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CHECKLIST AND TRAINING GUIDE-LINES

E5x & SGe5

Technology

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I would like to thank the crew of Prima Power, for answering all my questions. Taking time out of their work, to read and correct mine and also showing me in detail how the work is most sufficiently done. It made the learning, research and writing a very joy-filled, educational and valued experience, Thank you!

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TIIVISTELMÄ

Tekijä	Johnny Lärka
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Opinnäytetyö tehtiin Prima Power ryhmän Finn-Power yksikölle. Yksikkö on erikoistunut levytyöstökoneiden valmistukseen. Opinnäytetyön tarkoituksena oli suunnitella ja luoda muistilista sekä koulutusohjeistus yhdelle konetyypin sarjalle, johon sisältyy kaksi eri variaatiota, SGe5 ja E5x. Käytännössä variaatiot ovat samanlaisia lukuun ottamatta SGe5:n leikkaustoimintoa, jota E5x mallissa ei ole. Tästä johtuen koneistettavien osien suunnittelussa ja käytännössä työstettävien kappaleiden irrotusvaihe poikkeaa toisistaan.

Kouluttavan henkilön tulee tämän koulutusohjeen avulla pystyä kouluttamaan koneiden työkalujen käyttöä, huoltoa, kappaleitten suunnittelua sekä kuinka konetta ajetaan turvallisesti, vaikka hänellä ei ole aikaisempaa koulutuskokemusta. Kouluttajan pitää kuitenkin olla koneiden kanssa ennestään tuttu. Opinnäytetyön tietolähteinä toimivat Prima-Powerin omat asiakaskouluttajat, kirjoittajan oma tieto ja kokemus sekä Finn-Powerin jo olemassa olevat vanhat muistilistat ja manuaalit.

Koulutusohjeistus ja muistilista kirjoitettiin käyttäen Simplified Technical English tai STE kieltä. Koulutusohjeistus julkaistaan Author-IT ohjelmassa. Tällä tavalla tiedot pysyvät strukturoituna ja helposti käytettävissä tulevia sovelluksia ja käyttötarkoituksia varten. Koulutusohjeistukseen ja muistilistaan sisällytettiin piirustusten tekemis-osion, vaikka tämän tärkeys tulee olemaan käytännön merkityksen kannalta olematon. Ohjelmoija tai operaattori ei ole todennäköisesti suunnitteleva taho, joten manuaali keskittyy kappaleen piirustuksien jälkeen toteutuvaan työstösuunnitelmien tekemiseen sekä koneen ohjaukseen.

Avainsanat SGe5, E5x, leikkuutoiminto, STE, Author-IT

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ABSTRACT

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The thesis was done for Prima Power groups Finn-Power Ltd. The group specializes in manufacturing of sheet metal machinery. The aim of the thesis was to plan and create a checklist and training guidelines for a machinery series that includes two different variations, SGe5 and E5x. In practice the machinery are similar with the exception of the SGe5 having a shearing option, which the E5x does not. Due to this difference the planning and separation of manufactured parts take place differently.

The trainer should with this checklist be able to teach how to use machinery tools, how to do maintenance, how to design parts and how to operate the machinery safely, even without previous training experience. The trainer however needs to be familiar with the machinery. The information sources used in this thesis are Prima-Powers own customer trainers, the knowledge and experience of author himself and the existing old manuals of Finn-Power.

The training guidelines and checklist were written in Simplified Technical English or STE. The manual is published in Author-IT system. This way the manual stays structured and easily accessible for future applications and usage. The checklist and training guidelines include a blueprint creating part even though the practical importance of this will be non-existent, since the programmer or operator is not likely the designing person. The manual thus focuses on planning the tool-paths and operating the machinery after designing is completed.

Keywords SGe5, E5x, shearing, STE, Author-IT

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1. INTRODUCTION

Prima-Power manufactures a wide range of sheet metal machinery, and as such, the complexity of the design's vary from simple stand-alone products, with only the punching ability, to complex machinery combinations. The flexibility in profitability is thus larger on more complex applications. The objective of this project was to create a direct and individualized checklist and training guideline for two of the less complex and less profitable machines. The simpler the model, the faster and more logical the training must be. The need for better training guidelines on cheaper models is thus larger to ensure profitability.

For all machines there is an operator and a programmer, or a person that does both. So, the need was to make a checklist and training guidelines that views the training from all three aspects and for two different machines, so that the trainer can download and print the simplest and easiest checklist for applying in training.

The training always starts with having the trainees understanding the safe use of the machinery regardless of position. All persons involved with the machinery needs to know possible risk factors and how to avoid them. A major safety issue, not so much for the personnel, but for the machinery is tool assembly and installations. Incorrectly assembled or installed tools, can injure the machinery severely. Thus, this requires all personnel involved to attend.

It is after this the training differs, as the operators continue on to learn the machine control interface called Tulus, and the programmers go on to learn the CAD/CAM program called NC-Express, unless the trainee in question is planned to learn the full system, for which a full checklist and training guidelines for both machines were made. The largest changes are in the using of the program NC-Express, as the planned separation and use of the Shear Genius right angle cutting option removes a large quantity of otherwise necessary punches in the design.

The checklists and guidelines were written in Simplified Technical English /2/, to ensure translatability and understandability. These checklists were to be published in Prima Power intranet using the Author-IT system /1/, and anyone in Prima Power can download them. Thus, they required a very simple language and straight forward informative text, to ensure minimization of human errors because of lacking linguistic skills.

1.1. Brief History of Prima Power

Prima Power division of Prima Industrie group consists of two separate companies leading their own sector, Prima Industrie operating in laser and bending technology, Finn-Power with its servo-electric turret punches with or without right angle shearing technology combined with sheet loading and unloading devices or not. Prima Industrie also has a second division called Prima Electro who focuses in embedded electronics, motion controls, CNC's and high power laser sources /4/.

Prima Industrie developed the first 3D-laser in 1979 and Finn-Power established in 1969, introduced hydraulic crimping machines. Both companies became a leader in their own sector later on. In February 2008 Prima Industrie group acquired Finn-Power group, and in March 2011 the new brand Prima Power was born. All laser and sheet metal products, including services, are sold under the name Prima-Power. New subsidiaries were opened in all corners of the world, Brazil, India, Russia, Turkey, UAE, Australia, Mexico, Korea and USA /9/. Prima Power employs today over 1500 people. The EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) exceeded 30 million € the year 2013. The net sales were during 2013 at 335 million € and net result at 5.3 million € /4/

2. PRODUCTS

The sheet metal machinery faction of Prima Industrie, named Prima Power, is responsible for manufacturing a wide range of products. Some of the products are made in Italy, Turin and some in Kauhava, Finland. The Italian factory specializes in laser and bending products. They currently produce 2D lasers, 3D lasers with or without welding applications, drilling laser applications, precision laser applications and freely moving cutting machines with unlimited working area, that operate on rails fixed to the floor, manual sheet bending machines, automatic bending robots, storage applications and buffer robotics. The factory in Kauhava produces the electro-mechanical punching machinery, both as stand-alone and multipurpose production cells. The company also offers combination solutions. These can be assembled as a full production line, with sheet storage units, punching technology, shear application, bending buffer robotics and automatic bending robot, all in one, as the PSBB or Punching Shearing Buffer Bender /3/.

The products made by this system, if planned correctly and utilized to a maximum, will create assembling ready parts from plain sheets, without manual labor. The operator needs only to start the program and the machine does the rest, only assembly takes place manually.

This system also allows for attaching several production lines to one buffer & bender, so that two punching units feed the same bending robot, as this unit tends to be the fastest.

The 5-series this project is based on is the same punching and shearing units as the PSBB but in a smaller frame that works with a smaller working area and less force, in all other respects the machines are similar. The two smaller types are not, because of their size restrictions, able to work with sheet sizes and thicknesses as large as their larger counterparts can, the smaller frame cannot incorporate the biggest turret of 24 stations, either. All punching units can be fitted with loading

and unloading devices to minimize manual labor. These loading and unloading devices are slightly different than the sheets storage/buffer robot units of the larger PSBB line. However, they work with the same idea, minimizing the waiting time for the punching unit, as the punching unit is the one taking up most of the time in a sequence.

Because of the time consuming nature of a punching unit, they have been developed to do ever more detail rich work. This is the background for the shearing option as well as the more complex tools, such as forming, cluster, rolling and threading tools. The tools of today can be manufactured to specific needs, more or less in any shape. Even the nature of the Z-axis movement of a punching stroke is no longer a problem in making complex tools as the machinery can be programmed to make withdrawal movements to X- and Y-axes while retracting so that the tool does not make a straight up movement and thus destroy any possible forming done on the way down. The punching machines of today can, because of their large quantity and continuous tool development, create some truly complex shapes. Before, some of these shapes might have needed human help, or at least some additional auxiliary devices.

The customers that acquire products from Prima Power usually work in thin metal industry, such as HVAC or in making metal cabinets. Electric component manufacturers are a large part of the customer base, as the cabinets, tend to include cooling holes and other designs that require fairly cheap methods of manufacturing. These shapes would be very time consuming to create, if done manually. The quality of the work would also suffer, when the human factor is involved.

3. PROBLEM STATEMENT

The products that are sold by Prima Power use programs and applications, that are personalized to Prima Power equipment and requires Prima Power to train the operators and programmers of the customers when they acquire new machinery. This training can be done at Prima Power Technology and Training Center or at the customer's facilities, with the machinery they have acquired. This requires a checklist and training guidelines, so that Prima Power can ensure the training quality and equality to all customers. If all customers, operators, programmers and trainers use the same guidelines and checklist the deviations stay small and the time spent training eventually becomes minimized. When the training period is minimized it becomes optimized, and with it, the cost of the training.

The economic gain, provided by the checklist and training guidelines, can be easily argued. Firstly, previously all trainers did the training in their own way and as such the training was fairly individualized and there was no really clear common thread to follow. Secondly, training these things also needed a new trainer to be accompanied by someone who had previous understanding and experience from the training as such. The problem created by this situation is, that the company needs to acquire plane tickets, hotel rooms etc. for two persons to wherever the machine is sold, this can in worst cases be a very costly ordeal, especially on a unit that is cheaper. This checklist and the guidelines allow the new trainer to go by him/herself, provided he/she has experience of the machine in question but not the training part. The save made by the company with this personalized checklist and the guidelines, is the removal of time spent thinking about what to train next and the variable costs created by an extra person traveling with the new trainer. Instead, problem solving or helping (if needed) can be done over the phone.

3.1. Objective

The objective was to create a checklist and guidelines that make the training more time-efficient for the E5x/SGe5 models.

3.2. Research Question

1) How to sum up the information of the machinery, in the simplest and shortest teachable way possible?

2) Which order of teaching information is the clearest?

4. METHODOLOGY

Since most of the information is common knowledge with the trainers, my problem became, to learn from the trainers. Whilst learning, it was important to find out and put the information that they might see as obvious but a new trainer does not, down in writing. However, including all information in one report would in fact make it a manual, and as such would render it useless for training purposes. The checklist needed in training is merely guidelines that keeps the trainer on track and helps him in information flow. Using a machine or program manual for training purposes is impossible. Due to the copious amounts of information the regular manuals involve, the time would be spent trying to find information instead of showing how. With this equipment it would include three different manuals, one for each software and hardware. The manuals are of course part of the training, the trainees and trainers are required to read and understand them before using the equipment, but using them in a training sequence of a few days to a week is not optimal.

4.1. Research Methods

At the beginning of the project it became obvious that both qualitative and quantitative research methods had to be used. Most information and understanding was gained through personal training and listening to the Prima Power personnel explain problems, and the reasoning behind why one should not teach one thing and why one should stress other things. An opportunity came up to learn in the same way as the customer operators do, by one of Prima Power's customer trainers, giving the training. This was the qualitative side, as the learning took place trough observation and enquiry.

After a few weeks the information and knowledge was gained to start using the machinery independently, and at this point experimenting with the machine was started and learning by trial and error. This enabled a proper understanding and

quantifying some of the problems the personnel tried to explain earlier, as several of the problems were encountered. This was the quantitative side of the research.

4.2. Production Methods

This thesis was created with two main focuses, as previously mentioned it needs to be simple and it needs to be easily translatable. This was done by using two important tools. The STE-language, which is Simplified Technical English, and refers to a language created for ASD or AeroSpace and Defence Industries Association of Europe /2/. The basis is that it is a language which excludes a major part of regularly used verbs in the English language to minimize vague explanations and keep the explanations exact and proper. The other tool is Author-IT system /1/ which allows for the re-use of all material and doing so in a structured manner. All information can be simply modified in the base file, thus sources using it is changed automatically, and as such minimizes time used in creating similar manuals for other machinery that have a lot of information in common like the six checklists and guidelines made for this project, as the information in these checklists are similar to a large amount.

4.3. Safety

With every product that Prima Power delivers, it is required to show all personnel involved at the customer where the safety- and kill-switches are positioned, on and around the equipment. The machines are also equipped with an optical curtain that stops any movement if interrupted. These are for the users own safety and for the people in the close vicinity. The equipment uses high voltage and move large masses at high speed that can harm people or other equipment if not properly protected from interference.

5. TOOLS

The punching machinery at Prima Power uses the same basic tools. The tools are made by three main tool manufacturers, Mate, Wilson and Pass, Pass also is a partner of Prima Power /8/. The tool sleeves come in 5 standardized sizes simplified by letters from the smallest A to the biggest E /5/. However, the turrets that Prima Power uses, has E stations as an option only. They are not incorporated in the base design and they are always mounted, not drop-in tools as the rest most commonly are.

All tools have in common five things, the spring-pack, the sleeve, the punch, the stripper and the die. These vary a little in design, depending on the use and what station they are made for. Most new tools have quick locks that are easy to use and make the tools easy to assemble with slots that fit in to each other.

The tools of the machinery have slots and pins in the dies and sleeves to minimize human installing errors, when installing tools in the turret. The main difference is that the A and B stations have a pin in the die deciding the loading angle, whilst the C and D stations have slots in the dies. All punch sizes however have slots in the sleeve for punch tool.

The tools used in this machinery are individual and as such the length of every tool and die needs to be measured before using in the machinery. The length of the punch decides the setting of the idle ram in the machine and with a measure too long it will not go high enough between punches and with too short the punch will not penetrate the sheet correctly. The dies are, as a standard, 30 mm high, but with tool sharpening they will become smaller and as such need to be shimmed in the machinery to the 30mm height. The punch is measured by its full idle length.

The A and B station punch lengths can be adjusted quite easily by removing the sleeve by the quick lock and then rotating it on the threads to adjust the length. With the C and D stations the quick lock needs to be pushed and then rotated. One

should remember that the punch always should be adjusted to be 0.8mm shorter than the stripper, as the stripper cannot loosen the plate from the punch unless the punch retracts in to the stripper.

As mentioned, the Turrets equip five different tool sizes, A – E. The turrets are equipped with, either 16 or 20 stations for these tools. With the 20 station turret, 10 indexable stations sized B – D can be installed, the other 10 must be of non-indexable by nature, either B or C sizes. With the 16 station turret all 16 stations can be equipped as indexable D stations.

Filling a station with just 20 different tools will quickly make the tool amount quite inadequate, and thus we have multitools. The multitools come in several sizes and types. The multitool stations are optional and can incorporate 3 B-sized tools or up to 6 A-sized tools /6/. These are drop-in tools, meaning that they are changeable in a similar way as the regular station. Then there are also the none drop-in multitools where as many as 24 tools can be obtained with 8mm as max diameter, or 8 tools with a maximum of 24mm /7/. However, all multitools and special tools are option only and again might not be in the customer tool repertoire.

6. NC-EXPRESS

Prima Power uses a CAD/CAM environment named NC-Express that allows to create and import 2D-drawings, add tooling, plan part positions and optimize sheet metal work. The program is a simple version created by Finn-Power for the purpose of making everything in one environment. When it comes to the customers of Prima Power, the persons programming and operating the machinery are seldom the same; the NC-Express is the tool used by programmers, and as such this section (6) is not for operators, unless they are receiving a full training, to operate all aspects of the machines.

6.1. Setup

As with all products of a more complex design, mechanically speaking or otherwise, it has become necessary to have a protocol of how to start using the equipment, to ensure the safety of the machinery and the personnel. In this part it will be shortly explained some of the steps needed to insure proper use of the machinery.

6.1.1. Installing

With all punching machinery leaving the Prima Power factory, the customer is also recommended to acquire the program NC-Express. This program needs to be installed in the computer of the operator. This is done by finding the .exe-file in the CD or USB-Flashdrive that comes with the machinery and executing it. It will then install the program properly. It should be remembered that, properly organized folders and names, eases the user at a later stage.

6.1.2. Products

With the new program, when creating folders that will contain the product information used in the CAM programs it should be remembered that it is prudent to have clear and short file paths, as every time saving something new it will become

time consuming to find the right folder if it is not done properly at the start. This being said, a good folder structure and product library is always easier than putting too much information in one place.

6.2. New Program

When opening the program the base window appears with no information yet added, and thus the application 'New Part' will have to be chosen. The program then creates a new part. At this stage normally the drawing of the part required would begin, but as in common situations with customer training. The basic drawing will be explained very shortly, since this part would be already quite common knowledge for any designer and/or programmer. The part focused here is how to use the program after the component has been drawn.

The basic drawing functions can be found in the main menu of the NC-Express and by clicking it the basic drawing functions are available as in any other CAD/CAM environment. It is possible to draw lines, arcs, circles and squares. Also they all include some simple modification tools as extending, cutting and copying. These functions have snap functions which are simple to use when drawing and they also work with one-key fast commands such as 'C' for center, this meaning it will attach to the center of any object clicked on. These snap mode shortcut keys are the same as on other programs.

6.2.1. Import

When the training starts with the NC-Express, The first thing is to show how to import drawings that the customer uses and from there start making tool plans. In the main menu of NC-Express when making a new product it will show the choices New, Open and Import part. The import is a very useful tool, since it allows taking any .dwg or .dxf files directly in to the environment. There is also an optional add on that allows the import of 3D-models and opening of folds in to 2D-models. Having this part in the program allows for accurate drawing copies and as

such removes a large part of possible human errors, as well as speeding up the process a lot.

6.2.2. Export

Similarly to the ability to import drawings, the NC-Express has an export possibility, this allows for rapid sharing and storing possibilities as the drawings as .dwg and .dxf files can be exported.

6.3. Environment

When starting to design a new tooling environment for a new product, customer or project, it is smart to keep them separated from others so that the products do not become mixed in the database. When starting the program the base menu first appears. Here the settings can be opened. In the settings folder there is the environment where you can change material information and change directories. The file path can be changed from directories if needed. In the directories the option ‘zip machine data’ can be found, this tool is an important tool in helpdesk activities, as it allows the customer to send the full machine environment file directly and the customer’s problem can be found on the computer at the office, rather than doing it over the phone by directing, without really seeing the problem first hand. Usually as the training ends, the trainer also takes a copy of the base setup for himself for later reference and problem solving.

When the machine environment has been chosen, the information saved will automatically go in to that working folder, this includes parts, tools, nests and optimizations.

6.4. Tools and Turret

When Prima Power delivers a new punching machine, the turret is empty unless otherwise agreed. If the customer is new in the field of turret-punch equipment, it is likely that the programmer and/or operators have little or no previous experi-

ence with similar tools. If the operators do not have experience, and is new to the machinery, the trainer starts with installing the new turret with tools, and updating the tools in to the program tool library.

It is wise to give the turret a name that reflects the usage area. Give them names that represent the machine used, and/or in case of several machines use positioning names, this way the name of the machine is always linked to the turret separating them from others and there is a database telling what tools are where, thus minimizing un-necessary tool changes, since seldom any customer has two machines with the same exact equipment. When installing the tools one should remember, there are probably more tools than there are stations to be used. During the training and use, the tools will change and an optimal tool set-up is gradually achieved. Remember to keep this updated in the programs also, thus maintaining a tool library that is up-to-date. The punching equipment has intranet connectivity, so the turrets can also be kept up-to-date directly from programming computer if connected.

The customer might already have tools and requires only changes made in to the library, then the installing of tool data becomes much faster unless a large quantity need to be changed. The same principle applies here as with a new turret, keep the tool library updated to minimize human errors and extra work.

When making new tools they should be equipped with tool-specific information, so that they can be used. The tools need a name, the shape, the dimensions, the tool station size, the key/slots of die, the die sizes available, the optimizing group and the operating mode. All these can be added in the tool library.

In the tool library there are 5 basic groups of tools, the round, the square, the rectangle, the obround and the special tools. The first 4 groups are the most commonly used tools, the fifth, the special tools, is a group that includes all tools not represented by the first 4 groups. This includes all rolling and marking tools that the machinery can be equipped with, again optional and not included in the base set-

up. With the special tools the actual geometrical shape has to be drawn, and doing so with the correct measures as they define the tool in the environment.

When the tool library has been updated, the turret needs to be updated with the tools created. In the settings the turret option can be seen, and from it you get the complete turret layout that shows all stations, complete with color coding and what type of the stations it has.

6.5. Tooling

Once the part is finished, and the figure needed to punch out has been imported and drawn, all material settings are made and the die clearances are set. It is ready for applying tooling. First there are some basic things that one might want to think about when applying the tooling, the larger the tool, the less punches it takes to punch out the same area. However, always changing tool for a more fitting one might not be sound, as a tool change takes 15s each time. The machinery can do quite many hits in that time. Also from a production view, if there is a large area that is to be removed, it might not be sound to punch out all of it with tools, as it would be time consuming. Rather let the machine punch out the contour and leave the object attached with micro-joints. The micro-joint is basically a bridge between punches, in a way so that the component stays attached to the sheet. There are two types of micro-joints, the first and better one, is the corner micro-joint which is done by leaving an un-punched area in the corner of a part and thus has a better connection. The other one, that is not so good but still needs to be used in some places, is the bridge micro-joint. This is, as its name states, like a bridge, it is done by leaving an area between 2 punches on a straight surface. The micro-joints, if made properly and in the right size, should keep the parts together until they leave the machinery, but crack open as soon as the fall in the designated sorting shoot.

The NC-Express has 3 or 4 different basic tooling options, depending on, if it is for an E5x or a SGe5, the shearing option will not be in the program of the E5x.

The first one is the punch. This, as the name says, is a single punch. This tool is the one tool used to do most tooling. The punch has a few options in the base menu that changes the attributes of how it is applied. The geometrical surface of the strike can be changed, as a square or rectangle has 4 surfaces. The surface chosen will automatically connect with the line clicked on. It also connects with the corner closest to the clicking point. Once a punch has been made, it can be moved freely in the program. There is a helping function that keeps track of the closest lines to the moving point where the tool geometry was clicked on. This will help with applying the punches. The single point applying points can also be changed to, how they connect to the line. These self-explanatory changes are as follows: nearest vertex, center segment, closest point of segment and center shape. These location choices helps for example with applying round tools to a circle. The center shape function, allows to click on the line of the circle and the tool then applies it to the center of the circle. For the punch one can also choose the click point punch only. This function ignores lines and helping tools and, applies the punch wherever clicked. The function also allows you to change the angle. This tool is useful when destroying excess materials that are not connected directly to the drawn lines.

The second tooling function is the nibble function. This tool is as it states a, nibbling function that, nibbles along the line chosen. The nibble function allows you to apply a series of punches instead of applying all of them manually as you would with the single punch. The nibble, as the punch, have a few tooling choices that helps to apply them. The nibble does not have the segment choices as the punch, as it will always do the full length of the line chosen, but it has the choices of the reverse and micro-joints. The reverse changes the direction of the tool path and the micro-joints applies micro-joints at a predetermined distance, to the width required. The nibbling properties are also very useful, as all hitting distances can be changed to your suiting. The nibble as the punch has the click point function also, which ignores the lines and helping functions.

The third tooling is the destruct. This tool is used to remove large areas at once so there is no need to apply several nibbling paths. The tool is used mostly to, punch out full internal contours. Even though this tool is good, it is not used as much as the first two. This option has, as the previous tooling options, some choices on applying the tooling. With destruct scallop, overlap and notch expansion lengths can be chosen, and of course click point destruct, as with the previous two and it works as them, ignoring lines and helping tools.

The fourth tooling option is the shearing. This tool does not exist on the E5x and as such will only show in the program of a SGe5 machine. This tool is the final tool of all parts done in the SGe5. All parts programmed, have as their last operation a shearing cut. This cut separates the part from the rest of the sheet. As the shearing tools are stationary with the frame, and can move only in the Z-axis, the cuts will always be in the same direction. One linear to the X-axis, and one linear to the Y-axis. The cutting will always take place in rectangular or square formation. This is useful to remember when making the punching program. When programming the two longest perpendicular lines can be left without tooling, and just apply the shearing cut to the part. The part will automatically become sheared at those surfaces, saving a lot of time from punching the same distances.

6.6. Autotool

The NC-Express also has an autotool menu. This function is very useful and learning it is very important, as it can be used as a complementary to the already made tooling, or as a base on which to add on. This means the more complex shapes and routines can be added manually and having done that, it is finished with the autotool. There is again as with many other functions a few differences between the E5x and the SGe5, with the SGe5 a shearing option can be checked, so that it finishes the part with a shearing cut automatically. With the autotool many choices can be made on options previously chosen, such as which turret to use, which sorting address to use and applying alternative angles for the part, which include a new tooling setup, micro-joints, both internal shapes and external

shapes and the information needed for them. There is also a destruct function in the autotool, which destroys internal large areas and/or notches of your settings. Lastly general settings can be chosen for the autotool. This allows to set some rules for the autotool, such as punching and nibbling properties, tool utilization, which is given in percent and single hit tolerances given in millimeters.

6.7. Nest

When a component is drawn and tool paths have been made, the product needs to also be planned on a sheet. This happens by nesting pieces in to a sheet metal environment, which is basically a way of planning component placement on a sheet of pre-determined material and thickness. Several models can be included and varied as much as needed between models and numbers of them. The aim is, to fit as many pieces as possible to one sheet. However, one should also consider how many different models to fit on to one sheet, since the problem with fitting too many different models on to the same sheet is, if one piece fails or if one more is needed of either one, there might be a surplus of the others. Thus creating mass production with different models on to the same nest might not be economically sound.

With the E5x the same parts would need to be separated with at least a tool width, if applied with micro-joints. Without micro-joint's the separation would need to be two tool width's plus enough material between, to keep sheet integrity until removal, or alternatively with part removal after every 'last hit' made..

6.7.1. Global Parameters

As a new nest is started, the program will ask for some information on how to fit the pieces. The program will also ask for material type and die clearance, the material information can be also added at this stage unless done before with new part information. After the basic information has been fed to the program and it has been accepted, the nest menu 'Global Parameters' will appear. Here another difference between the two machines will appear, the E5x has a nest accuracy option,

this number equals to a theoretical grid system the program tries to fit the pieces. The number 1 equals to a grid system of 1mm maximum distances between any components fitted. Usually with large quantities and complex design, this is where the memory of the computer will become the bottle neck, and will give an announcement that it is out of memory. Then it is a matter of just inserting a larger number in accuracy and re-nest for a less accurate and easier nest for the computer. In global parameters other important information needed can be chosen to create an optimal nest, such as the turret used, part separations, sheet margins which means how much of space it leaves on sheet edges, the nesting direction and if the sheet is manually loaded or if it is automatically done by a loading device, this again however is only an optional device.

6.7.2. Part List

Parts can be added to any nest as long as they are the same material and thickness. Already when making the nest parts can be added from the library without any restrictions except the material information. By opening the parts in the part list the amount can be chosen as well as the allowed rotations. This means the computer is allowed to rotate parts to fit them on the sheet and as such might need different tooling, since if a non-indexable tool has been used in a certain angle it might not work if the part orientation angle is changed. One also needs to remember that if more components are requested, than there is room on one sheet, the program will nest the components not fitting to the next sheet with the program, then planning it as two sheets.

6.7.3. Material Sheet List

The largest sheet that can be punched and cut in once is 2500x1250mm, but there is also the possibility of using smaller and longer sheets. When going in the material list folder of the nesting, there the plate sizes can be changed to smaller and bigger, the Y-axis measure of 1250mm is, however the maximum and larger

sheets cannot be taken. With materials longer than 2500mm, the machine needs to do a clamp change to be able to punch at all co-ordinates.

After the nest has been made, the parts still can be dragged and dropped as required, as the computer does not always manage to get them nested in the absolutely most logical way. With large internal shapes for example that are cut out, they can be used for smaller parts, so that the complete internal shape does not become waste. The nest can be altered afterwards also with adding and removing sheets, there is also the possibility of re-nesting only one sheet and the parts on it.

6.8. Optimizing

After the nest is satisfactory, it needs to be optimized. This is where the actual hits in the program are assigned and all double hits, or hits on the same co-ordinates are removed by the program, however they need to be exactly in the same co-ordinates for the computer to remove them. The optimizer differs a little between the machines also, as the E5x does not have the shearing cut, it does not need to handle the remnants as objects. The sheet skeletons are most commonly removed with the parts or as a single skeleton, if not destroyed with punching. In the E5x optimizer there are some choices that include, tool orders, unloading orders, clamp positions and some additional actions.

With the SGe5 there are both the punch and shear optimizations. It differs a little from the E5x, as one gets the previously mentioned remnants handling with the shearing option. This means the remnants can be removed in sizes of your choosing without making changes in the tooling itself, as they can be set as default.

6.9. Modify

The optimization creates a logical tool-path for the tools and this can be changed. If there is a need to change punching orders, one can do so in the modify section. This is useful when thinking about situations where there is a large amount of punches on a sheet in a small area. Punching the sheet is comparable to hitting it

with a hammer, for every punch the sheet becomes a little wider and a little thinner. Thus punching out large areas with the purpose of creating patterns, might be smart to do early in the program, so that when the cold-forming happens it does not affect more important cycles that include important measures. As a general rule however one needs to remember that the cold-forming does not create so many measuring faults, the biggest problem is the tension that is created. This will bending the sheet, and when the bend is too large, the sheet will eventually grab or hit the turret tools or some other narrow place, creating a machine error and stopping the production. The shearing is in this a great tool. Al though it takes time, removing a patterned sheet removes the tension it creates as well. But again this is not an option with the E5x. So, in the program it would be best to separate punches and tooling packages, thus doing a part of the series at one stage and moving the rest to a later stage. Or, the tool path could be changed to a shorter, more optimal one.

6.10. The View Only

The view only is basically the same as modify, with the difference that there is no possibility to change anything in it, but it will show the different co-ordinates and movement paths of the tools.

6.11. Interactive Zones

Interactive zones is a tool that is used to change information concerning the work zones mentioned in the optimization section. The options allows for change in component work patterns and paths, from which punches to do in which zone, to moving single parts from one zone to the other, and of course creating and deleting zones. The interactive zones differ a little between the two machines. The SGe5 allows you to change the pressure-pad positions and type, which the E5x doesn’t. Also, remember that re-doing the optimization sequence always returns the patterns to the default settings.

6.12. Retool Sheet

The retool functions called interactive nest tooling and automatic nest tooling, are quick tools for changing and adding tooling in the nest view, thus not forcing to go to drawing level. The interactive nest tooling acts like a manual option and the automatic assigns the tooling according to the specification. The retooling operations are mainly used to add on punching functions that the computer does not add on by itself, or finds difficult to do.

6.13. NC-Code

The NC-Code is the translation routine the computer does so that the machinery will understand the programming as co-ordinates. When the program is ready, there is the NC-Code tab, which does the translation. After the NC-code has been made, it needs to be accepted and this is done by accepting it in the sheet list. The program then compresses the pictures, tools and general information to a zip-file for the machine so it can be used in the mechanical environment. This is when the actual information is transferred and made NC-readable.

7. TULUS

The control interface of the machines is called Tulus, the program used by the operators, and at this stage the programmers will not be present in the training unless it again is the full training. In this control interface nearly all data can be still be changed if wanted, it is, however, time consuming, so well planned programs eases operations in Tulus. The Tulus interface is also connectable to the intranet and as such can be connected to programming computers. With the computer connected the first thing one should do is to import the turret file, and as such get the exact tools request as programmed by the programmer. This can be done with USB-flash drive also. When installing new tools, the previously measured tool lengths will come of importance. Once the tool length has been added it is equally important to choose the die clearance if not done by the programmer or in case of a change has been made.

When starting the installation of tools in the turret, there are two ways to turn it in to position. Either it is done manually at the turret on the designated control buttons, or it can be done through Tulus. Tulus allows you to choose a station, and then turning it under the ram or to the tool changing area quicker than the manual rotation function.

Once the turret has been turned so that the station the tool change takes place in is at the changing point, it is safe to open the trap door, and open the hatch for tool changing. This also cuts the optical curtain, and needs to be reset after finishing. The tool installing in the turret, is simple and straight forward. As previously explained in the tool section, the pins and slots have their counter parts in the stations. The tool can be installed in the wrong angle, so it should be taken care to see that the tool and die actually point in the same direction and that they are installed in the angle you have programmed. The program does not know where the tool itself is pointing and a tool punching in to a die, installed in the wrong angle, will destroy the tools, possibly the machinery and the material used.

The tools can be installed in the machine already, but in a different station that the programmer has in his file. This is no problem as the program will accept the tool in a new station, and just informs of the accepted tool position, if the information for the tool in other aspects is correct. The program will not accept it if the names are different however, so a good name structure should be kept with the tools. It must be mentioned as well, that the name cannot be longer than 16 characters.

The other parts can also be operated from the Tulus interface. The manual functions panel shows the different manual movement options that can be operated. When an option is chosen it is moved on the +/- symbols, on the control panel.

Within the Tulus control interface, there is also an option called MDA or Manual Data Automatic, from which quick programs can be made in the Tulus for whatever smaller drive routines required, such as driving to loading/unloading points or a reference point. This program is not used to do complex programming or parts, as it is too simple.

7.1. Production

When starting to run a product, depending on if a loading device is used or the sheets are loaded manually, the set-up run needs to be done, which moves the clamps to their right positions and goes to plate collecting point. In the manual loading there is also a pin to insure sheet position. When the set-up run is done, it is a matter of pressing the start button and the program starts punching the components out. One should remember that there is a roller to change the speed in real-time and it is with a new program sensible to do a half-speed run to ensure first that no human errors has occurred while programming and tool changes.

7.2. Shut-Down Procedures

As with most machinery there are shut-down procedures, so also with Prima Power punching machinery. One should remember to never shut down the main power before the computer has had time to shut down completely. This happens by shutting down the Tulus program and then the computer. If not done properly the computer will be affected.

8. CONCLUSION AND RECOMMENDATIONS

I was offered a chance to beta-test the checklist and training guidelines first hand on a customer that had acquired an E5x turret punch. The customer was situated in Estonia, and the information given before leaving was that I was to train two persons in the duration of one week, one programmer and one operator. I was also accompanied by another experienced trainer that could take over, when/if I did not know something and needed help.

Arriving at the customer it became apparent fairly quickly that the operator spoke almost no English. The programmer also was without experience in using CAD/CAM programs. Because of this, I had a perfect beta-testing phase, as the language barrier and the lack of experience in both the programmer and myself, became a very good test on how good my guidelines work whilst training. When a person with fairly little experience trains a person with no experience, the guidelines need to be good and working. The real issue, however was that the customer wanted to start using the machine as quickly as possible, and because the training between the two persons differs, where do you fit in the separate trainings? The trainees will after learning the tools learn different things. Starting with the programmer, the operator waits for you, and vice versa. I did not work out any better way of doing this dual training than when the first program was done, we had to take the operator training in between, so that the operator was able to start working with the first program whilst the programmer starts on the next. This first program was a simple one and did not include all the finer applications possible in NC-Express. The fact that the programmer did not have any more questions than 8 on the last day, of which all questions where something he did not remember, instead of something I did not go through, gave me a fair estimate of him understanding the things we had trained. The operator also, with his rather big obstacle in the language barrier, seemed to understand our training. On this note I do consider the checklist and guidelines an overall success, as it did what it was sup-

posed to do. It gave me something to lean my training on. I expect future trainers to be able use it without problems.

As for recommendations, I would suggest the trainers to explain directly to the customer at arrival that both operator and programmer need to be present the first day, and on that day go through the safety issues and the tools in general. The operator does not need to be present the following day, since this is most certainly going to be focused on the programmer and the operator could do something else during that time. Also, it is prudent to explain to the customer not to expect any products made the first 2 days, so that they do not expect the machinery to start producing as soon as it is powered up.

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