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RENOVATION OF CONTROL SYSTEM OF THE CONTOUR CUTTER FOR EPS CUTTING

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Abstract: We are working on many projects within the cooperation with praxis. One such cooperation was the project of changing the contour cutter control system for cutting of expanded polystyrene (EPS) in PLASTIKA a.s. Nitra. The OEM was composed of hardware from different manufacturers; it was old and served out. For all that the CNC system Siemens SINUMERIK 802D sl had been used as a new control system. The change was made in six weeks and consists of the delivery and assembly of the new servo – drives and control system. Some custom solutions were also made to fulfill the requirements of the customer e. g. 12 bit AD converter for speed control and 8 bit DA converter for temperature control. The cutter has three axes, where two of them are coupled. This problem was solved through a custom postscript, which postprocesses the cutting program. The working – out of the documentation and induction course for the staff was of course certainty. Since our job was done the contour cutter has bigger memory (for storing the cutting programs), it has higher precision and more user friendly GUI. Using a simple CAM system full visual control during a cutting program creation was achieved, which makes the work for designers more comfortable. Furthermore the price was minimized as much as possible to achieve satisfaction on both sides - ours and customers.

Keywords: contour cutter, control system, CNC, SINUMERIK 802D sl.

1 INTRODUCTION

Our job was to renovate control system of contour cutter for EPS cutting (see Fig. 1), which was approximately fifteen years old. The cutter is used for cutting optional 2D shapes, designed in CAD system, from EPS blocks by means of the resistive method using the heated wires. The customer has only a few requirements. The two main requirements were:

1. To renovate the control system in six weeks.

2. To retain the original small control panel for controlling the speed and temperature of the wires, and with the controls of manual movements. This panel is placed directly on the machine.

Some custom solutions were developed during the realization of this project. Some of them will be discussed in further text. The main aim was to design and implement complex control system with user friendly GUI, which will be easy to program, as cheap as possible. We dare to say, that we made it successfully.



Fig. 1. Partial view on the contour cutter

2 THE PREVIOUS CONTROL SYSTEM

The previous control of the cutter was covered by the DMC system GALIL, which has had simple one line display with some function keys for data entry. Memory of this system was very small; it could not save more than 10 programs. At every change of the machining program was necessary to manually adapt it, then connect a computer to the cutter (it was an old PC 286, which must operator bring to the cutter) and load the program into the system. The control system GALIL was connected with servo – drives and servo – motors HAUSER, which provided the axes movements. The logic of the cutter conveyors was controlled using PLC MITSUBISHI, which had also controlled the thyristor units, which controlled the temperature. After approximately five years from the first start of the cutter, an automatic EPS blocks tilter was added. The tilter was controlled by an independent PLC system OMRON.

The need of renovation came into attention after the burn out of the servo – drives HAUSER. The reparation, neither the purchase of a brand new servo – drive was not possible, because of age of the system and because the manufacturer did not exist any more. That is why the customer decided to change the whole control system (both PLCs and the DMC) including the obsolete servo – drives. The simplest solution had has to be found, which was able to replace all three mentioned control systems and furthermore included a HMI.

3 SELECTION OF A NEW CONTROL SYSTEM

According to requirements mentioned above, the need to provide a simple way for the conversion of existing programs and the need of simple operating control the decision to use the NC control system SINUMERIK from the Siemens Company has been made. Siemens offers more types of this system, which are different mainly in the number of implemented functions. After the consideration of all requirements (the number of NC axes, complexity of the system, and the number of I/O) the winner was the lowest type of SINUMERIK, in the concrete the Siemens SINUMERIK 802D sl.

SINUMERIK 802D solution line is a NC control system, which integrates PLC, HMI and NC systems into the one device. With its five axes (two of them could be operated as spindle), it represents ideal control system for lathes, milling machines and drilling machines in middle capability class.

The advantages of field – proven SINUMERIK 802D are combined with merits of the new drive concept SINAMICS S120. (Siemens corp. 2008)

The advantages of field – proven SINUMERIK 802D are combined with merits of the new drive concept SINAMICS S120 [1]. The SINAMICS S120 motion drives control unit is integrated in SINUMERIK 802D sl, this fact makes the commissioning of drives and problem diagnostic much easier. The decision to use two motor modules for our purposes has been made; one single motor module and one double motor module. These modules maintain the power for servo – motors and they are connected to the control unit using the communication interface called Drive-Cliq. This communication interface is used for connecting the in drive embedded position encoders too. Advantages of such configuration are obvious. Such system is easy to assembly, easy for the commissioning, easy to tune and easy to maintenance.

As mentioned above the main advantage of this solution (see Fig. 2) is, that it is totally integrated control system, because it integrates NC system for controlling the cutting process, HMI operator interface, PLC for controlling tilter and process logic and SINAMICS S120 for movements control. The main problems were the cutter mechanical axes configuration and the absence of analog inputs and outputs in the basic configuration of SINUMERIK 802D sl. These are the reasons why it was acceded to development of some custom solutions.



Fig. 2. SINUMERIK 802D sl with peripheries and SINAMICS S120 motor modules

4 INTEGRATION AND ADAPTATION OF THE NEW CONTROL SYSTEM

The cutter mechanical axes configuration and the control axes configuration are geometrically different. While the control axes are perpendicular one to each other, two of the mechanical axes are parallel. The control is done in three axes, where two axes (X and Y) are parallel and their movements are simultaneous. The cutting process is being done simultaneously in two planes XZ and YZ. Control of such configuration offers Siemens SINUMERIK from the version 840D and this option is called „Gantry axes“. (Siemens corp. 2008) This option provides interlock of two axes, thanks to this are their movements always simultaneous and they appear as only one control axis. But this type of SINUMERIK was uselessly expensive and complicated for the project. That is why we had to keep looking for another solution of this problem.

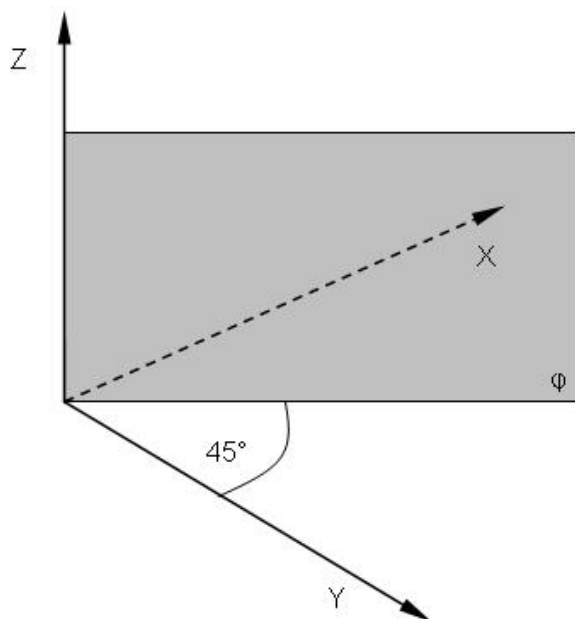


Fig. 3. The cutter operating plane ϕ in 3D space

The program for the NC SINUMERIK is being written as a G – code script. In order to provide parallel movements in the planes XZ and YZ, which are appearing in fact perpendicular for the system, the same coordinates for axes X and Y has to be entered. That means that the programmed contour is being drawn in a plane, which contains a 45° angle with the cutting planes XZ and YZ. This makes no problem by the linear interpolation, because the movement vectors are projected as lines with required length and direction. The problem occurs by the circular interpolation, because in this case the circles are projected into the cutting planes as ellipses, due to this it is not possible to use this kind of interpolation. For better notion you can see the planes layout in figure 3.

The user requirement was to make the conversion of the contour from a drawing to a G – code script, which is suitable for CNC, automatically. Every converter, which is able to convert DXF files used for drawing in the AutoCAD to a G – code script, interprets circles and arcs using the circular interpolation (instructions G02 – clockwise circular interpolation and G03 – counter clockwise circular interpolation in G - code), which is unsuitable for the project purposes. It was necessary to find a way for automatic conversion of circles and arcs to polygons, which could be interpolated as a pattern of vectors using the linear interpolation (instruction G01 – linear interpolation in G - code).

The solution is to use a DXF to G – code converter, which allows to alter the generated script using a method called postprocessing (it is automatic additional altering of generated script).

After a review of abilities of some available commercial and freeware converters, it was decided to use a commercial CAM system called SheetCAM. This software could process drawings in DXF format and generate a G – code script from them, besides of mentioned its postprocessing offers wide range of options. The postprocessing scripts, which are used for altering of the generated G – code script, are written using the Lua programming language. The Lua contains all commands, which are necessary for arithmetic and trigonometric operations, program branching and cycles.

Because the production drawings are drawn 2D in the shape, the first function of postprocessing, which has been made, was the extension of the G01 instructions by a third coordinate.

The second, more complicated function, which had to be created, was a script for converting every instruction G02 and G03 to a pattern of instructions G01. The parameters of the instruction G01 are coordinates of vector end point, while the vector start point is actual position in the machine coordinate system. The parameters of G02 and G03 instructions are the coordinates of an arcs end point and coordinates of a circle mid point. The start point for an arc

or circle is the actual position as by the G01 instruction. For our application is sufficient to represent every circle as a polygon with 1mm long side. Such polygon cuts a circle considering the thermal cutting technology, which the cutter uses. The job of the script is to divide a circle or arc step by step to a relevant count of vectors. This count depends on the perimeter of the circle or arc. A new end point coordinates are calculated using the Pythagorean Theorem in every step of the dividing cycle. The end condition of the cycle is reached when the end point coordinates of the calculated vector are equal to the end point coordinates of divided circle or arc. The principle of the described sequence is shown in figure 4.

The last function of postprocessing was to handle the addition of all necessary instructions and parameters e.g. cutting velocity, coordinate system (absolute or relative), end of cutting program etc.

The resultant G – code script, which passes thru the postprocessing, contains explicitly instructions of linear interpolation. The biggest disadvantage is its size. For example, a circle with radius of 200mm, which could be drawn using one instruction of circular interpolation, is drawn by 1256 instructions of linear interpolation. The difference is obvious and it could be seen that the size rapidly increases. But thanks to the fact that the G – code script is simple text file and according to the system memory size it doesn't make any problem. Even by files, which exceed the size of 100 kB, the control system is able to store thousands of cutting programs. The valuable improvement of the contour design is obvious. The designer just has to draw the desired contour in AutoCAD and convert it in SheetCAM to get the cutting program. There is no need to make any additional changes to the cutting program thanks to our solution.

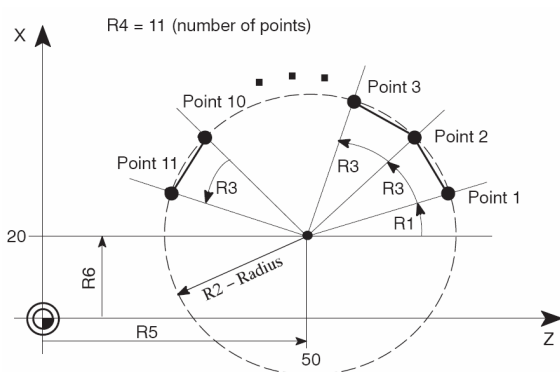


Fig. 4. The principle of circle to polygon conversion (R1 – starting angle of the arc, R2 – circle radius, R3 - unit angle, R5, R6 – circle mid point coordinates) (Siemens corp. 2008)

This way the control system adaptation had been achieved. The control system, which is primary dedicated for perpendicular three axes coordinate system, was transformed into a system, which works in two parallel geometrical planes with one common axes.

To fulfill the requirement of the small panel retention, another customization was necessary. Because the SINUMERIK doesn't have any analog inputs and the speed control on the small panel is realized using a potentiometer, a custom 12 bit AD converter had been designed and constructed. The value from the converter is read and the actual cutting velocity is set according to it in the range from 0 to 200% of fixed cutting velocity, which is preset in the cutting program.

To handle the temperature control of cutting wires according to the cutting velocity, a custom 8 bit DA converter is used, which provides the analog control signal for the temperature controller according to the actual velocity of movements in Z axes direction.

5 CONCLUSION

The customization mentioned above, was made for the customer satisfaction. The complete control system of the contour cutter was renewed in a relatively short time (6 weeks) as cheap as possible. The old – fashioned and non – homogenous control system was successfully changed by the new totally integrated system from one manufacturer.

Finally we dare to say, that our solution brings increase of operator comfort, simplifies the maintenance, improve the precision and reliability of the contour cutter.

6 REFERENCES

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