

## ASPECTS REGARDING THE AIDED PROGRAMMING OF THE ELECTROEROSION MACHINE ROBOFIL 310

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### ABSTRACT

*This paper presents the solutions to some practical issues regarding the design of technologies with the wire electroerosion numerical command machine ROBOFIL 310, produced by the Swiss manufacturer Charmilles. As part of the study an AutoCAD application was designed using Visual Basic and the .NET platform, aimed at helping the designer identify the minimum radius of a contour before sending it to the machine*

### 1. Introduction

The electroerosion phenomenon is used in some high performance technological procedures, especially in the fabrication of dies and molds. This phenomenon consists of the dislocation of material from two electrically conductive objects with different electrical potential. When the two objects are brought close together an electric arc that travels through the dielectric material (air, water, oil) between them is produced and a certain quantity of material from each of the objects is released. To remove the dislocated material one uses currents of liquid inside the existing dielectric.

This destructive phenomenon was studied and optimized to be used constructively. Thus the electroerosion machines using massive electrodes or wires have emerged. The massive electrode machines use a copper or graphite electrode that forms a cavity inside a metal piece in the electroerosion process.

The wire electroerosion machines are more sophisticated in that the electrode is a wire with the

of 0.15 – 0.3 mm. For these machines it is necessary to program the wire trajectory which can be a complex task. ROBOPROFIL 310, on which the procedures described in this paper were tested, is such a machine.

### 2. Programming possibilities for ROBOFIL 310

The programming of the numerical controlled wire electroerosion machine ROBOFIL 301 can be done both manually (for simple contours) and computed aided. The machine incorporates a software named AlphaCAM that implements a geometric processor for describing the contours and a post-processor for the output CNC code. It also offers the possibility to import contour geometries from other CAD applications in the format of .DXF or .DWG files. Our main focus in this paper will be in this direction. The possibilities of programming the machine are synthesized in Figure 1.

Of all these programming alternatives this paper

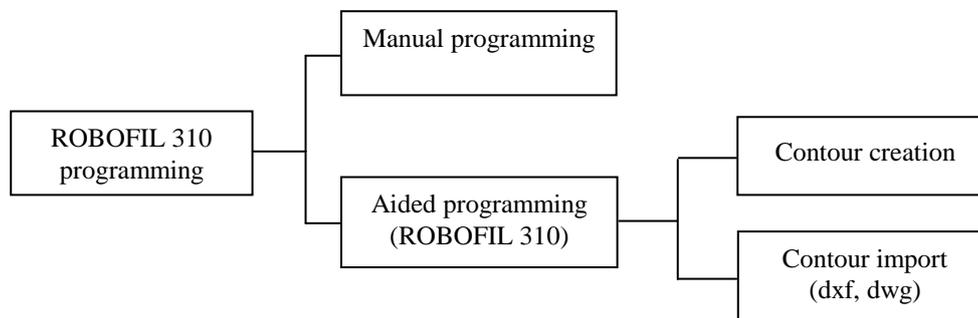


Figure 1. Programming alternatives.

diameter of merely 0.1 – 0.25 mm, continuously running through the interaction area with the piece being worked out. The result is a gap with the width

will deal with the aided programming using imported contours from AutoCAD. This situation is very common because the contours to be programmed

often come from projects conceived in AutoCAD. AlphaCAM has the possibility to import data both in .DXF and .DWG format.

The most straightforward approach is to copy the contour in a new AutoCAD drawing and then save it as a data exchange file (DXF) using the command *dxfout* or *Save As*. The saved contour is then

In the first case (left) – part of the contour (corresponding to the minimum radius) was lost;

In the second case (right) – the wire cuts outside the programmed contour.

In both cases the resulting piece is a waste. This can happen without notice, some numerical controlled electroerosion machines do not signal the

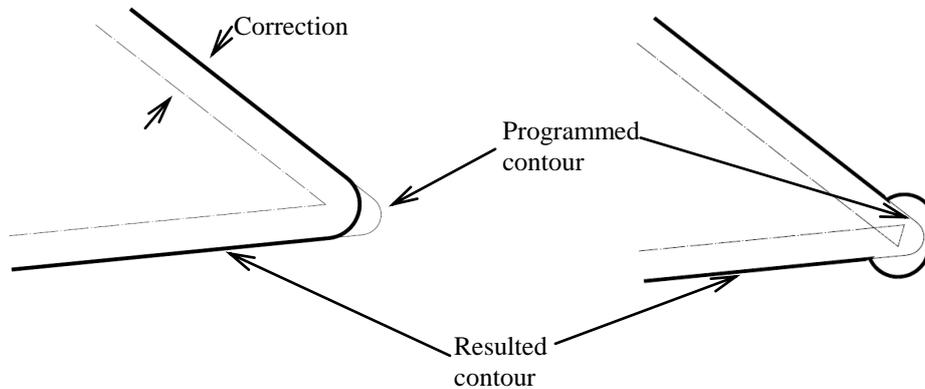


Figure 2. Errors caused by the radius being smaller than the correction.

imported in AlphaCAM where the CNC program is written with the help of the post-processor named *Charmilles 2 simple axes*.

One major problem that the CNC programmer needs to address is the generation of the contour with the dimensions given in the drawing by applying a correction to the trajectory equal with half the width of the cutting gap. It's possible that one or more radii of the contour are smaller than the applied correction. In this case the wire electroerosion machines present

fault. For example Figure 3 presents a case where the radius is smaller than the correction in the case of a die. Both the upper die and the cutting plate were processed using the same trajectory but with different corrections.

It can be observed that the upper die was fabricated properly because the correction was applied in the exterior but for the cutting plate the correction had to be applied on the interior which led to the effect described before.

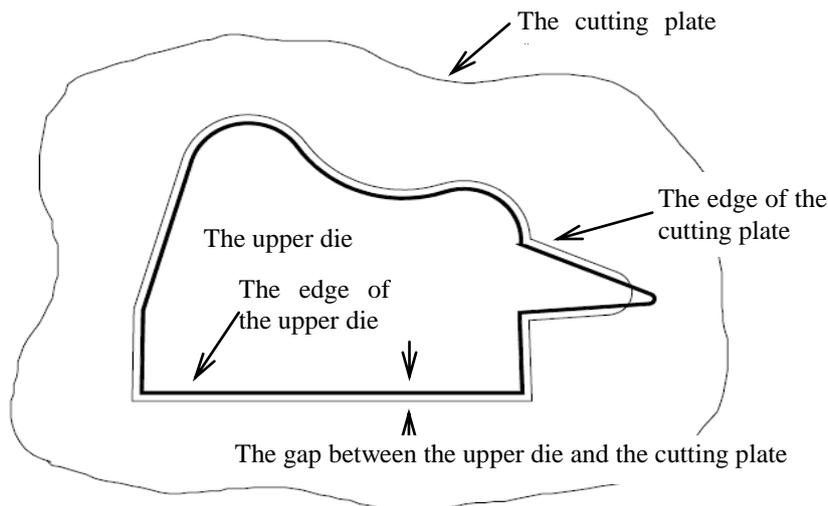


Figure 3. The upper die does not fit into the cutting plate.

one of the behaviors presented in Figure 2.

Considering this manufacturing belongs to a cutting plate it can be observed that:

Some newer numerical command electroerosion machines signal when such an error is possible to happen but this problem shouldn't normally be

allowed to get to the manufacturing stage. Instead, it should be dealt with in the design phase.

To overcome the above problems two aspects have to be considered:

- a) If the programming of the cutting plate contour was made using the machine software AlphaCAM the programmer has to be careful not to use radii smaller than the correction.
- b) In the case the contour is imported from AutoCAD (the one considered in this paper) this needs to have all the radii greater than the correction. It's worth noted here that typically the person designing the contour in AutoCAD is not the same as the CNC programmer. To solve the problem presented the solution proposed by the authors consists in a AutoCAD application written in VB.NET that assists the programmer finding and manipulating the radii of a polyline (the contour) that are smaller than a given correction.

### 3. The „R minimum” application

This application was designed to work under AutoCAD determining all the radii of a selected polyline that are smaller than a value introduced by the user, representing the correction.

As it's well known ([1], p.2) each AutoCAD entity has a list attached containing all the information (including the geometric ones) about that entity. Each parameter of the entity has a code and can be accessed with specific constructs of the VB.NET language.

In order to be able to access programmatically the

libraries needed are *acadmgd.dll* and *acaddbmgd.dll* and can be found in the AutoCAD main installation directory.

As all AutoCAD entities, the polyline is represented in VB.NET as an object. Considering the object oriented paradigm of .NET languages, the polyline parameters are accessed using the methods and properties of the polyline object. The main information about the polyline is obtained by querying its nodes, called „vertices”. The vertices have an associated property called the „bulge” (code 42 in the file database), its value determining the radius of the following segment of the polyline. The bulge can be zero, in which case the segment starting from the node is a line segment or it can have an arbitrary value in the case of an arc segment.

The bulge represents the tangent of the quarter of the arc central angle between its extremities.

$$\text{bulge} = \tan(\alpha/4)$$

where,

$\alpha$  – the central angle of the arc between its extremities (Figure 4).

In order to determine the coordinates of the center and the radius for the arc P1P2 we need to inquire the polyline object and its properties.

According to [1], p.3 the radius and the center of the arc P1P2 are calculated with the formulae:

$$r = \frac{x}{\sin \frac{\alpha}{2}} \quad (1)$$

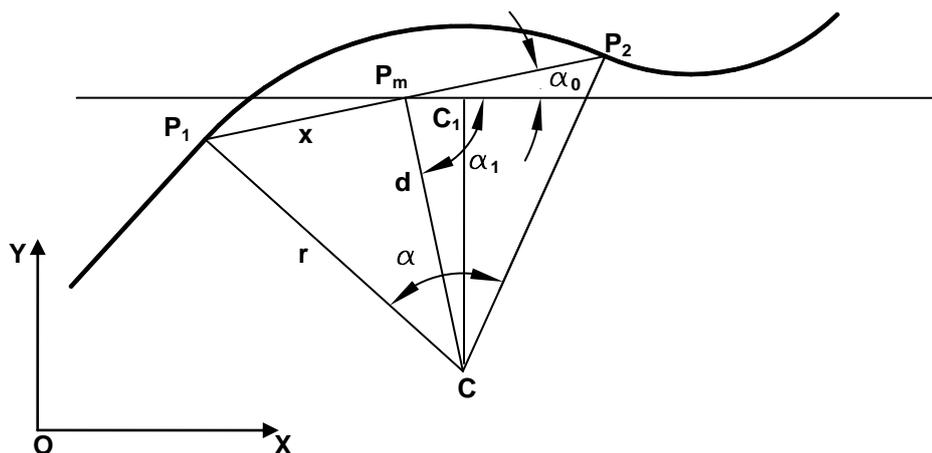


Figure 4. The geometric parameters of an arc belonging to a polyline.

AutoCAD object model from VB.Net code it is necessary to load the namespaces containing the managed libraries offered by Autodesk. The two

$$\begin{aligned} x_c &= x_m + (\text{sign}(r)) * d * \cos \alpha_1 \\ y_c &= y_m + (\text{sign}(r)) * d * \sin \alpha_1 \end{aligned} \quad (2)$$

The application iterates through the list of vertices associated with the selected polyline, displaying their coordinates and their radii (calculated as presented above) in a list box control. The application allows the input of a value for the correction and highlights both in the drawing and in the list box the arc segments with a radius smaller than this value. At the push of a button the application then changes those arc segments so their radius matches the correction.

To launch the application the user needs to load the application library using the AutoCAD netload command which prompts for the dll file representing the library. Once the library is loaded the command „rmin” can be invoked like any AutoCAD native command and this starts the dialog representing the user interface of the application. All the features described above are accessed from this central point.

#### **4. Conclusions**

This paper presents the solution to a technological problem for the numerical controlled wire electroerosion machines. The problem refers to the connection between the minimum radius of a contour and the correction the wire trajectory needs. The

results were verified on the machine ROBOFIL 310. The original aspect is the manipulation of the AutoCAD database using the object oriented language VB.NET in order to solve technological problems. The use of the application is very simple, it runs like a native AutoCAD command. By using this application the designer of the piece contour verifies if this is technologically correct so that when it reaches the manufacturing phase the errors caused by the minimum radius are eliminated. After this operation the contour can be exported in DXF format and sent to the technology design workshop.

The method can be used as a model for other applications based on the inquiry of the AutoCAD database, an inexhaustible source of valuable information.

#### **5. References**

- [1] Mocian, I., Cazacu, R., *New advances in application development for the AutoCAD environment*, Proceedings ...
- [2] \*\*\*, VB.NET Documentation.
- [3] \*\*\*, AutoCAD Documentation.
- [4] \*\*\*, ROBOFIL 310 Documentation.