The 40th International Conference on
Mechanics of Solids, Acoustics and Vibrations &
The 6th International Conference on
"Advanced Composite Materials Engineering"
COMAT2016 & ICMSAV2016
Brasov, ROMANIA, 24-25 November 2016

DETERMINATION OF THE DRAWINGS OF BENT METALLIC PRODUCTS ACHIEVED ON CNC MACHINES

Neta PUŞCAŞ (POPESCU)
Technical College of Architecture and Public Works "I.N. Socolescu", Bucharest, Romania,
e-mail: netapops@yahoo.com

Abstract: *This paper continues the research and studies on determining the drawing of the bent metal components. In the study were obtained the bending coefficients of metal parts of steel sheet type OL 37 with 2mm and 2.5 mm thickness.*
The geometry of the bending tools and their dimensions represent important variables that can influence the quality and conformity of the products created with digital control machines.
Keywords: *bending, metals components, digital control machines, the drawing (the single parts), quality.*

1. INTRODUCTION

The needs of the customers are being met with offers from the producers in a market that is growing in dynamic. In a strong competitive environment, with limited economic resources, the producers must find answers to questions like: What? How much? How? For whom? Why? - to produce [1]. The permanent feature and fluctuating tension between unlimited human needs and limited resources (rare) determine different rational behaviors. In both cases the comparison is made between the attained effect and the effort made.
The rational behavior of the consumer makes him choose the economical product that can offer maximum satisfaction with minimum expense (minimizing the effort).
The customer compares the side utility of the additional product bought with a monetary unit represented by the price.
The rational behavior of the producer determines him to manufacture a higher quantity of economic goods with his limited resources.
His goal is to minimize the expenses for obtaining a maximum profit.
The quality of the products and services as an expression of utility, guaranties a quality production and an exceptional staff, contributing to the development of the organization.
From Armand Vallin Feigenbaum's perspective, it is necessary to integrate efforts in all manufacturing stages (effective system) to create, maintain and improve quality[2].
The creator of the Total Quality Control (TQC) concept, Armand Vallin Feigenbaum considered that a total client satisfaction is made with efficiency.[3].
Quality management becomes important, a concept that is based on different rules than traditional ones, has the purpose of ensuring quality products [4].

2. TECHNICAL REQUIREMENTS

In this paper, the studies and research were conducted on bending marks made out of metal sheets OL37 with a thickness of 2 mm and 2.5 mm. The geometry and dimensions of the tools used in the bending process, influence the precision and quality of the components manufactured with digital control machines. The wearing of the tools and their misuse can determine the development of unknown forces (force of friction) that negatively influences the creation of bent metal marks [5].
The method used to determine the bending coefficients is based on the experimental trials and measurements. The purpose of this research is to tabular highlight these bending coefficients and their usage in the design and manufacturing of metal marks.

2.1. Cutting semi-manufactured materials with CNC machines

The semi-manufactured cutting is obtained with two CNC machines:

1. Hydraulic guillotine scissors type CNC HVR 3100x10;
2. Stamping machine TC 200R.

The semi-manufactured materials, made out of metal sheet OL37 with thickness of 2 and 2.5 mm were cut with the hydraulic guillotine scissors. They were the base of the research to obtain evidence using the bending digital control machine.

The ideal bending coefficient obtained by experimental trials and measurements, were used to calculate the drawings of the samples. Fig 1, Fig 2 and Fig 3 show the drawings for samples 4, 5 and 6 made out of metal sheet OL37 with 2 mm thickness.

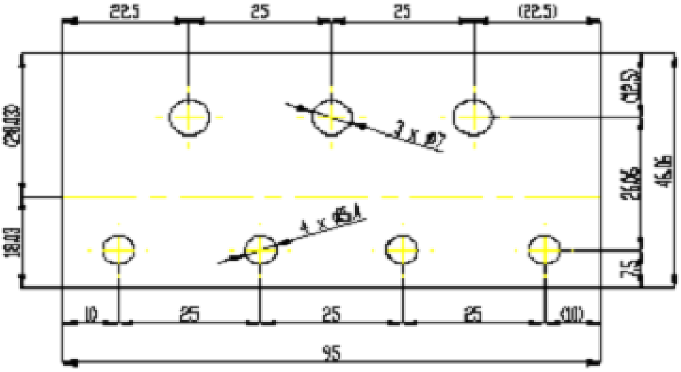

Figure 1: The drawing of the sample no.4

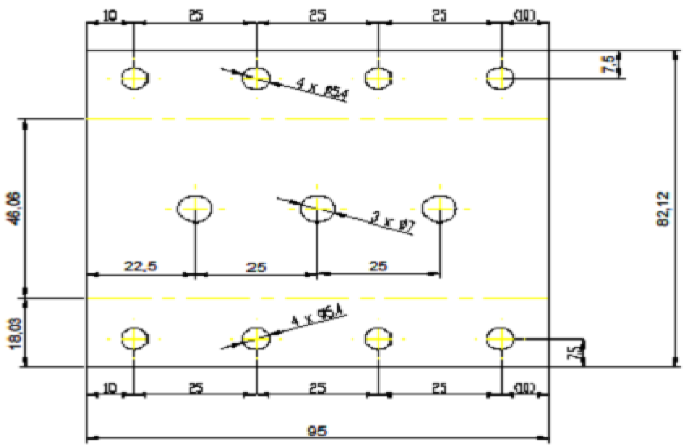

Figure 2: The drawing of the sample no.5

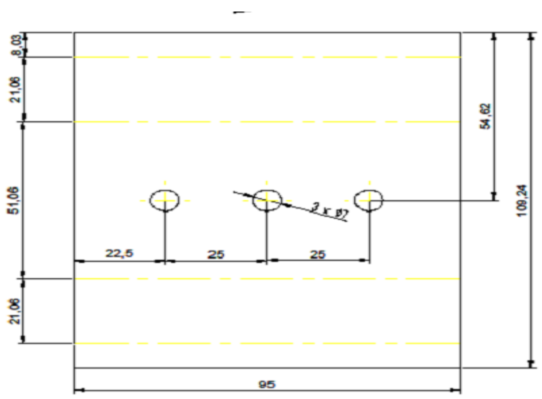

Figure 3: The drawing of the sample no. 6

The drawings of the samples 7, 8 and 9 metal parts of steel sheet type Ol37 with 2.5mm thickness are presented in Fig. 4, Fig. 5 and Fig. 6.

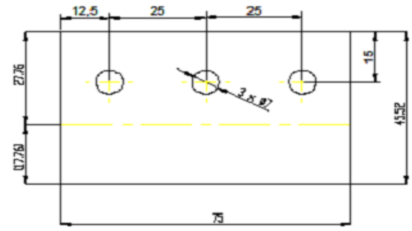

Figure 4: The drawing of the sample no.7

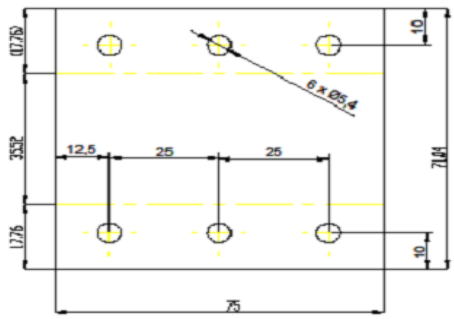

Figure 5: The drawing of the sample no.8

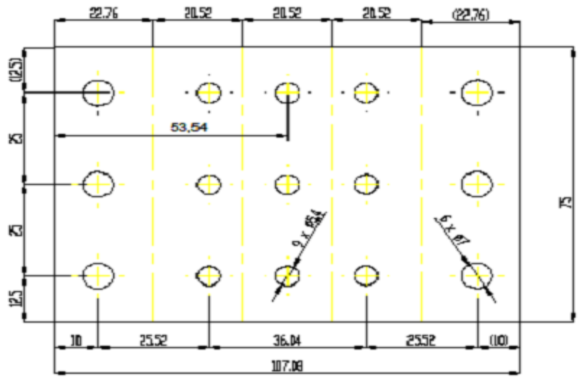

Figure 6: The drawing of the sample no. 9

In AutoCAD have designed the drawings parts were imported into the Drawing module of the ToPs 300. The program used for processing (Punching Programming in Tops 300) was exported in the stamping tool program TC 200R for processing the components [6].

2.2. Bending the semi-manufactured materials

Bending the stamped drawings (samples 4, 5, 6,7,8, and 9) is made with a hydraulic bending digital press machine type SAFAN. Bending is made with pair tools type punch and die (stencil) with a V shape. Compared with free bending, the curbing using a stencil with a V path, is much more precise, but has the disadvantage of its change depending on the thickness of the material. Using the stencil V12 for parts bent that have a 1.5 and 2 mm thicknesses and the stencil V16 for components with thickness of 2.5 and 3 mm.
When determining the size of the tools used for the bending process it must also be considered the lamination path of the semi-manufactured material. The lamination path of the semi-manufactured material influences the minimum accepted value of the bending radius. For the curves made along the lamination path, the minimum accepted values are greater than when done transversal (crackers that can appear) Fig 7 [7].

Figure 7: Bending transverse direction producing crackers.

2.3. Calculating the dimensions of the semi-manufactured materials (drawings)

Because the ratio between the width and thickness of the semi-manufactured material is greater than 8, then it is considered that only deformations of the longitudinal fibers (parallel with the neutral axis) are produced. The calculation of the drawings is made based on the length of the neutral fiber, according to the formulas (1) and (2) [7].

$$L = \ell_1 + \ell_2 + ...\ell_n + \ell_{\varphi_1} + \ell_{\varphi_2} + ... + \ell_{\varphi_n} \tag{1}$$

$\ell_1, \ell_2, ...\ell_n$ - folded portions of the piece straight lengths

$$\ell_{\varphi} = \frac{\pi \times \varphi}{180}(r + x \times g) \tag{2}$$

φ - the angle of bend; x - coefficient determining the neutral fiber depending on the radius of the punch

g - the thickness of the material; r - inner bend radius

The samples made out of metal sheet OL37 with thickness of 2 mm, made on CNC machines are represented in Fig.8 and Fig.9.

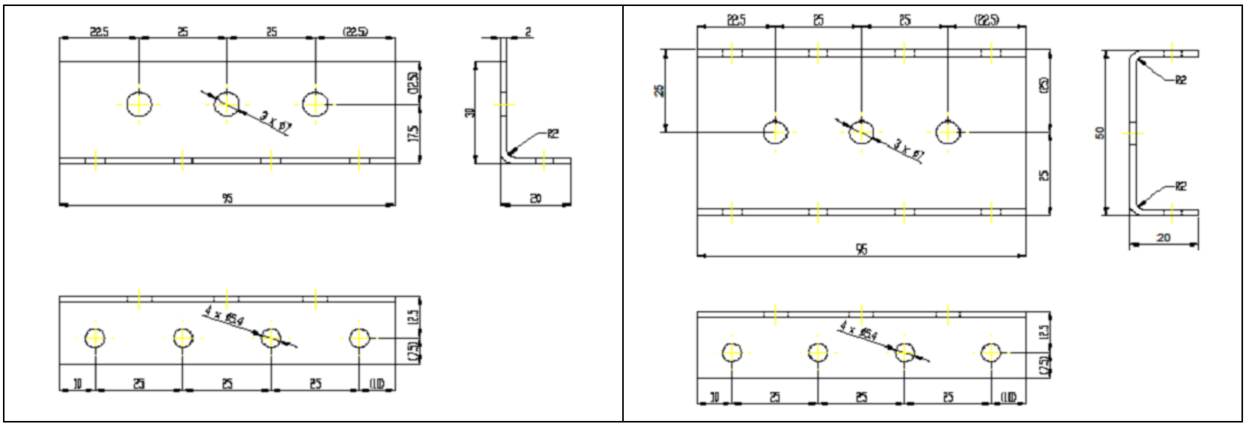

Figure 8: Support (Sample no. 4) – left; Support grip (Sample no.5) - right

Sample no. 4 (Support)

$$L_4 = \ell_1 + \ell_2 + \ell_{\varphi} = 30 - 2\times g + 20 - 2\times g + \frac{\pi \times 90^0}{180^0}(r + 0.45\times g) = 30 - 2\times 2 + 20 - 2\times 2 + \\ + \frac{\pi}{2}(2 + 0.45\times 2) = 26 + 16 + 1.57\times 2.9 = 42 + 4.553 \cong 46.553 mm \tag{3}$$

The following data was considered:

$\varphi = 90^0$; $r = 2mm$; $\mathrm{x} = 0.45$ [8].; $g = 2mm$

Sample no.5 (Support grip)

$$L_5 = \ell_1 + \ell_2 + \ell_3 + 2\times \ell_{\varphi} = 20 - 2\times 2 + 50 - 4\times 2 + 20 - 2\times 2 + 2\times \frac{\pi \times 90^0}{180^0}(2 + 0.45\times 2) = \\ = 16 + 42 + 16 + 3.14\times 2.9 = 74 + 9.106 = 83.106 mm \tag{4}$$

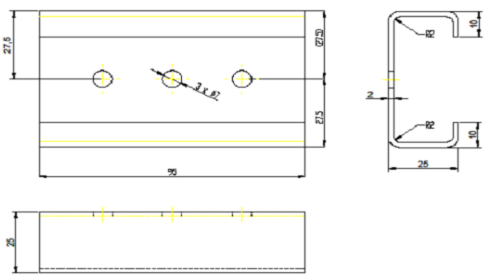

Figure 9: Bearing support (Sample no. 6)

Sample no.6 (Bearing support)

$$L_6 = \ell_1 + \ell_2 + \ell_3 + \ell_4 + \ell_5 + 4\times\ell_\varphi = 10 - g + 25 - 2\times g + 55 - 4\times g + 25 - 2\times g + 10 - g +$$

$$+ 4\times\frac{\pi\times 90^0}{180^0}(r + 0.45\times g) = (10-2)\times 2 + (25 - 2\times 2)\times 2 + 55 - 4\times 2 + 3.14\times 2\times(2 + 0.45\times 2) = \quad (5)$$

$$= 16 + 42 + 47 + 6.28\times 2.9 = 105 + 18.212 = 123.212mm$$

The bent metal sheet samples with thickness of 2 mm are represented in Fig.10 and Fig.11.

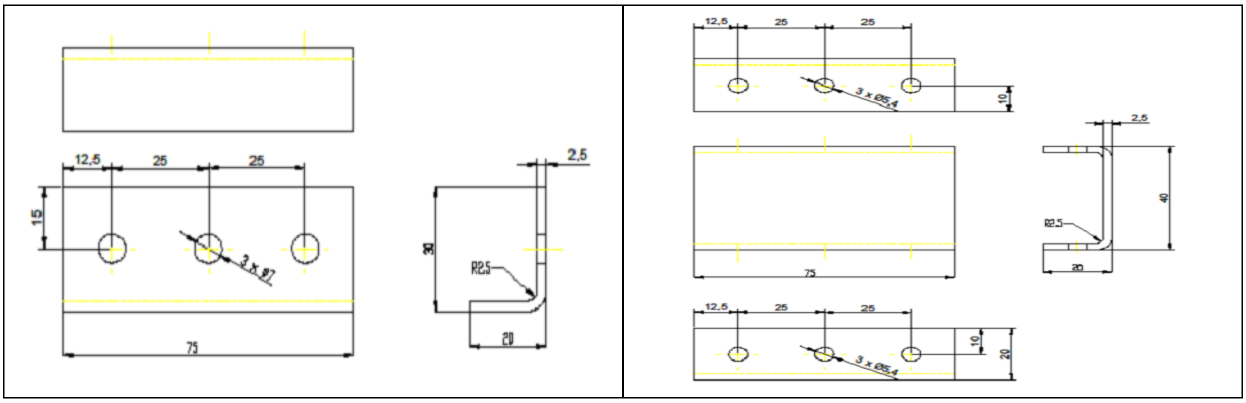

Figure 10: Fixing piece (Sample no. 7) – left; U support (Sample no. 8) - right

Sample no. 7 (Fixing piece)

$$L_7 = \ell_1 + \ell_2 + \ell_\varphi = 30 - 2\times g + 20 - 2\times g + \frac{\pi\times 90^0}{180^0}(r + 0.45\times g) = 30 - 2\times 2{,}5 + 20 -$$

$$- 2\times 2.5 + \frac{\pi}{2}(2.5 + 0.45\times 2.5) = 25 + 15 + 1.57\times 3.625 = 40 + 5.691 \cong 45.691mm \quad (6)$$

The following data was used to calculate the drawings:

$\varphi = 90^0$; $r = 2.5mm$; $\mathrm{x} = 0.45$ [8].; $g = 2.5mm$

Sample no. 8 (U Support)

$$L_8 = \ell_1 + \ell_2 + \ell_3 + 2\times\ell_\varphi = 20 - 2\times g + 40 - 4\times g + 20 - 2\times g + 2\times\frac{\pi\times 90^0}{180^0}(r + 0.45\times g) =$$

$$= 20 - 2\times 2.5 + 40 - 4\times 2.5 + 20 - 2\times 2.5 + 3.14\times(2.5 + 0.45\times 2.5) = 15 + 30 + 15 + \quad (7)$$

$$+ 3.14\times 3.625 = 60 + 11.382 = 71.382mm$$

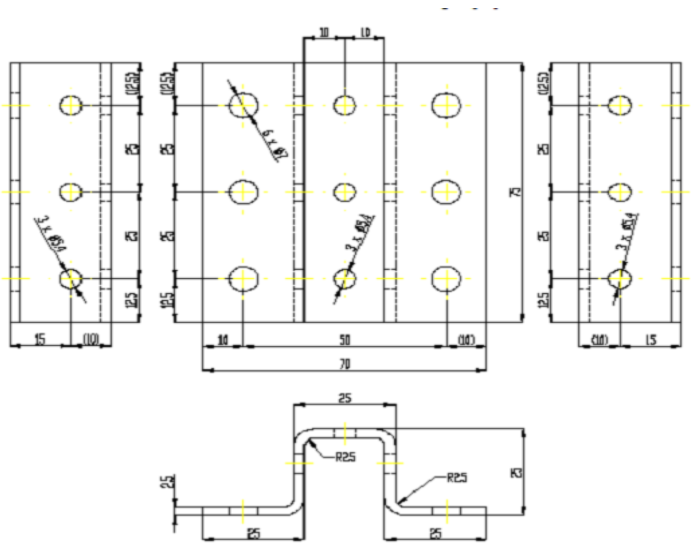

Figure 11: Omega Support (Sample no. 9)

Sample no. 9 (Omega Support)

$$L_9 = \ell_1 + \ell_2 + \ell_3 + \ell_4 + \ell_5 + 4\times\ell_\varphi = 25 - g + 25 - 2\times g + 25 - 4\times g + 25 - 2\times g + 25 - g +$$

$$+4\times\frac{\pi\times 90^0}{180^0}(r+0.45\times g) = (25-2.5)\times 2 + (25-2\times 2.5)\times 2 + 25 - 4\times 2.5 + 3.14\times 2\times \quad (8)$$

$$\times(2.5+0.45\times 2.5) = 45+40+15+6.28\times 3.625 = 100+22.765 = 122.765 mm$$

The data determined in this paper has been centralized in table 1.

Table 1: Drawing samples calculated and determined by tests

Sample name	The sample's material and thickness g	Drawing calculated on neutral fiber	Drawing determined by tests and measurements
Sample no.4-suport	OL37; g = 2 mm	46.553 mm	46.06 mm
Sample no.5-support grip	OL37; g = 2 mm	83.106 mm	82.12 mm
Sample no 6-bearing support	OL37; g = 2 mm	123.212 mm	109.24 mm
Sample no 7-fixing piece	OL37; g = 2.5 mm	45.691 mm	45.52 mm
Sample no 8-U support	OL37; g = 2.5 mm	71.382 mm	71.04 mm
Sample no 9- omega support	OL37; g = 2.5 mm	122.765 mm	109.08 mm

3. CONCLUSION

There are differences between the drawings of the semi-manufactured materials (flat) obtained with evidence and measurements and the ones calculated based on the length of the neutral fiber.

Determining the bending coefficients after the research facilitates the calculation of the drawings for the bent components in the design and as well in the manufacturing process.

The calculation of the drawings is important because it contains also the deformations created during the bending process. The resulted bending coefficients Ki, balance the deviations in the final levels of the metallic components, as many variables negatively influence their execution.

For the metal parts of steel sheet OL37 and thickness (g) =2 mm, the bending coefficient $K_î$ obtained from the research is $K_î$ = 0.06 mm/bending.

For the metal marks of steel sheet OL37 and g=2.5 mm, the bending coefficient Ki established during the study is Ki=0.52 mm/ bending.

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