

## USING UNCONVENTIONAL TECHNOLOGY IN STAMPING SHOP

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### ABSTRACT

*This article deals with technological possibilities in production of sheet metal in a stage of development-testing, when a shearing tool for serial production is not yet available. In the case of production of irregularly shaped functional samples unconventional technology can be used, especially WEDM (wire electrical discharge machining) method. This electroerosion technology of machining is still underutilized in stamping shop and its potential diffusion in small scale production can bring along significant economic savings during the stage of technical preparation of production. The issues of production of pressing tools necessary for cutting irregularly shaped blanks including optimisation of placing irregular cuttings in the plan at table or at roll sheet could thus be eliminated. By processing multiple layers of material at the same time, the unconventional technology allows producing a set of cuttings in one process.*

**Key words:** *blank sheet, wire electrical discharge machining, programming, ISO code*

### 1. INTRODUCTION

Blanks, e.g. metal blank sheets, manufactured by traditional cutting are common basis for the drawing technology. If the desired curves are of regular shapes the production shall be smooth even considering the positioning in cut-in plan. The shape and size of respective blank sheet, for example for purposes of drawing of hollow cylindrical shapes are specified in the ČSN 227301 standard. The parameters of hollow square shapes are specified in the ČSN 227303 standard. If the curves are of irregular shape (typically in case of a shape container), which is not normalised, the so called “cutting method” can be applied. Due to drawing, caused sheet metal’s extension and its anisotropy the method is, however, very laborious, especially with regards to determining the extended surface line of the irregular shaped component. The maximum shear stress method can be eventually applied as well. This method usually brings better results than the one in which the

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desired shapes are determined by cutting. Resulting blank sheet is of smaller surface which translates into partial material savings. More significant savings can be however achieved if so far not wide spread unconventional technology such as electro-erosion machining method is employed. To certain extent this method can be substituted by laser or plasma beam machining. The irregular shape in question (shape container) can thus be manufactured smoothly and cost-efficiently.

Looking at the method from the big picture, it will perform well in a small scale production when only a few (up to ten) sample products are needed, and also in consequent test series reaching quantities up to hundred pieces. Wire electrical discharge machining (cutting) also allows changing the input parameters if the drawing process requires it, by adjusting or by complete replacement of the desired shape of semi-product's flat contours. In the test series up to fifty blank sheets can be combined and executed within one cut. Required accuracy is achieved without finishing cut.

A solution for the "shape container" blank sheet is outlined on following pages. Adequate unconventional technology for given task, performed on duralumin sheet of 1 mm thickness, is the laser or plasma beam separation technology. The beam technology achieves lower accuracy, making separate cutting of each individual blank sheet from starting sheet necessary. Despite that, the laser technology is more productive [1], [2], [3], [4], [5], [10], [11].

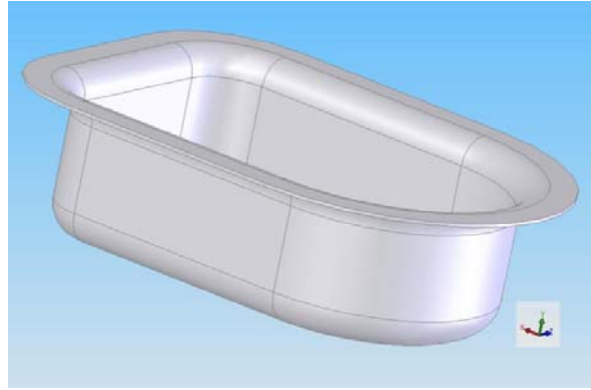
## 2. EXPERIMENT

The experiment was conducted on electro discharge CNC wire cut machine MAKINO EU64 [6]. The NC control programs are created in the Wire Cut software. The software is equipped with CAD, CONIC, TECHNO and NC-SIM program units. The first step consists of designing a 3D model of the desired workpiece (the CAD unit). This model then serves as a basis for a creation of a pattern (via dedicated program PAM-STAMP), out of which only its contour path is utilized (the CONIC unit). Finally, the NC program is set according to the parameters of the path (the TECHNO unit).

Before the cutting process itself was started, a simulation through the NC-SIM unit took place. The simulation shown positive results and the electroerosion cutting cycle could be initiated. The technical parameters of the machine in charge are listed in table 3.

### 2.1 Creating the 3D Model

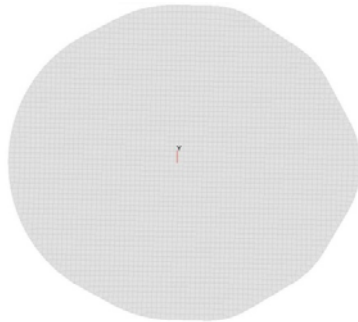
The final CAD-designed blank "shape container" is outlined in figure 1. As figure 1 suggests, the final shape is rather simple. It consists of linear sections and rounded arches. Figure 2 shows the blanks' shape in spatial projection. The figures depict the shape of the blank sheet. If minimal amount of scrap leftovers during the final stages of large scale production is required, the final shape of the blank sheet will be very irregular and any preceding simulation will need to be adjusted according to the real situation.



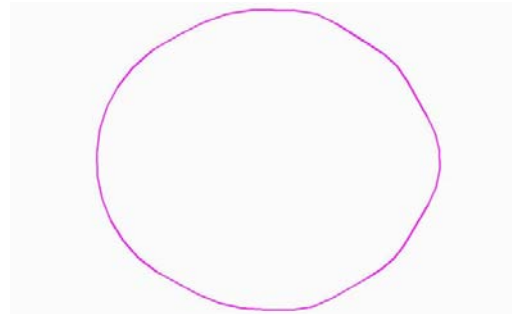
*Fig. 1 - 3D model of the shape container blank*

## 2.2 Designing the pattern

Figure 2 shows the PAM-STAMP generated pattern. The pattern was originally developed in cooperation with TPL Ltd. In the experiment it is used as a basis for determining the circumferential contour by means of linear sections and rounded arches.



*Fig. 2 - Generated pattern*



*Fig. 3 - The path of the electro discharge machine tool*

## 2.3 Determining a path for the cutting process

During the cutting process itself the electrodischarge machine tool will follow a path determined by the contour of the shape container pattern. The basis for the path is the pattern depicted in figure 2. The outer limits of the path are represented by a 212 x 180 mm rectangle.

The contour is necessarily distinct from the original 3D model. Consisting largely of linear sections and rounded arches it is mostly of elliptical shape. The path's data are saved in a DXF file, which is a standard format used by most of the CNC operated machines. When visualised, the DXF file is converted into a JPG file while the colours are inverted (see figure 3). A path designed in this manner can be relatively easily adjusted according to actual results as they emerge during the drawing operation [12], [13].

## 2.4 NC program

Table 1 shows the ISO programming functions and addresses [14] that appears in the NC program. In some cases their meaning differs from the one used during standard conventional machining.

*Table 1 Meaning of selected ISO functions*

ISO function	Meaning	ISO function	Meaning
O	NC program's title	G40	Diameter correction cancellation
G92	Starting point set up	M17	Generator on
M6	Wire threading	M0	Stop
G01	Linear interpolation	M30	Program end point
G03	Circular interpolation (CCW direction)	L1	Wire threading cycle subprogram
G42	Right equidistant line	E90	Technology selection (erosion parameters)

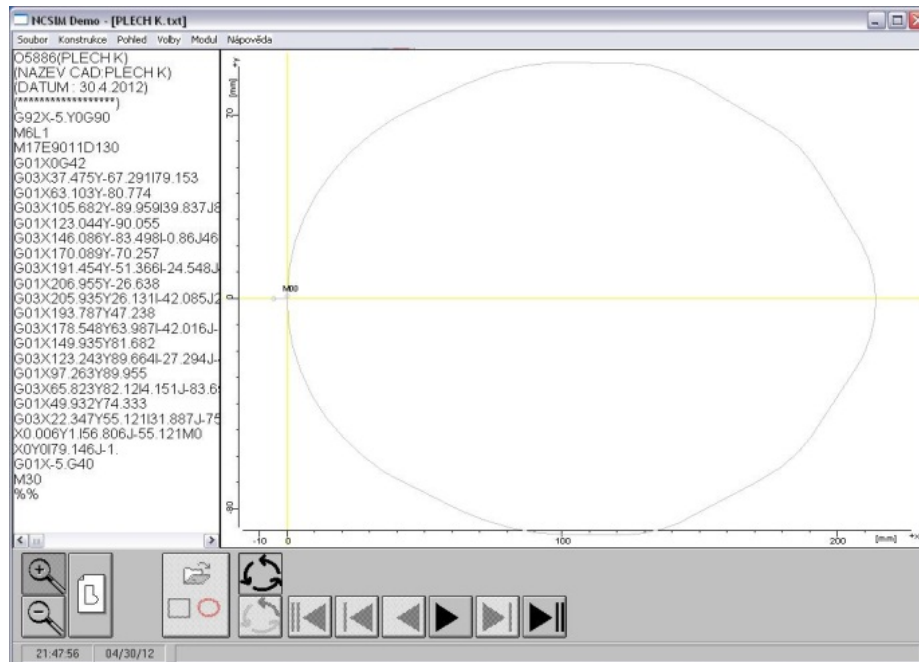
TECHNO unit generated NC program is shown in table 2. It deals with production of the respective workpiece by means of a single stocking cut.

*Table 2 The NC program*

O5886(SHEET K) (NAME CAD: SHEET K) (DATE : 30.4.2012) (*****))	G01X206.955Y-26.638
G92X-5.Y0G90	G01X149.935Y81.682
M6L1	G03X123.243Y89.664I-27.294J-42.652
M17E9011D130	G01X97.263Y89.955
G01X0G42	G03X205.935Y26.131I-42.085J25.58
G03X37.475Y-67.291I79.153	G01X193.787Y47.238
G01X63.103Y-80.774	G03X178.548Y63.987I-42.016J-22.921
G03X105.682Y-89.959I39.837J81.385	G03X65.823Y82.12I4.151J-83.654
G01X123.044Y-90.055	G01X49.932Y74.333
G03X146.086Y-83.498I-0.86J46.788	G03X22.347Y55.121I31.887J-75.194
G01X170.089Y-70.257	X0.006Y1.156.806J-55.121M0
G03X191.454Y-51.366I-24.548J49.291	X0Y0179.146J-1.
	G01X-5.G40
	M30
	%%

## 2.5 NC program simulation

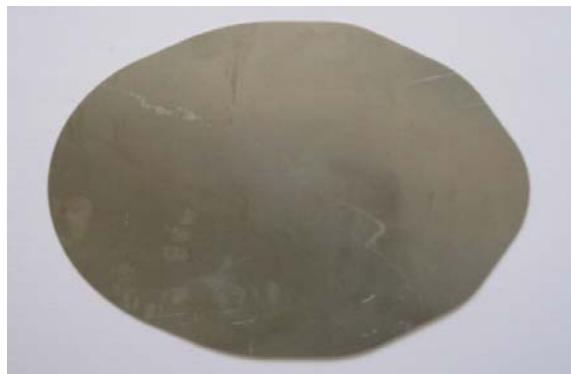
The NC program simulation was executed at the NC-SIM unit. Among other things, the unit allows to capture a static screenshot. Figure 4 provides an example of such screenshot including the final movement of the electroerosive wire together with entry to and exit from the blank sheet's final contour. The text box shows the above mentioned NC program (see table 2).



*Fig. 4 - The NC program simulation*

## 2.6 Manufactured sample

A millimetre thick superduralumin metal sheet was used as a semiproduct for the sample. On the surface of the sheet there is a special foil, which allows productive processing also by another unconventional technology, e.g. laser beam cutting. Material characteristics of the semiproduct are as follows: proof limit  $R_{p0.2} = 230$  MPa, ultimate drawing strength  $R_m = 400$  MPa, ductility  $A_{80} = 10$  %. The sample is depicted in figure 5.



*Fig. 5 - Manufactured sample*

An aperture of 3 mm diameter marks the entry point of cutting. The entry point can be seen in figure 6 (rotated by 90° vis-a-vis figure 6).



*Fig. 6 - Cutting entry point close-up*

## 2.7 Selected technical parameters of the machine

The electrodischarge wire cutting machine was manufactured by Japanese company MAKINO. It is a mid-sized machine which achieves high accuracy and surface quality [7], [8]. The selected parameters are listed in table 3.

*Table 3 Selected technical parameters of the machine*

Parameter	Value	Parameter	Value
Travels in X, Y, Z axes [mm]	600, 400, 260	Applicable wire diameters [mm]	0.20; 0.25; 0.30
U x V travel [mm]	+/- 75	Maximal turning angle	+/- 15° / 100 mm of thickness
Work table size [mm]	920 x 600	Positioning accuracy [mm]	+/- 0.0015
Maximum weight of a workpiece [kg]	1500	Repeatable accuracy [mm]	+/- 0.0015

## 3. INTERPRETATION OF OUTCOMES OF THE EXPERIMENT

The introduced path designing practice simplifies and streams construction and testing of a die. In the production process, the die precedes the drawing itself. It needs to be acknowledged that even the most accurate correction cannot guarantee sufficiently accurate final shape of blank sheet. The finalizing contour cutting operation cannot be therefore omitted. Corrugation of the peripheral parts of the stamping can nevertheless be reduced by a drawing-wise optimal blank sheet [9]. Despite being far less accurate than electroerosion, under certain circumstances the unconventional laser beam cutting technology seems to be the suitable method for the task. At the accuracy of ca0.15 mm the blank sheet can be produced far more efficiently than by electroerosion. Large scale deployment of this method can however be constrained by logistic as unlike the electrodischarge wire machines the laser beam cutting tools are rather rare in contemporary tool rooms.

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## 4. CONCLUSION

The key benefit of introduced method is a profound time saving in preparation of a prototype sample as the method does not require a precise cutting tool in a situation when the final shape of the blank sheet's contour is not yet known. Each change of the contour then does not bring along need for new solution and for production of a die. The method can also be successfully employed for production of a test series. When producing ca 50-100 sample pieces the electroerosion method with its ability to cut more layers of material at the same time proves useful. Apparently, the electroerosion parameters would be different when producing 1 sample piece of 1 mm thickness and when producing 50 pieces of overall thickness ca 50 mm. This yields to different duration of the electroerosion process.

## ACKNOWLEDGMENT

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## PRIMENA NEKONVENCIONALNE TEHNOLOGIJE U OBLASTI OBRADJE LIMA

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### REZIME

*Ovaj rad se bavi tehnološkim mogućnostima proizvodnje u fazama, u slučajevima kada alati za serijsku proizvodnju nisu dostupni. U slučaju proizvodnje nepravilnih delova mogu se koristiti nekonvencionalne tehnologije, kao što je WEDM (elektro-erozivna obrada žicom). Problematika proizvodnje alata za oblikovanje delova nepravilnog oblika putem ove tehnologije je opisana u ovom radu. Ključna prednost ove nekonvencionalne metode je ušteda u vremenu prilikom izrade prototipa, jer ovaj metod ne zahteva precizne alate rezanja u slučaju da tačne dimenzije zahtevanog radnog dela od lima još nisu u potpunosti definisane. Svaka promena u konturi ne zahteva izradu novog rešenja za izradu alata. Prilikom proizvodnje 50-100 test delova elektro-erozija se pokazala kao veoma uspešna, pre svega zbog mogućnosti da vrši rezanje materijala na više slojeva istovremeno. Ipak, elektro-erozivna obrada je i dalje nedovoljno korišćenja tehnologija u pogonima i u slučaju maloserijske proizvodnje može doneti velike uštede.*

***Ključne reči:*** *lim, žica, elektro-erozivna obrada, programiranje, ISO kod*