figure 7 Block Diagram of Sorting Process

Following this process, normally the sorting time for one customer is 30 minutes to one hour depending upon the types and diameter of the tools. So, on average the sorting time is 40 minutes.

Problem 1:

Cutting tools are received mixed, also in large numbers. Singulating them requires lots of human efforts and time. For some tools confirming whether they are to resharpen or scrap with the help of magnifier as in figure 8 is another time-consuming operation during sorting. Employee, there has developed codes based on the size, types and sharpening machine. Based on several years of experience employee knows the codes of each tool. So, he writes the codes roughly on a paper during sorting. Then the same code is again written in the ERP system of the company. It Seems like operating same task twice.



Figure 8 Checking edge of tools

Suggestion: During sorting, the process of writing the codes roughly in a sheet of paper could be removed by directly writing the product code into ERP system. This decrease sorting time. Then the entire sorting process will be as figure 9.

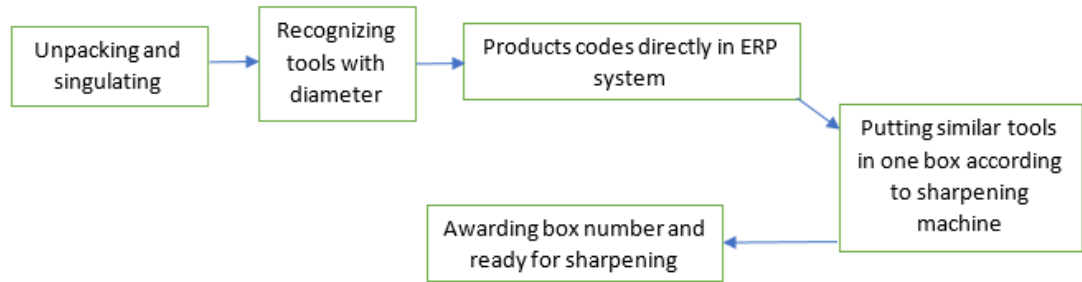


Figure 9 Block diagram of sorting process after merging two steps

This decision will reduce the time-consuming process (writing the codes roughly in a sheet of paper). As product codes will be directly written to the ERP system of the company, about 10-15 minutes times of sorting time will be saved.

Order confirmation: Now the details of tools are entered to the ERP system (C9000) and order number is created. During this process price of each tool, sharpening time and expected delivery time of the specific order can be known. Then order confirmation as in figure 10 is sent to the customer along with all details. Two copies of order details are printed in this step. One copy of printed paper goes along with the box and other paper remains on the shelf as an original document waiting for sharpen tools.

JR-TOOLS		Order Confirmation		Page 1 / 5	
Optimised tooling solutions		Order confirmation	Date	2019.03.25	
Customer address SANDVIK MINING AND CONSTRUCTION OY BREAKERS LAHTI Taivalkatu 8 15170 LAHTI		Delivery address SANDVIK MINING AND CONSTRUCTION OY BREAKERS LAHTI Taivalkatu 8 15170 LAHTI		1006	
Tel Contact person ROOPE LAINIO		Tel Contact person			
Seller PASI KORNN Terms of delivery TOP, TOIMITETTUNA PERILLE Meth. of dispatch JR SERVICECAR		Order date 2019.03.25 Time of delivery 04.04.2019 Assembly drawing			
Terms of payment 60 days net Your reference TYOKALUHUOLTO MARKO LEHTINEN Our reference Mark		Name Offer Work number LH19225 Customer work No. Customer order No. 21.03.2019			
We thank you for your order and confirm as follows: NB! Orders regarding client-specific tools: We reserve the right to deliver +/- 10% (or +/- 1 item) of the ordered number of tools					
Line	Drawing number Product number	Name Customer work No.	Qty Unit	Del.time	Unit price Tot EUR
1	99111007	TER.ISS PORA D7 ERIKOISPITKÄ ZSO CONTRACT DISCOUNT	4,00Pcs.	04.04.2019	6,73 26,92 -13,46 13,46
2	99111008	TER.ISS PORA D8 ERIKOISPITKÄ ZSO CONTRACT DISCOUNT	3,00Pcs.	04.04.2019	6,73 20,19 -10,10 10,10
3	99116014	TER.KM-VÄLJENNIN D13,85 ZSO CONTRACT DISCOUNT	1,00Pcs.	04.04.2019	21,14 21,14 -6,34 14,80
4	98910020V	TER+VIVA-X KIERRETAPPI D20 ZSO CONTRACT DISCOUNT	5,00Pcs.	04.04.2019	39,60 198,00 -59,40 138,60
5	98910020V	TER+VIVA-X KIERRETAPPI D21 ZSO CONTRACT DISCOUNT	1,00Pcs.	04.04.2019	39,60 39,60 -11,88 27,72
6	98910024V	TER+VIVA-X KIERRETAPPI D24	5,00Pcs.	04.04.2019	45,25 226,25
JR-TOOLS OY Kirkkokatu 11 41160 TIKKAKOSKI http://www.jrtools.fi		Telephone/Telefax/E-mail +358 20 7622220 +358 20 7622229 info@jrtools.fi Domestic: JYVÄSKYLÄ		Bank account 104530-194851 IBAN FIR3 1045 3000 1948 51 NDEAFIHH Business ID/VAT: 0194835-4 / F101948354 Takotettu C9000 jäsenmääriä	

Figure 10 Order Confirmation

Assigning box number and Put-away: Sorted tools in a box are given a unique box number. Different boxes have different numbers though they are of same customer. Figure 11 shows the box with its number containing different sizes tools ready for resharpening.



Figure 11 Assigning box number

4.2 Outbound logistics of JR-Tools Oy

After successfully sharpen and coating, the tools are taken to the packaging rooms and kept to the shelf, waits till all the tools gather and then dispatch. During this operation, several outbound processes are carried out.

Picking: After arriving on all the tools in the shelf of the packaging room, according to the delivery date and time, tools are picked for packaging. As per the order list tools are picked manually.

Packaging: Tools ready for delivery are very sensitive and the sharp edge of the tools can harm human bodies. Tools should be packed in such a way that they do not collide with each other. So, packaging work should be handled with care. The packaging task in JR-Tools is done manually. Plastic packaging tubes as figure 12, wooden and plastic boxes, plastic cases are the packaging kit for the tools.

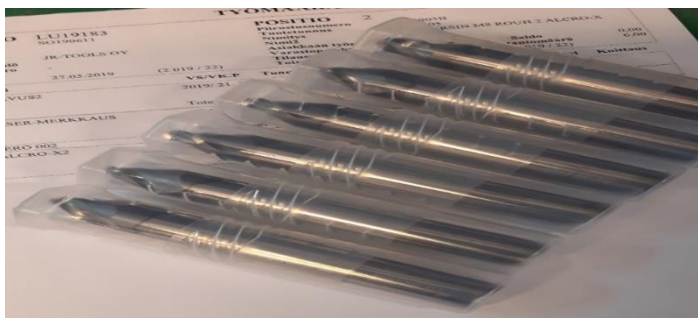


Figure 12 Packaging of tools

Problem 2:

As per the tools should be handled with care and requires more human efforts during packaging, company is looking for an automatic packaging system. But due to differences in the length, size, and ways of packing it's being hard to manage automatic system for the packing process.

Documentations: Now details about the dispatch are printed and attached to the packet of tools. Post-delivery, delivery to customer and customer pickup are three ways of dispatch of tools.

5 Research and Findings

Research for the thesis was started by searching the companies that are manufacturing and sharpening of the cutting tools. As the major focus was on sorting process during sharpening of cutting tools, many companies like JR-Tools was found among them 5 company was selected. One of them is in Finland whereas others are mostly in USA. Finnish company was visited during the research period, and for other company emails were sent and phone calls were made to the respected department and person. Only 2 companies replied to email and phone meeting was arranged with both parties agreed to keep secret the name of the company and their typical process. As the research was related with sorting of sharpening tools, conversation was only on these related.

Company research was done to know whether they are using manual, semi-automatic or fully automatic system in sorting and packaging. Also, to know if they want to use automation in future. From this research, it is found that using automation in sorting and packaging phase is a wise decision, but this has many constraints and expensive. Details on company's research is on appendix 1. Main findings of the company interviews are:

- None of the companies are using automation system in both sorting and packaging process.
- One of the companies only sharp their own manufactured tools and have sharpening form implementation which makes sorting process easy and maintained.

- Manufacturing and sharpening are carried out simultaneously. So, company 1 has only 2 weeks delivery time.
- Company 2 has product number in use (product number is marked on tool), this helps in easy and quick recognition of tools.
- Two companies are using automation (robots) on manufacturing area.

5.1 Research on Fully Automatic

Two cases for each process was studied. Details on cases are in appendix 2.

Sorting

The purpose of the case study was to know about the sorting process performed by other companies, their technology used and mainly to compare the findings with JR-Tools Oy. Main findings of this case study are:

- In both cases, automating was developed only for the respective company by analyzing all the possibilities and challenges.
- Different technology is used in two cases. In-sight 5100 Cognex vision system to sort about 180,000 pieces of drill bits per day and Laser scanner to sort 6000,000 tools a year measures length, diameter for recognizing tools.
- From both case it was found that, maintaining correct position of the cutting tools during singulating is major challenge.
- Designed for bigger Boeing who is re-sharpening own tools though they purchase from various manufacturer. So, almost impossible for those having numerous customers. (Evans F.L, Kaser Bruce A., 1992)
- Designed and operated by the single manufacturer for specific purpose, it's hard to find or buy in the market. Also, cannot estimate the price of the products. It is assumed to be very expensive to buy and operate.
- Skilled manpower is required to operate the system. Complex in installation and after sales maintenance are assumed to be drawbacks found in this case study.

The system is not so simple as explained, in both the cases analyzing software is so synchronized that reduces error. Sorting and recognizing mechanism are directly connected to the re-sharpening machine and storage system with respective product ID. The one and only benefits of the system is it recognizes the large number of tools without human efforts.

Packaging

Case 1: ‘Summit automation’ a manufacturing company, develop envelop packaging for cutting tools. 20 different envelop sizes was developed for 20 different sizes cutting tools. It uses proven drum count and feed system. The machine is run by single operator and one size cutting tools in one time. (Bhondlik, 2019)

Case 2: A tray full of similar cutting tools was conveyed to the packing room from manufacturing area. Robots picks them one at a time and feed to rotary indexing dial for ultrasonic cleaning, laser engraving and inspection. Now the tools are again pick and placed to plastic tubes which were feed to the asebmly area using vibratory feeders. Packed tubes are unload onto the wrapping machine for wrapping 3-4 pieces in one wrapper. All these process and equipments are fully automated with no direct labor. (Steven Douglas Crop, 2019). Machine details and pictures can be found on appendix 1.

The case study was done to know about the technology used in packaging of cutting tools. Main findings of this case study is size of the tools matters alot for the technology to be used for packaging and price of the system is also high.

5.1.1 Automation approach to JR-Tools Oy

Sorting

Before planning automatic sorting let’s examine the whole sharpening process of the company. Figure 13 shows the total time calculations for whole sharpening process of one customer in JR-Tools.

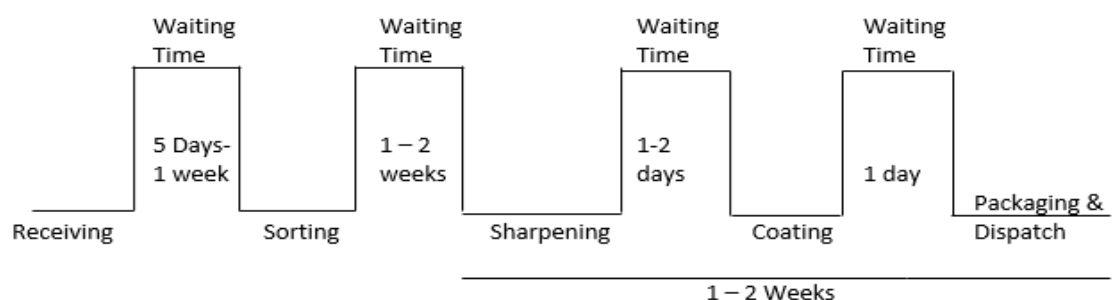


Figure 13 Time calculation for whole sharpening process

During observation, for one customer, when tools are received normally the waiting time before sorting is about one week. But in case of urgent tools are sorted right away after receiving. As already mentioned, average sorting time is 40 minutes. Then the tools go to the shelf of the respective machine and waits there for about minimum 1

week and maximum 2 weeks. Sharpening time for 50 tools is about 2-3 days. Now the tools are ready for coating and goes to coating room. Sometime coating is done immediately but normally they waits for 1-2 days. After coating tools are brought to packaging room, it takes about 1-2 days to gather all the tools of respective customer then after packaging tools are dispatch to the customer. It was found that total lead time for one customer is about 3.5-4 weeks.

Now if JR-Tools got the desired automatic solution for sorting process let's examine what happens to the entire process of the sharpening. On research it was found that automatic sorting system operates on large number of tools in limited time. This directly decrease the waiting time before sorting i.e. form 1-week time to about 1 day. But other entire processes of the sharpening are same. So, somewhere the waiting time will be increased unwantedly. Figure 14 shows the bottleneck to the entire system.

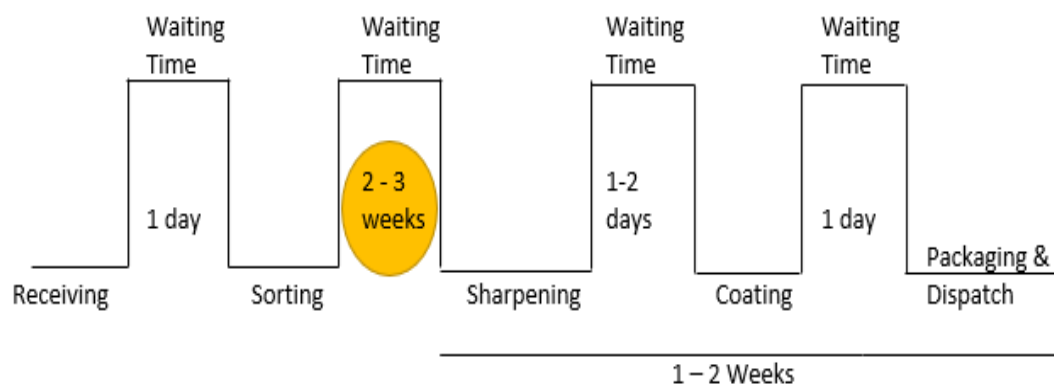


Figure 14 Time calculation after reducing 1st step waiting time

As, whole sharpening process after automatic sorting are same and operating in the same way before automatic sorting, all waiting time before sorting is added to waiting time before sharpening. 1 week waiting time will be added to the existing waiting time before sharpening. This shows that deliver time for one customer will remain same.

In other hand, total number of tools to be sorted in a day is about 150 tools. In a week it goes about 800 maximum 900 tools i.e. in a year total tools to be sorted are about 40000. During research it was found that any automatic sorting or recognising system sorts very large number of tools. For example a machine sorting for 100000 tools,

machinary parts are same to the machine sorting or recognising for 40000 tools. Also the cost will be same.

Packaging

Based on the research (Case1 and 2 Packaging), it is found that automatic packaging of the tools are used only for manufactured tools. The major thing is only similar tools are packed in one processing though machine can pack different size tools. This means one size and one length (For example: diameter 12mm and length 10mm) are packed in one processing i.e. different sizes tools different processing time.

Normally in JR-Tools, packaging of tools is done after receiving all the tools of respective customer. Tools divided in number of boxes comes one by one in the shelf of packaging room after completiing all the related process (Sharpening and Coating). On the day of delivery packaging is done manually. Plastic tubes as shown in figure 11 according to the size (Length and Diameter) of cutting tools. So, during observation it was found that a customer order have different sizes and types of tools. Pictures of one customer order can be found on appendix 2, to know about the number of tools, size of tools and types of the tools. From this it is clear that a customer has different types and sizes of tools.

For installation of automatic packaging in JR-Tools Oy, the step could be:

- Ater receiving all the tray of sharpening tools, all tools should be kept in one tray or different tray in a conveyor. Conveyor conveys trays to the picking area.
- Robot picks the tools and put them in machine vision system for determining length and diameter or in anyother system that helps to recognise length and diameter of the tools.
- After succesfully measuring, machine vision gives signal to another robot to pick respective plastic tubes for packing.
- The packed plastic tubes are conveyed to respective box of customer. And wrapping is performed by the wrapping machine.

The steps seems to be easy for explanation but its quite hard and takes long time and more efforts for numbers of automation engineers. It requires large area for installation. Though prices could not be estimated now, its sure that it will be very expensive may be hundreds of thousands. (Automation Engineer, ABB, 2019)

Based on this findings, atleast for now, for limited customer and limited tools installing wide range of automating packaging system will not be wise decision. But looking for

manual packaging with less human effort and time will be good steps for JR-Tools Oy. This helps to save time and money.

6 Recommendations

6.1 Manual Sorting

During working as a trainee in JR-Tools, brief observations of entire sorting process it was found that, whole sorting process was not the problem. Main thing in the sorting process was recognizing the tools for respective sharpening machine. Different size and types tools go to one machine. So, gradually it is hard to recognize the tools for non-experience employee.

So, based on the research and observation, coding (Laser marking) in the tools may be good idea for manual sorting mostly recognizing the tools for specific sharpening machine. Company has developed codes (Product ID) for each tool for easy recognition. In table 3 two example of product code is shown with their meaning and details.

Product ID (Codes)	Details
99120007	TER+NANO-X KM-PORA D7
99020412	TER+NANO-X ETJ KM-JYRSIN D12 Z4
Meaning of Code	
99120007	Tools for Re-sharpening
99120007	Drill bits; if 0 its End mills
99120007	Diameter of the tools
99120007	Types of metal 1 – High Speed Steel; 2 – Cobalt; 3 – Both
99120007	Normal size tools. If there is any number (X) that means tools is that much times diameter (D) longer than normal i.e. (X*D)
99020412	Number of edges in tools head

Table 3 Product ID details

Everytime when tools comes in, employee have to always sort them though same tools repeat time and again. During observation it was found that normally tools repeat for

3-4 times for definite customer who are also the big and regular customer for the company. So for the first time when tools comes in, printing product code in the tools might take some time for printing but laser printing doesn't take more time i.e. 2 minutes for 100 tools depending on the printing machine. Which will definitely reduces sorting time for next time.

This printing process will completely remove codes writing roughly in paper during sorting which also saves the time that is used for measuring diameter. The codes in the tools can be directly written in the ERP software and further information about sharpening machine and coating machine can be obtain. This process can easily be known and use efficiently even by new worker too.

For those tools manufactured in the company, all the related codes can be printed during manufacturing.

During research "Technifor" a manual laser marking machine manufacturer was found. Technifor provides all kinds of marking machine. For JR-Tools Oy a small manual marking machine was enough. Based on this, research was done as a result Technifor was selected.

Technifor manufacturer 'laser marking station LW2' model "F20Energy 20W fiber LW2" is the top model widely used for laser marking in production area because of its automatic selection of marking file, error proof process and automatic adjustment.

6.2 Manual Packaging

Figure 15 shows the overall process of sharpening of the cutting tools.

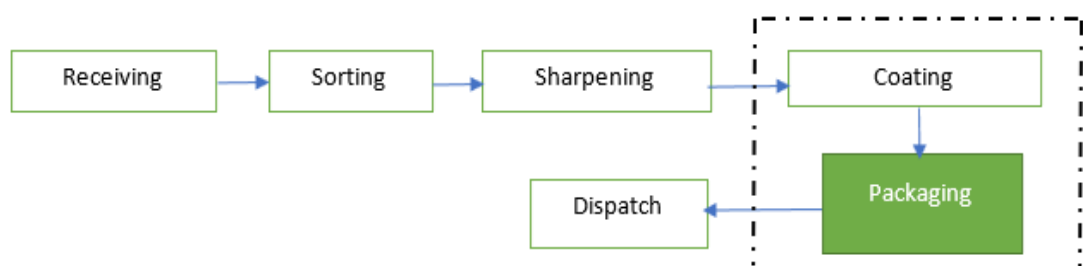


Figure 15 Block diagram of overall process of JR-Tools

In coating department tools are brought after successfully sharpening. Most of all the tools are to be coated. Let's examine for one customer. Suppose it has 50 tools of different sizes and types. It is divided in number of trays (for example 3 trays), each

tray has about 15, 20,15 tools. Now these trays go one by one to the coating department depending upon the sharpening time. For example, tray having 20 tools goes first to coating. Now coating is done sometimes in a group and sometimes individually. So, during coating, ready tools of the same tray must wait other tools until coating is done. Waiting time for each ready tool or group of tools depends upon other group of tools undergoing coating. After completing of coating of whole tray, tray is brought to packaging room and kept on the shelves which again waits for other trays and after gathering of all the tools on the dispatch date all the tools packaging is done. Packaging of all the tools same time needs more human efforts and time.

Based on this observation merging of coating and packaging department was recommended to save time and increase outbound efficiency. Figure 16 shows the proposed block diagram for JR-Tools Oy

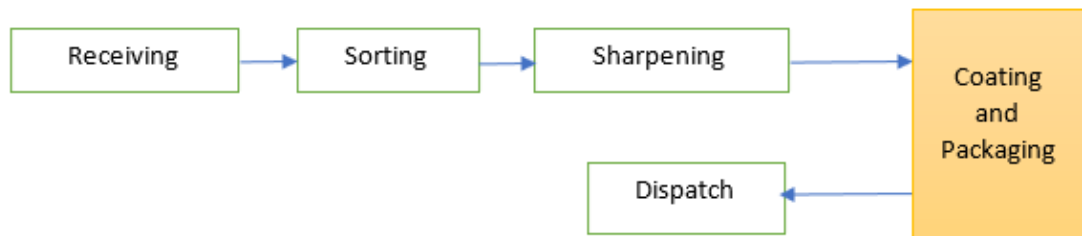


Figure 16 Block diagram after merging coating and packaging department

Advantages of merging two departments are:

- Double waiting time will be reduced to single waiting time.
- During waiting time to gather all the tools of respective customer, all the related documents for dispatch can be prepared
- Employee on sorting department can fully concentrate on sorting, this increases efficiency of work and reduces risk of being mistake in sorting.

7 Conclusion

	Sorting		Packaging	
	Automation	Method in use	Automation	Method in use
Company 1	No	Sharpening form for customer help to sort	No	Coating is Outsourced so packaging is done after coating
Company 2	No	Marking of product number in tools are used to sort and recognize tools	No	Manual Packaging
Finnish Company	No	Manual sorting (experience Employee)	No	Never had big number of orders. So, manual packaging.

Table 4 Results of Company research

Table 4 shows the results of different companies research on their ways of performing sorting and packaging task. It was found that none of the companies used automation for the respective task. As all of these companies were same as JR-Tools Oy, the results of the research helps to convince the JR-Tools representatives about the use of automation in sorting and packaging of the cutting tools.

Fully Automation		
	Sorting	Packaging
Case 1	Machine vision in-sight 5100 Cognex used for sorting	Proven drum count and feed system in use.
		Different sizes envelop in use for packing. One size at a time
	Sorts 180,000 pcs per day	Used for manufactured tools
Case 2	Laser scanner in use. 2 station, 2 scanners. One in each	Robots are used to pick and rotary indexing dial to hold cutting tools
	Sorts 6,000,000 pcs in a year for Boeing company	Plastic tubes for packaging and used for manufactured tools

Table 5 Results of fully automation

Two case of fully automation for each task (sorting and packaging) was studied, table 5 is the tabular representation of the results. This result was compared to the findings of current state analysis of JR-Tools Oy, mainly with the total number of incoming tools in a week and different sizes of the tools. Besides this companies whole sharpening process for one customer was studied. This study helps to identify bottleneck in production (figure 13 and 14). So, comparing current state of JR-Tools with the results of other companies research and results of fully automation and also evaluating the whole sharpening process of the company, the decision of not using automation atleast now for both sorting and packaging task was taken which is the answer of the first research question.

As the major goal of the research was to check the possibility of automation for sorting and packaging, speeding up the manual work for recognizing tools and packaging with improving inbound and outbounud processes was other goal set during research. Observing all the circumstances, manual sorting and manual packaging was recomended. It was found that whole sorting process was not problem, recognising tools for respective sharpening machine was consuming more time and requires experience worker. Company has already used product number (Table 3 product details) for specific tool, and the same number is used in ERP system as well, pricing of the respective sharpening tools was also obtained from same product code. So, changing product code was not possible. On research it was found that some companies are using product code for sorting the tools. Laser marking for the incoming tools was recomended with manual marking machine model. And about the packaging task it was observed that, there was double waiting time for tools i.e. waiting time during coating of tools and other is waiting time in packaging room untill all the tools of respective customer are collected. So, process change (figure 15 and 16) was pruposed to reduce waiting time of the tools which is believed to speed up the packaging of the tools answers second research question.

The research was fully based on only sorting and packaging of the company. Sorting is only part of the inbound process. Others process like receiving and inbound transportation are still under research to improve the whole inbound process. But from this research report it can be assured that sorting process will improve (figure 9, block diagram of sorting process after merging two steps). For outbound process merging of packaging department to coating department was prupossed, to reduce

waiting time for cutting tools, which is hope to speed up the packaging and dispatch process of the company. Form this it is belive to improve outboud processes of the company.

The company showed the attention on findings of the report about the possibility of automating sorting and packaging task. After brief analysis report of sorting and packaging, company was aware about the bottleneck that may introduce after installing automation system and agreed to the decision of possibility of automation. And will think about the possible implementation prupossed by writer.

8 Suggestion for Future

During observing and analyzing of sorting and packaging, whole process of the company was also somehow studied. Suggestions for overall improvement in future are listed as:

- **Scheduling:** There is not any schedule for unpacking and sorting of received tools. This is resulting in maximum 2 weeks waiting time for sorting after arriving in company premises. There is schedule of regular receiving of tools by company van on every Wednesday of week and third week from around Jyväskylä and southern part of Finland respectively. This increase the number of incoming tools on respective day. So, proper scheduling will help to reduce waiting time and pressure to employee and increase inbound process
- **Automation in Production:** There is possibility of using automation in production area as many other manufacturing companies does. A research should be done on this to increase productivity and reducing delivery time of sharpening tools.
- **Bottleneck:** At least there is bottleneck in production. It should be fixed for increasing performance of the manufacturing and sharpening. It is highly recommended to identify bottleneck on production.
- **Lack of resources:** If possible, company should hire production engineer to schedule all the production and sharpening process or an ERP operator. As production worker are not access to ERP system, lots of paperwork are carried out.

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Appendices

Appendix 1. Details of company interview

Company 1:

We deal mostly with the manufacturing of cutting tools (Drill bits and reamers) also some special end mills. We sharp only those tools manufactured in own company. So, this makes easy for us to sort the tools incoming for sharpening. As we all know drills and reamers goes to different machines for sharpening, sorting and recognizing tools is most sensitive part and task. We have tool sharpening form on implementation which is received along with tools. All the details of the tools are in the form, our sorting process is easily maintained. We only sharp drill bits and reamers it's easy to recognize tools. After sorting, tools are arranged on tray marked with delivery dates and are moved to the respective machines with our automatic vehicle. Sharpening of respective tools is done along with the manufacturing of the tools which is automatically done with the help of arm robots. Production and sharpening doing at the same time has always save our time with increase in production. This is the reason we have only 2 weeks of delivery time. After sharpening process, all tools are collected in a station, if necessary, tools are taken to other place (Company) for coating or dispatch according to delivery dates. If tools gone for coating packaging is done at the same time otherwise, we pack them in plastic tubes manually. Once we think about automatic packaging and tried but was not helpful because of low number of tools. We have limited customer with limited number of tools for sharpening for example, one customer has maximum 100 different tools. So, that was transferred to the packing of new tools. (Production Engineer, 2019)

Company 2:

We sharp about 500,000 cutting tools (brills, mills, routers, cutters) in a year including sharpening of other company manufactured tools but most of the incoming tools are our own produced. We have well experienced employee in sorting area, they easily can recognize tools. As most of the tools are own manufactured, they have specific manufacture number (product number) which gives all the details (diameter, types) of the specific product makes easy on sorting. Along this we have different sharpening service for high speed steel tools and carbide tools. So, we basically sort the tools on their

types. Tools are separated on tray and are taken to the respective machines with the help of overhead conveyor. Trays are provided with EDP (Electronic data processing) number which helps them to track any time. After successfully sharpened and coated if necessary, they return to the same room and packed for delivery. We have 3-4 weeks of delivery time. Our packaging process is also done manually. (Sales Manager, 2019)

Finnish Company:

We are small private owned company, mostly we deal with the manufacturing and design of new tools with re-sharpening facility. As we are small, first thing is till today we do not have the necessity of automating for sorting and packaging. Second thing is, during sorting, tools are received mix we must check them whether to sharpen or throw. Probably it's hard to design automation for sorting or recognizing tools. We have everything in our brain and recognize all of them by our years of experience in this field. In case of packaging, we never have big order or delivery so we can pack the tools manually though it requires hard work. (Office manager, 2019)

Appendix 2. Details on Fully automation case study.

Sorting

Case1: On august 2008, an article “Drill bits sorting using machine vision” was published describing about the automatic sorting of drill bits. A machine builder ‘Schuster Parazision’ from Germany developed a sorting machine using in-sight 5100 Cognex vision system to sort about 180,000 pieces of drill bits per day. A container is filled with several thousand drill bits, sliding apparatus moves the tools onto a conveyor. Cognex vision system and special gripper makes sure that drill bits in correct direction. With the help of sensors used, drill bits are correctly positioned correctly. With this reliable, advance technology and outstanding system helps us to meet quality, save time and cost. (Schuster, 2008)

Case 2: On 1991, Faville, Paul E invented an automatic recognition of cutting tools (drilling, cutting, milling bits and blades) for Boeing company in Washington state. The company is using 6,000,000 general purpose cutting tools in a year. It is found that cutting tools are returned seven times for re-sharpening during its life span. Those received mixed and bulk cutting tools of different sizes and types are first automatically separated with the help of sorting machinery and mechanical conveyor. This mechanism feed individual bits to the laser scanner. There are two scanners, first scanner scans the initial information of each tools and check the end to end orientation of the tools and positioned correctly for the second scanner. Now second scanner scan tools in deep to measure the crosswise diameter of each tool from various angle and length of the tool. These data are sends to the computer connected to the system for further analysis and recognize the tools types, diameter, length and edge characteristics. (Faville, Paul E., 1992)

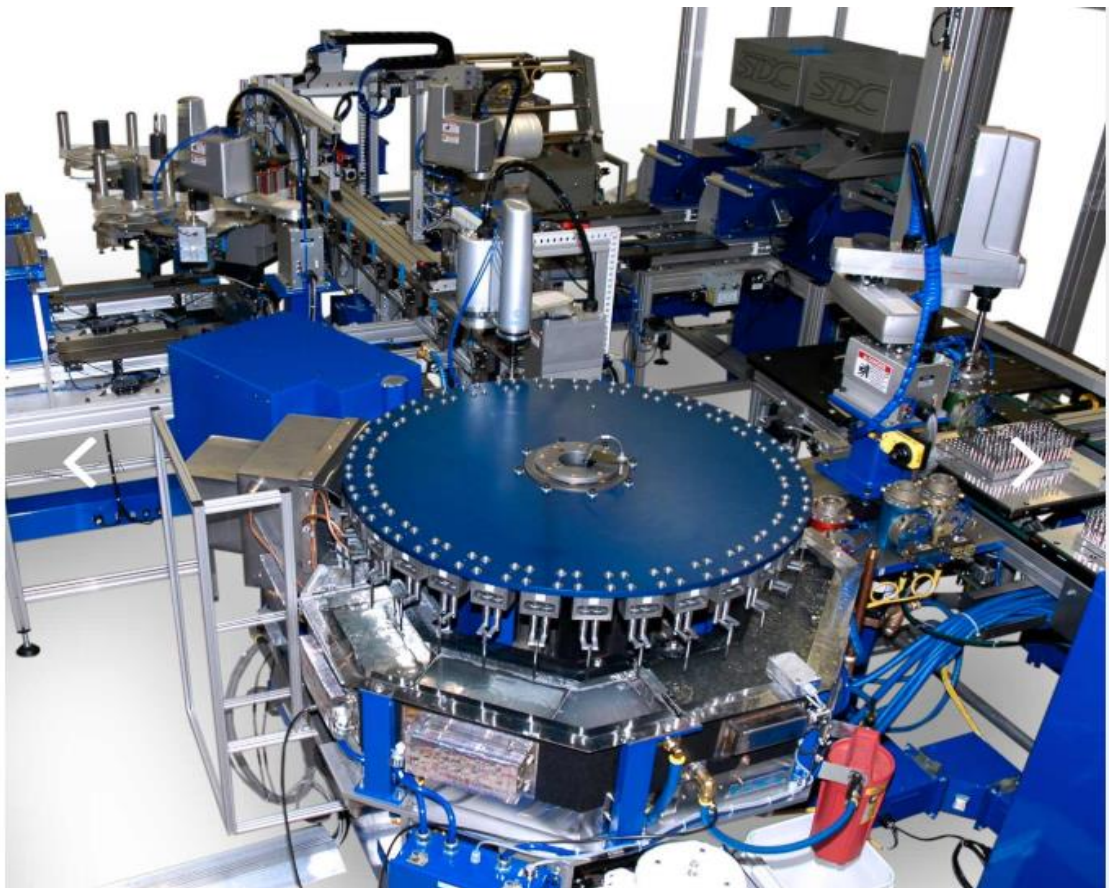
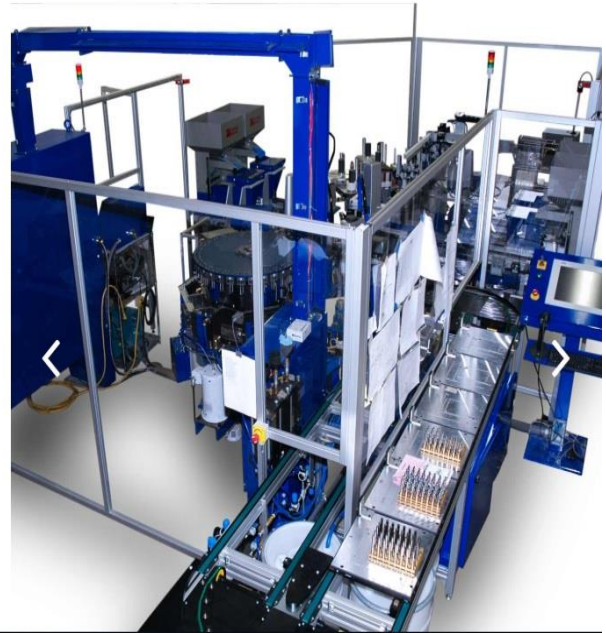
Appendix 3. Packaging machine details

StevenDouglas Crop (SDC) automatic packaging of cutting tools.

WHAT'S INCLUDED

MACHINE DETAILS

- PLC based machine controls
- Automated cassette unloading
- Vision inspection systems
- Ultrasonic washing
- Automated rust prevention application
- Vibratory parts feeding
- Automated labeling
- Shrink wrapping
- Robotic programming and parts handling
- Complete machine safety system



Appendix 4. Customer order

Example of Customer order for sharpening to get information about the content of tools (number of tools, size and types).

JR-TOOLS OY		TYÖMÄÄRÄIN		25.03.2019	
TYÖNUMERO LH19225		Asiakas			
Tilausnumero	SO190454	Asiakkaan tilausnro	21.03.2019		
Piirustusnumero		Asiakkaan työnro			
Nimitys		Toimitusaika	2 019 / 14		
Positio	Tuotetunnus	Piirustusnumero	Nimitys	Määrä	Toimitusaika
1	99111007	99111007	Re-sharpen TER.HSS PORA D7 ERIKOISPITKÄ	4,0	2 019/ 14. 4
2	99111008	99111008	TER.HSS PORA D8 ERIKOISPITKÄ	3,0	2 019/ 14. 4
3	99116014	99116014	TER.KM-VÄLJENNIN D13,85	1,0	2 019/ 14. 4
4	98910020V	98910020V	TER+VIVA-X KIERRETAPPI D20	5,0	2 019/ 14. 4
5	98910020V	98910020V	TER+VIVA-X KIERRETAPPI D21	1,0	2 019/ 14. 4
6	98910024V	98910024V	Resharpen coated. TER+VIVA-X KIERRETAPPI D24	5,0	2 019/ 14. 4
7	98910030V	98910030V	TER+VIVA-X KIERRETAPPI D30	3,0	2 019/ 14. 4
8	99112008	99112008	TER+NANO-X, HSS-STPORA D8	1,0	2 019/ 14. 4
9	99112009	99112009	TER+NANO-X, HSS-STPORA D8,5	1,0	2 019/ 14. 4
10	99112012	99112012	TER+NANO-X, HSS-STPORA D11,5	4,0	2 019/ 14. 4
11	99112014	99112014	TER+NANO-X, HSS-STPORA D13,5	2,0	2 019/ 14. 4
12	99112015	99112015	TER+NANO-X, HSS-STPORA D15	2,0	2 019/ 14. 4
13	99112017	99112017	TER+NANO-X, HSS-STPORA D17	1,0	2 019/ 14. 4
14	99112021	99112021	TER+NANO-X, HSS-STPORA D20,5	1,0	2 019/ 14. 4
15	99112021	99112021	TER+NANO-X, HSS-STPORA D21,15	1,0	2 019/ 14. 4
16	99112027	99112027	TER+NANO-X, HSS-STPORA D26,5	1,0	2 019/ 14. 4
17	99121008	99121008	TER.KANUUNAPORA Ø7	1,0	2 019/ 14. 4
18	99121008	99121008	TER.KANUUNAPORA Ø7 KATKAISU	1,0	2 019/ 14. 4
19	99121008	99121008	TER.KANUUNAPORA Ø8	6,0	2 019/ 14. 4
20	99121009	99121009	TER.KANUUNAPORA Ø8,9 KATKAISU	1,0	2 019/ 14. 4
21	99121010	99121010	No Resharpen KANUUNAPORA Ø10 ← Thrown away.	1,0	2 019/ 14. 4
22	99121011	99121011	TER.KANUUNAPORA Ø10,9	2,0	2 019/ 14. 4
23	99121011	99121011	TER.KANUUNAPORA Ø10,9 KATKAISU	4,0	2 019/ 14. 4
24	99121011	99121011	TER.KANUUNAPORA Ø10,95	1,0	2 019/ 14. 4
25	99121012	99121012	TER.KANUUNAPORA Ø11,9	1,0	2 019/ 14. 4
26	99121013	99121013	TER.KANUUNAPORA Ø12,95	2,0	2 019/ 14. 4
27	99121014	99121014	TER.KANUUNAPORA Ø13,95	2,0	2 019/ 14. 4
28	99121015	99121015	TER.KANUUNAPORA Ø15 KATKAISU	2,0	2 019/ 14. 4
29	99121030	99121030	TER.KANUUNAPORA Ø28	2,0	2 019/ 14. 4
30	99121030	99121030	TER.KANUUNAPORA Ø28 KATKAISU	1,0	2 019/ 14. 4
31	99120008	99120008	TER+NANO-X KM-PORA D8	1,0	2 019/ 14. 4
32	99120012	99120012	TER+NANO-X KM-PORA D12	1,0	2 019/ 14. 4
33	99120015	99120015	TER+NANO-X KM-PORA D15	1,0	2 019/ 14. 4
34	99120018	99120018	TER+NANO-X KM-PORA D18,05	1,0	2 019/ 14. 4

JR-TOOLS OY

TYÖMÄÄRÄIN

25.03.2019

TYÖNUMERO LH19225

Tilausnumero SO190454

Piirustusnumero

Nimitys

Asiakas

Asiakkaan tilausno 21.03.2019

Asiakkaan työnro

Toimitusaika 2019 / 14

35	99020316-MM	99020316-MM	TER+NANO-X MINIMASTER D16 Z3	5,0	2019/ 14. 4
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36	60410013	60410013	NANO-X D12,8	5,0	2019/ 14. 4
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TYÖVAIHEET



Tunnus Nimi

Työnumero + 1. positio + työvaihe

Tunnit Ylityötunnit Hyväksytyt kpl Hylätty kpl Kuittaus

DEC	DECKEL ALAKERTA	8,67				
		Toteutuneet				
KAN	KANUUNAPORAT	10,17				
		Toteutuneet				
NANO	NANO-X	6,58				
		Toteutuneet				
NC1	GEMINI	7,00				
		Toteutuneet				

SANDVIK MINING .. MINIMASTER Ø16 Z3
 TEROITUKSEN JÄLKEEN MINIMI Ø MITTA 15,5
 JOS Ø MITTA ON PIENEMPI NIIN TERÄ ON ROMU

NC2	ARIES	4,00				
		Toteutuneet				
VIVA	VIVA-X	2,33				
		Toteutuneet				