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Work instructions

User guide for milling door frames

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ABSTRACT

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The thesis was done for a local company that manufactures doors and windows for renovations and building projects. The topic was to examine the milling work station in the manufacturing process and create work instructions to support working. The target was to help improve the efficiency of work done in the milling work station.

The door frame production process was walked through as a whole, and the milling station was focused on as the subject of the thesis. Different types of knowledge and their interaction and role in the workplace were examined. Dimensions of quality were introduced as a way of defining quality-related aspects in product manufacturing. Interviews were conducted to gather data from the process.

The work instructions' situation was observed before and after making the new work instructions for the milling station. Conclusions were made of the results and of future methods of execution on similar subjects.

Key words
Instructions, Knowledge, Milling, Quality

ABSTRACT
CONCEPT DEFINITIONS
CONTENTS

GRAPHS

1 INTRODUCTION

The thesis has been made for Inwido Oy located in Eskola, Kannus. The thesis consists of gathering information and creating work instructions based on that information, pondering the best way to collect tacit knowledge, and present it in a concise way. The topic is limited to the work done in the door frame milling station.

Making the work instructions requires familiarizing to the work process in milling the door frames. There are several varieties of products done in this work station so the instructions are limited to the single-leaf door frame product. The purpose of the work instructions is to help and clarify the information to the workers, especially those who are new in training in the work station; the instructions help to understand as to what and how different steps during the work process are done.

Practical information is usually passed on by word-of-mouth and isn't documented well or at all, or can otherwise be difficult to obtain when needed. Ability to share this information is the main focus in creating these instructions, since personnel knowledgeable of important details are scarce in this working environment and personal guidance or immediate help can be difficult to obtain in a timely manner.

The other part of this thesis focuses on gathering the silent information known as tacit knowledge: gathering correct and relevant information concerning the work process, ensuring its validity and usability, and compiling the material to a concise package. In preserving valuable information the thesis also focuses on finding and using practical methods to go through aforementioned steps to retain tacit knowledge, currently held by workers in the company.

The company, Inwido Oy thrives on the craftsmanship of skilled employees and the importance of proper work instructions is high, since they're used as tool supporting in training and everyday work of manufacturing their high quality customizable products. Different work stations have already got updated instructions which state the main actions and how-tos in a clear and concise manner, so this thesis work is in a way a continuation to an ongoing common theme of updating and revising instructions and practices to improve the manufacturing work done.

2 THE COMPANY

Eskopuu Oy is a Finnish-based company located in Eskola, Central Ostrobothnia; they manufacture modern wood-aluminum windows and doors for residential houses and high-rises, which they sell throughout the country. Each product order is custom-made to specific features desired by the customer. The company is a part of the Nordic market leader Inwido group. (Eskopuu 2015.)

Eskopuu Oy started as a cement foundry in 1939, thus beginning the basis for manufacturing production in Eskola. Rebuilding after the war offered vast market opportunities for a variety of construction-related companies and soon the manufacturing of wooden products was also started in Eskopuu Oy, including the first windows and furniture. In the '70s the growing business acquired more facilities for expanding, and new carpentry machinery became an essential part of product manufacturing when the focus became more concentrated on wooden products. Later on exclusively windows and doors became the products being manufactured in Eskopuu Oy. (Eskopuu 2015.)

Nowadays with more sophisticated computerized machinery and through new product development, the company produces popular wood-aluminum-windows and balcony doors with a made-to-order mentality, for renovations and new building projects across Finland. Eskopuu Oy employs over a hundred people in-house in their business. In the last few years Lean 5S-program has been implemented almost throughout the factory, improving the working conditions and reducing waste and working time in the production process, which is the basis of manufacturing a wide product range with the ability to customize products for different needs. (Eskopuu 2015.)

The company's drive to improve their processes doesn't stop with the Lean 5S-program. Inwido Oy finds it important to keep also improving the personnel and their ability to do the

work, and the objective is to enhance the potential of human resources. The means to improve information flow include implementation of issues such as: employee training, work rotation, team meetings, and work instructions. This thesis is based on gathering tacit knowledge and making work instructions to assist in improving employee capabilities in the milling work station within the manufacturing production process. (Eskopuu 2015.)

3 PRODUCTION PROCESS

Businesses have main processes that can be listed as: real process, income distribution process, business process, monetary process, market value process. Real process is described as being the means of the production function which generates the production output. This contains the various steps in production which generates products from a variety of inputs of different quality and quantity. For clarity the real process perspective is used here to describe the production process, related to the door frames, in action. From the production the various product-related parts of the manufacturing process are introduced and looked over for a thorough understanding of the restrictions and requirements encountered in the production environment. Next the production process of the door frame, and related actions, is broadly walked through to give a general sense of events of the process environment as a whole. (Saari 2006.)

3.1 Milling

The process starts with wooden raw material planks, pine is used as a material for the frame and it is milled using a CNC-machine to certain required dimensions, holes for fittings and hinges are also drilled in this phase, then the frame is sanded, finally the parts are loaded onto pallets with identification information and transported to the painting station. (Vuolle 2015.)

In this stage the frames are also inspected to ensure that the machining quality, dimensions and features satisfy the conditions of the product order, so that the products can proceed to the next work station. If the product fails to meet the conditions required, it is either fixed, if possible, or done again to ensure product quality. Since machining the frame or doing rework after painting is quite difficult, time consuming or in some cases impossible and re-

quires lots of resources and reworking to get right, the proper inspection is an important step in discovering and identifying possible faults in the early stages of production to prevent waste and problems in later stages of production. (Vuolle 2015.)

3.2 Paint

The painting is done as an industrial cover painting by using a liquid-based paint in an automatic painting machine and a drying oven. This stage not only creates the desired gloss and color or varnish for the finished surface of the product, but also seals the wood grain into the material to prevent it from rising and creating an uneven surface finish, and to protect the product from different weather effects. The quality of the finished surface is inspected for possible faults and the frames are sanded, and repainted by hand if necessary, to achieve desired product quality.

3.3 Fixtures

In the next stage, fittings, hinges and aluminum trims based on customer-specific orders are installed to the frames. In this stage the possible hidden problems will come up, as the part being installed may not fit properly and the frame requires reworking, to meet the proper dimensions. The finished and trimmed frame pieces are connected by screws to create the complete door frame.

3.4 Assembly

Finally in the assembly stage the finished frame is connected to the finished door leaf by the hinges. The finished product is packaged with plastic wrap and cardboard for transportation

and piled onto pallets and fastened in place, and then the product is ready to be delivered to the customer. Throughout the manufacturing of the product, its parts are inspected multiple times to ensure the product quality meets the required standards in order to satisfy customer expectations.

3.5 Overview

As a whole, the various steps that a product goes through in the production line seems quite simple at first glance, the brief walkthrough is a conscious decision as not to dump too much information at once. For a more thorough understanding the subject of milling and the actions related to work performed in that work station is taken under closer review. Later on the milling process is divided, inspected and explained for a more comprehensive view of the subject at hand.

4 PROCESS IN MILLING STATION

Work done in the milling station is precise and must be done with utmost care since it lays the foundation for a successful product in later stages of production. During the machining even small mistakes in the frame, such as a milled edge being 1mm shy of required, can affect the dimensions to be out of the required limits which causes additional rework. Installing fixtures in the later stages of assembly becomes difficult and the fixtures won't fit properly if the machining quality of the piece isn't up to par. Familiarization of the product order's features and other significant information available is essential in the process of making a good quality product without unnecessarily wasting resources. (Vuolle 2015.)

4.1 Orientation

Introduction for new workers must be done to this position by an experienced worker and/or a supervisor. First thing to do is ensuring safety, considering the conditions and working environment. Employees are required to wear; safety boots with steel tipped toes and penetration protection soles, certificated safety goggles, and hearing protection. These items are required because of the hazards; falling or flying objects, sharp objects on the floor and continuous noise above safe limits from the machines, which can cause permanent damage in the working environment. There is also other optional safety wear depending on the task at hand. Getting to know the general safety procedures, identifying potential hazards, and internalizing action protocol in case of accidents are important. To make sure the working environment is as safe as possible for everyone in the facility, these issues are to be noted before starting to work at this position. (Vuolle 2015.)

4.2 Preparation

The preparation for work starts by turning on the lights and extraction vacuum system, then turning on the computer and the CNC-milling machine, and checking behind the machine that the vacuum system is working properly, pieces of wood are removed so the vacuum doesn't clog. Sensors, conveyors and drilling-units are checked and cleaned of dust and wooden rubbish with compressed air. Emergency stop is pressed and unlocked to make sure the machine does the reference cycle on the first drive, where it determines the locations of machining units. (Vuolle 2015.)

4.3 Information

In acquiring information about the next job, here we will use the word job for a customer order. Information is found by going through the weekly updated production load list to determine the next job. Job specific blueprints in the database are looked through to identify and mark specific details to be taken into consideration in doing the work. Based on the dimensions and features in these files the product parts are made, so ability to read and internalize this information is an essential part in making the product in the correct way. When working on a job, the progress is entered in the production tracking program as a part of the information flow in production. (Vuolle 2015.)

4.4 Machining

Based on the previously acquired information about the job; the dimensions, fixtures, and other features that require milling and machining are entered into the CNC-milling machine through the operating system. Inputting the specifications must be done carefully to ensure that the part will be milled correctly and no unnecessary waste is created by making sub-

standard product parts. A wooden plank is measured and inspected visually to match the desired outcome and fed onto the conveyor, then the milling program is started and the CNC-machine runs through the program entered earlier, on the piece being machined. Due to the of nature of the material, warping can occur in the piece while storing which causes flaws during machining, such as incorrect positions or depths in processing. So the milling process should be observed all the way through the program cycle to spot out flaws and mistakes during the machining right away. (Vuolle 2015.)

4.5 Finishing

After the piece has been milled a conveyor brings it up to the sanding station. Excess sawdust is removed from the piece, and the machining quality is inspected visually and by hand to detect minute variations on the surface. Depending on the wood quality and moisture the work quality can vary greatly, which creates the need for a proper inspection. Uneven edges, excess material, and rough planes are sanded with a pneumatic sander to create smooth surfaces, but without removing too much material since small differences matter in product quality. Knots and cavities on the wood surface are filled with putty and also sanded to achieve a satisfactory surface for further processing. Using a sample piece of a hinge the depth of machining is checked to ensure functionality. A staple is shot to the end of a finished piece to help with the paint stage. The finished pieces are loaded onto pallets with their identification number and details. (Vuolle 2015.)

5 QUALITY ASSURANCE

Quality as a concept has many definitions depending on the situation and the source determining what is quality. Describing quality usually falls into a few possible categories such as: bad, poor, satisfactory, good and excellent. Understanding the differences between the categories of quality can be difficult, so first boundaries must be established to achieve a clear vision. Based on the environment of the situation these boundaries are defined and determining quality becomes feasible in a more detailed manner.

5.1 Defining quality

The definition of quality depends on the current perspective on what actually is quality, and in order to narrow down the variables, some characteristics are set. Based on these characteristics quality is defined. David Garvin, the professor of business administration at the Harvard business school defines eight dimensions of quality:

1. Performance
2. Features
3. Reliability
4. Conformance
5. Durability
6. Serviceability
7. Aesthetics
8. Perceived quality

While some of these complement each other, that isn't the true in every case. Quality can be used as a competitive strategy by improving key areas of quality in production. Not every

dimension should be pursued simultaneously, but by weighing trade-offs and focusing on the important aspects concerning the product and production environment. (Garvin 1987.)

Using the different dimensions of quality as a point of perspective to observe which aspects of a product or production environment are affected by which actions, will grant some insight on what quality is in this case and what value it holds. Whilst the eight dimensions of quality is a reasonable approach to defining quality it shouldn't be looked upon as be-all and end-all to understanding quality.

5.2 Quality in the process

Quality in the door frame production process is heavily based upon functionality. The finished product is required to function seamlessly; this is achieved when the dimensions of crafted parts match the dimensions of fixtures, moldings and parts in general and they are assembled effortlessly and without the need of modifying or reworking any pieces. The features themselves can be multiple and of various types, so they set requirements for the functionality. Conformance limits are specific but due to the simple design, fitting parts to each other results in a tight fit. Durability and reliability go closely in this case, these characteristics are achieved by stress-testing finished products and choosing suppliers with the ability to deliver long-lasting materials. The materials affect also the two previous dimensions of quality since they can either complement or damage them. (Yrjänä 2015.)

Serviceability reflects the design of the product, where repairs can be conducted easily and within a reasonable time-frame, also the ability to make replacement parts on short notice increases serviceability. Aesthetics are based on observers preferences, so products are customized based on customers' requirements to a certain extent, this way aesthetics quality is achieved naturally in during manufacturing. Perceived quality is based on technical specifi-

cations such as: thermal resistance values and stress-test results. Consumers receive a sense of the quality by observing the presented data of these specifications. (Yrjänä 2015.)

Based on these examples it is becoming clearer on how different aspects of quality should be perceived. There are certain dimensions considered more important or valuable than other, some might occur naturally or with little effort to reach a desired level, others can be of lesser value and deserve not as much focus. The trade-offs can be seen in a process where the manufacturing is set up in a way that the important aspects are achieved with much more certainty and stability, while maintaining a low chance of variance of the desired aspect of quality.

6 WORK INSTRUCTIONS

Work instructions in general are a valuable asset in a process. In manufacturing companies work instructions are used to ensure the standardization of products in production, which helps to keep up the level on consistency, regarding: quality, processing times, materials and labour, among other related key topics. Knowing the limits of the manufacturing process is important, and adding to that being able to control and reduce the variations within those limits by standardizing procedures creates not only a more stable process as a whole, but the opportunity to gather accurate and valuable data. Work instructions themselves don't guarantee a well working process, but rather are a substantive piece in a larger puzzle towards building maintained practices, to be used as tools in controlling and developing production in manufacturing environment.

6.1 Situation before

The work instructions for the milling station are either non-existent or outdated. Most of the information is several years old and doesn't match the current parameters of products being manufactured in the milling station. The rest of the information available is hand-written on multiple pieces of paper, which can be unintelligible to read. This information consist of mainly exceptions to old products parameters available, making the access to proper and current information cumbersome. The notes are based on observations by the employees' experiences while doing the work, so finding the right information from the poorly collected pool of data is difficult at best, and in some cases there is no information available at all for certain circumstances concerning the work. (Vuolle 2015.)

Current situation relies heavily on the expertise and memory of the worker to perform the work correctly. Which makes training a new worker to the work station long and arduous

process, while at the same time the situation requires expertise-level support to be available if a trainee cannot remember all the details, or unexpected conditions occur, in the work process. Similar problems are faced when acquiring a replacement to the work station when a regular employee is unavailable due to a holiday, sickness or other reasons. These circumstances create the need for updated and clear work instructions, for easier training and reintroduction to the work station. (Vuolle 2015.)

6.2 Goals for work instructions

The goals for the work instructions as to what it should include and achieve were mapped by multiple parties involved. Mapping out the work process in the milling station was the key theme and it should include such concrete things as: safety issues and potential hazards, common mistakes and problems in the work, digital signing in information system, cleaning responsibilities, and reworking issues. The more theoretical topics to be handled in the work instructions are: quality aspects and guidelines for control, how to get help and support in a problem situation, collecting tacit knowledge, getting rid of excess paperwork in the station, and having the instructions in a digital format for good accessibility and ability to update with ease. (Huhtakangas & Yrjänä 2015.)

6.3 Collecting data

Collection of data in this case is crucial, not only is it important to gather a substantial amount of data available but also to determine what information is to be relevant in making the work instructions. The first step is determining what issues are to be included, the previously listed goals act as a guideline as to where the focus will be. After establishing clear boundaries, the plan for acquiring information from relevant topics is drafted. The plan consists of: a timetable to determine where and when data collections occur, a list of required

equipment used to record information, and the methods to perform data collection. In this case the data was collected during a shutdown day, when there was no pressure for production and issues could be walked through undisturbed. Interviews with preplanned questions were performed, alongside with familiarizing with the frame-milling station and the work-steps included in the process. Written notes were made to support the video footage taken with a camera.

6.4 Analyzing data

Analyzing the gathered data consists of checking the material and picking up relevant points in the subjects. Going through the extensive amount of video material provides a lot usable material, but it needs to be sorted under topics and different stages in the work process for it to be coherent information. The video material also gives insight to the proper actions required in practice of doing the work. The interview notes are also internalized to gain a better understanding of the work station, the notes also provide support to the video footage in creating a clear image of the work process. For creating the work instructions the aforementioned analyzed data is used to create an applicable summary, which demonstrates guidelines to be followed in the work station. (Vuolle 2015.)

6.5 Assembling the instructions

The instructions are laid out topic after topic in a chronological order, based on the steps on how the actions would be performed. Firstly some basic things, such as general safety issues and work-specific protective equipment, were covered alongside the importance of orientation in the workplace. This is followed by pre-work check-ups of equipment and the proper sequence for turning on the machinery. Next are steps on how to access the right product-information from the databank and handling it properly for proceeding. The importance of

correct information accessed here, whilst taking possible exceptions into consideration, is the key of avoiding uncertainty in the following steps. Based on the information, important values of the features are checked to ensure how the machinery is to be programmed to achieve a correctly made product. The next step is inputting the correct values and feature options into the machining program and inserting the correct size work piece to the conveyor before running the actual milling program. After the piece is milled the specifications of the finishing touches are covered alongside issues that ensure product quality. The proper way of handling and loading the finished pieces are established as a final step of the machining. Lastly basic maintenance and cleaning guidelines are covered in the instructions. The finished work instructions can be found in the APPENDIX 1. (Vuolle 2015.)

6.6 Situation after

The work instructions were inspected and evaluated by a foreman and an experienced worker. Both have different kind of perspectives on the work station, and the information required to run it, based on their experiences and knowledge about the work station. The instructions were considered generally good and applicable as a support material alongside proper orientation in the work station. However concerns were raised that in the case of a trainee with less orientation, the priority for more thorough explanation of work steps, alongside clarifying pictures, would be required for an exhaustive set of instructions which assist in doing the work in practice. This is a case that can come up if the time frame for orientation is restricted and learning the ins and outs of the work station cannot be achieved, which happens because of the vast amount of information that has to be absorbed in a relatively short time can be difficult to recall from memory. The feedback also states that the results truly prove on how much work is required to make good work instructions and keep them up to date, alongside the difficulties faced when doing so. (Yrjänä & Vuolle 2016)

For future development the next action would be to establish practices on making and storing the work instructions in video format, where different steps of the work for every station are clearly presented and stored. This is a method which could also be easier to make, use and update in the future. Using this kind of approach would involve more planning in gathering and mapping out the relevant information based on their subjects and tagging them accordingly, also designing the videos to include essential instructions in a concise way without being overwhelming would be one of the main points of focus. (Yrjänä & Vuolle 2016)

7 KNOWLEDGE COLLECTION AND MANAGEMENT

Tacit knowledge can be described as being understood without being openly expressed, meaning knowledge that we haven't got words for. Tacit knowledge is a practical approach, usually based on personal experience to share action oriented know-how. The generally more shared knowledge is called explicit knowledge representing process, which can be described as academic knowledge; this is presented in formal language using different types of media to approach a subject of established work processes. These two types of knowledge vary greatly from each other, but also supplement one another to achieve a more complete understanding of a subject. (Smith 2001.)

7.1 Explicit knowledge

Explicit knowledge is based on its ability to easily share and express information through communicating by words and numbers. Explicit knowledge is expressed in an identifiable form which can be stored and retrieved easily on request. These information documents are described as systematic knowledge or "know-what", they can be reviewed, modified, discarded or shared with ease to respond to the changes of an individual situation. Since explicit knowledge aims to ensure that what people need, they have access to, the information must be kept up to date based on the current situation. Otherwise the knowledge could contain false information which can lead to detrimental results. This is why gathering and using explicit knowledge requires a relatively unchanging environment, complemented with stability and predictability in the case of possible changes in the future, to be effective and thorough when used. (Smith 2001.)

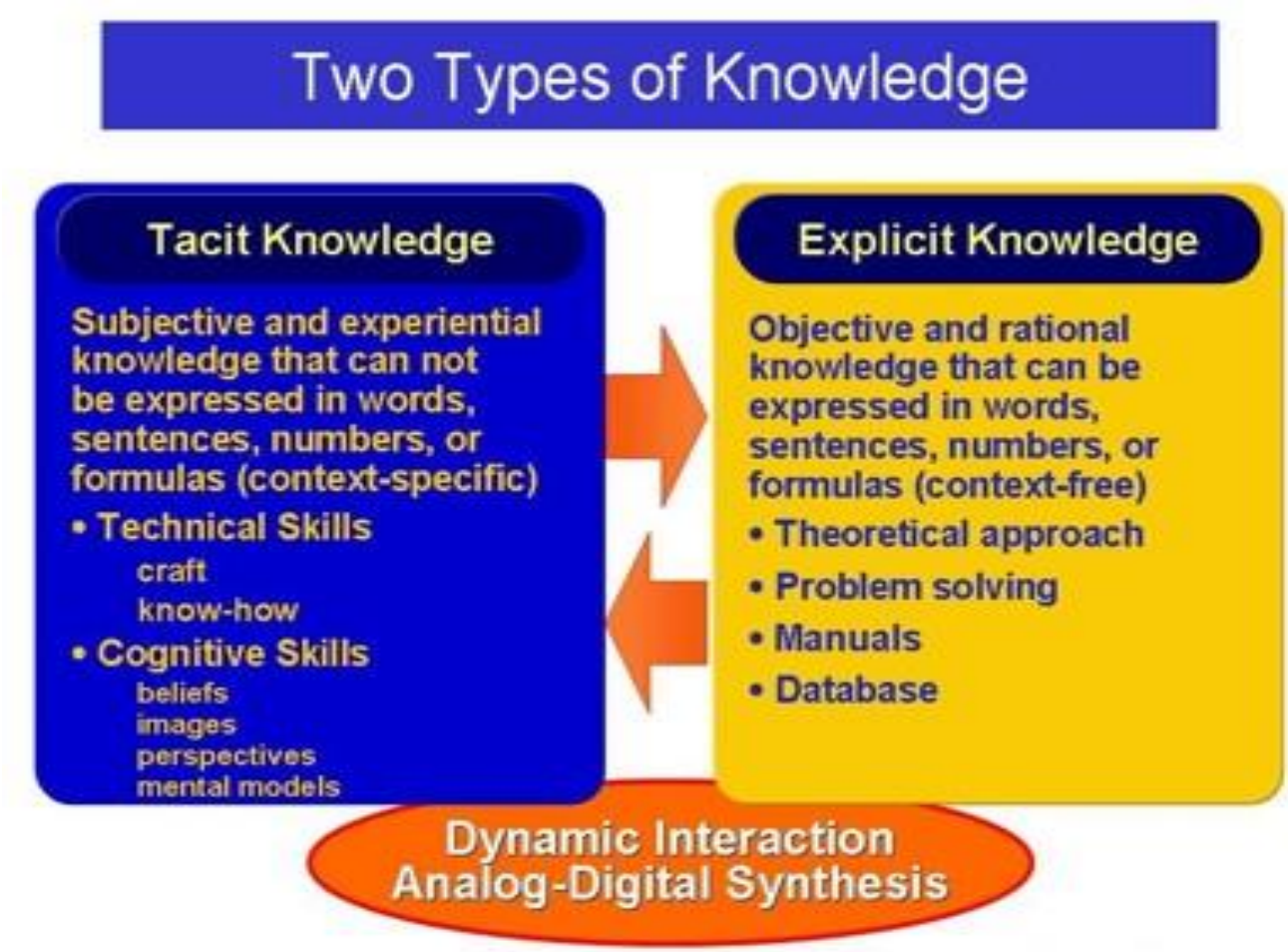
7.2 Tacit knowledge

The idea of tacit knowledge was introduced by philosopher Michael Polanyi, who described it as having knowledge of something without thinking about it, and knowing more than can be told. Tacit knowledge in itself isn't written down or stored in any tangible form but is more of an informal and subjective way of representing the insights, assumptions and perceptions acquired through practical events, such as learning to master a craft through experience by performing the work-related actions of the craft in question. Through these experiences a practical know-how is formed, which can be referenced in future situations of similar fashion for personal insight. (Smith 2001.)

Using tacit knowledge is intuitive and usually done automatically without much though or time spent. Making decisions based on tacit knowledge can be difficult to justify, since tacit knowledge is such a context dependent matter. With enough experience tacit knowledge is represented in the human minds as values and mental models that include: attitudes, skills and expertise, which all are commonly used in both professional and everyday –environments. (Smith 2001.)

7.3 Knowledge management

Sharing tacit knowledge in a workplace can be done by different ways, most common being job rotation, company tours, and word-of-mouth. As with explicit knowledge the teaching is done by experienced people who pass on tacit knowledge by sharing information of best practices by various methods. Although the two aspects of knowledge differ from each other, both explicit and tacit –knowledge should be used to create a balanced relationship of combined knowledge, to assist in achieving professional goals and improving the performance of an organization. (Smith 2001.)



GRAPH 1. Two types of Knowledge. (APO 2016.)

The graph 1 illustrates the relationship of the two types of knowledge, emphasizing the differentiating aspects of each type of knowledge respectively. Synthesis is formed when both kinds of knowledge are used side by side through dynamic interaction, as in: using a product manual and craft skills to manufacture a product. (APO 2016.)

The dynamic interaction consists of knowledge conversion which helps both, tacit and explicit knowledge to grow in quality and quantity when used together. Knowledge conversion has four different ways of interaction:

1. Socialization (from tacit knowledge to tacit knowledge)
2. Externalization (from tacit knowledge to explicit knowledge)
3. Combination (from explicit knowledge to explicit knowledge)
4. Internalization (from explicit knowledge to tacit knowledge)

These types of conversions of knowledge expand and reinforce each other through dynamic interaction. (Nonaka & Takeuchi 1995.)

7.4 Knowledge in work instructions

Creating the work instructions for the milling work station required collecting and analyzing both explicit and tacit knowledge. Vital information is gathered from the process, which is then refined to make the basis for the work instructions. The instructions are a helpful tool to be referenced upon when required their purpose is to preserve and share essential information, as explicit knowledge to guide the organizing of tasks and reducing variance in the environment, and as tacit knowledge to encourage insight and inspire creativity through practical user experience.

8 CONCLUSION

The thesis project began with discussing the needs of the company and determining which of those needs could be included in the theme of the thesis work, as practical and theoretical aspects were mulled over the boundaries for the subject scope started to take place. Defining the objectives required some pondering to include the necessities and excluding the excess to ensure a clear image of what is to be actually done in regards of this project.

At first, a different work station was offered as the subject and after some preliminary research and introduction, it was determined as not suitable for the project. The main reasons for choosing another subject were that it didn't properly respond to the needs of the company and would be lacking in depth as a subject overall concerning goals and objectives for both parties. Next the door frame milling station came up as a potential subject and it showed much greater promise, considering the situation that it had a much greater need for work instructions, it was decided to be the subject of the project.

I haven't really done this type of research before, so I wasn't feeling overly confident in my abilities at the start of the project. At this point there weren't many expectations on how all of this is going end up, since it was mostly uncharted territory for me. Looking back now it seems that the unknown in itself was a bit less obscured than I initially though since more and more familiar issues emerged during the project.

Through background work and learning by doing the project started to take its shape within the predetermined boundaries. The data gathering taught some aspects on the importance of preparation, such as having spare recording equipment and a preplanned frame of what should be covered to obtain relevant material to work on, as well as the value of correct up-to-date information. The ways on what quality can consist of, and how comprehending it may differ based on the perspective gave me a better understanding on the importance and

issues revolving around quality. Certainly the biggest impact was made by the aspects I learned about knowledge, its value, and the ways it appears in this kind of environment, and how knowledge always keeps on evolving.

All goals were not met within the project, such as including more demonstrative elements for guidance, but I'm satisfied with the results since they are still applicable and will be helpful stepping stone when striving towards a better system by implementation and future development. Based on the experiences in this project, which include both pitfalls and strides of progress, I would take a somewhat different kind of approach in the future.

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