International Journal of New Technology and Research (IJNTR)
ISSN:2454-4116, Volume-3, Issue-9, September 2017 Pages 44-48

Studies, Researches and Development Prospects on The Quality of Metal Products Made on CNC Machines

Neta PUŞCAŞ (POPESCU)

Abstract— **The paper presents studies and researches in the field of bending of metal parts (thickness between 1 and 3 mm) on CNC machines. This paper tries to provide answers to the many problems arising in the companies due to the quality of the economic goods. The paper proposes laborious research and studies on determining the drawings of metal parts with the thickness g=1.5 mm, considering that other variables such: the temperature variation during the processes of punching and bending, tool usage, the tolerance between the surfaces of the bending tools, the vibrations of the machines, their usage and the roughness of the sheet metals may influence the quality and precision of the products. The calculation of the drawing (the geometry in plane of the piece) becomes important because it must include the deformation caused by the bending operation. Bending coefficients $K_î$ must compensate for deviations from the final dimentions of the metal parts, because of the many variables that can adversely affect their execution. During the study we obtained the bending coefficients for the components made out of metal sheet OL 37 with 1.5 mm thickness. The bending coefficient $K_î$ is determined by experimental tests and measurements, depending on the material thickness, chemical composition, its quality, bending complexity, the movement between the surfaces of punching and bending tools, vibration of the machines, their usage, the roughness of the sheets metal as a result of lamination process and other variables that may influence the quality and precision of the products.**

***Index Terms*- bending coefficients $K_î$, CNC machines conformity, metal parts, the drawing (the single parts), quality.**

I. Introduction

The 1980 year has started with a new vision for the global market, extremely dynamic, companies worldwide facing a globalized competition which is increasingly tougher. The world economic system has enabled the introduction of ISO 9000 in the early 1990s, that had a powerful impact on trade between countries [1]. At this point, manufacturers have proposed solutions and ideas about the utility of economic goods in their entirety, respectively products, services and information offered, starting from the need to meet consumer needs, which are unlimited and dynamic.

Contemporary market must provide products that adapt to customer needs, which requires large investments and long-term employment. Producers have to take care of the buyers' different way of thinking.

The world's image in full era of globalization seems even, without barriers, the same economic goods can be found in different markets of the planet [2]. The quality of products and services is an important economic indicator. The most important is the quality control, a concept that is based on other than traditional rules, that has the purpose of ensuring quality products [4].

In the technological flow of achievement of a metal product, bending is very important, the quality and conformity of the product depending on this operation.

II. TECHNICAL REQUIREMENTS

In this paper, the studies and research were conducted on bending marks made out of metal sheets OL 37 with 1.5 mm. thickness. The precision and quality of the samples obtained is affected by the presence of variables caused by the machines that perform various activities and also by the tools used and elements that create a system (machine/tool) for delivering the desired purpose [5]. These variables are not included in the software used for the computer aided design and manufacturing. 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 [5].

The method used to determine the optimum bending coefficients $K_î$ 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 three CNC machines:
1. Hydraulic guillotine scissors type CNC HVR 3100x10;
2. Stamping machine TC 200R.
3. Stamping machine TruPunch 3000 R.

Semi-manufactured metal sheets type OL 37 with 1.5 mm thickness, cut using a guillotine scissors are the base of the research, being used for obtaining information using a digital controlled pressing machine. Trials and measurements were conducted to establish the optimum bending coefficient. The bending coefficient ($K_î$) obtained, has been included in the calculation of the drawing as seen in Fig.1, Fig. 2, Fig.3.

Neta PUŞCAŞ (POPESCU),Technical College of Architecture and Public Works "I.N. Socolescu", Bucharest, Romania

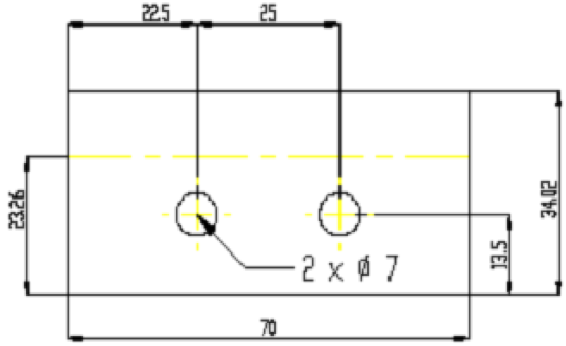

Figure 1: The drawing of the sample no.1 (L Suport)

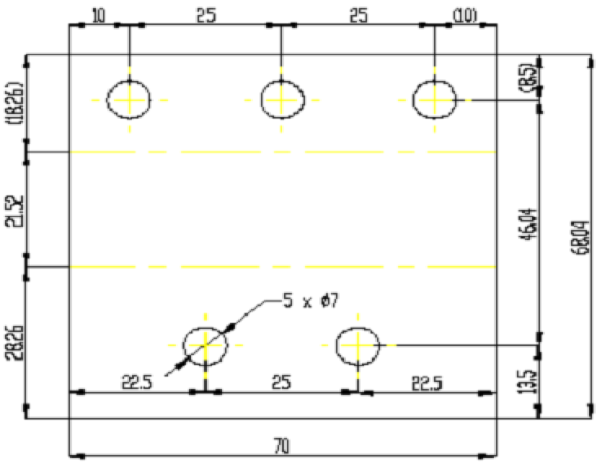

Figure 2: The drawing of the sample no.2 (Z Support)

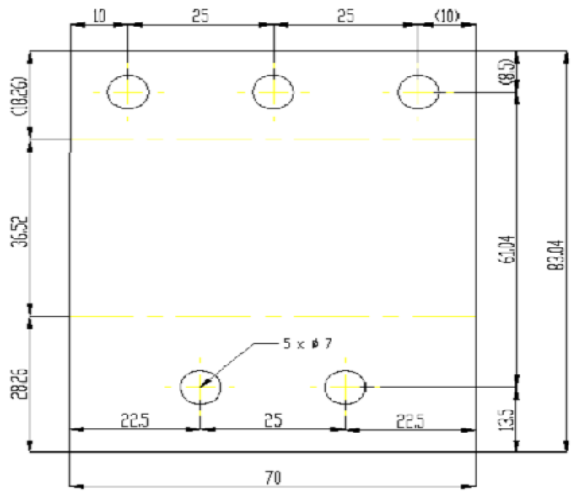

Figure 3: The drawing of the sample no. 3 (U Support)

The drawing of the single part designed in AutoCAD were imported in the punching program (Punching Programming in ToPs 300) corresponding with the stamping machine TC 200R and TruPunch 3000 R [6]. For each type of flat pattern there were used four types of calculations. The drawings (flat patterns) were calculated in four ways:

a) The drawing (the geometry in plane of the piece) was calculated using the bending coefficient K_{Ai} resulted in the first stage (Fig. 1; Fig. 2; Fig.3)

b) The drawing calculated mathematical on neutral fiber.

c) The drawing calculated on neutral fiber using the coefficients K_{Ei} obtained from the table;

d) The drawing calculated by the bending machine software.

2.2. The steps of elaborating the drawing (the single part)

The calculation of the drawing is important because it contains also the deformations created during the bending process. Bending the drawings samples no.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 is made with a hydraulic bending digital press machine type SAFAN and ERM 30135.
For the component “L Support” (Fig. 4) there were suggested 4 types of samples depending on the drawing calculated.

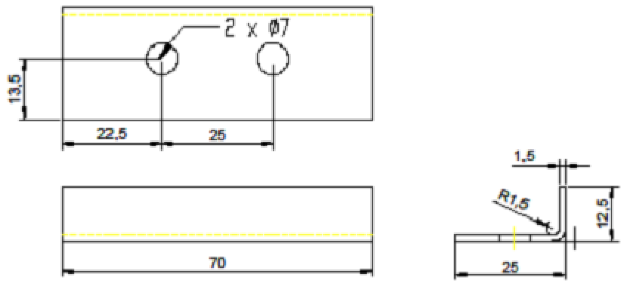

Figure 4: Sample no. 1, 2, 3, 4 (L Support)

Sample no.1 (L Support)

The drawing was calculated using the bending coefficient K_{Ai} resulted in the first stage

$$L_1 = \ell_1 - g + \ell_2 - g + K_{Ai} = 25 - 1.5 + 12.5 - 1.5$$
$$- 0.48 = 23.5 + 11 - 0.48 = 34.5 - 0.48 =$$
$$= 34.02mm \tag{1}$$

Sample no.2 (L Support)

Calculation of the drawing of the single part is performed based on the length of the neutral fiber [7].
If the ratio between the width and the 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 [7]. The formulas have been used for calculations, according to the relations (2) and (3).

$$L = \ell_1 + \ell_2 + ...\ell_n + \ell_{\varphi_1} + \ell_{\varphi_2} + ... + \ell_{\varphi_n} \tag{2}$$

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

$$\ell_\varphi = \frac{\pi \times \varphi}{180}(r + x \times g) \tag{3}$$

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.

$$L_2 = \ell_1 + \ell_2 + \ell_\varphi = 25 - 2\times g + 12.5 - 2\times g + \frac{\pi\times 90^0}{180^0}\times (r+0.45\times g) = 25-2\times 1.5+12.5-2\times 1.5+\frac{\pi}{2}\times (1.5+0.45\times 1.5) = 22+9.5+1.57\times 2.175 = 31.5+ 3.41475 \cong 34.91475mm \quad (4)$$

The following data was considered:

$\varphi = 90^0$; $r = 1.5mm$; $x = 0.45$ [8].; $g = 1.5mm$

Sample no.3 (L Support)

The drawing was calculated on neutral fiber using the coefficients K_{Ei} obtained from the table;

$$L_3 = \ell_1 + \ell_2 + K_{E3} = 25 + 12.5 - 2.65 = 37.5 - 2.65 = 34.85mm \quad (5)$$

The following data was considered:
K_{E3}= -2.65 mm / bending at 90^0 degrees angle;
the thickness of the material g=1.5mm;
the radius of the bending punch R=1.5mm

Sample no.4 (L Support)

The drawing was calculated by the bending machine software.

$$L_4 = \ell_1 - g + \ell_2 - g + K_{soft} = 25 - 1.5 + 12.5 - 1.5 + 0.24 = 34.5 + 0.24 = 34.74mm \quad (6)$$

For the component "Z Support" (Fig. 5) the 4 types of samples depending on the drawing calculated.

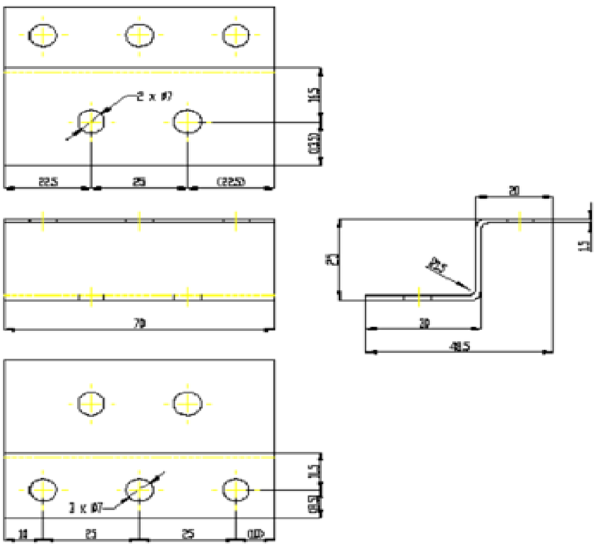

Figure 5: Sample no. 5, 6, 7, 8 (Z Support)

Sample no.5 (Z Support)

The drawing was calculated using the bending coefficient K_{Ai} resulted in the first stage.

$$L_5 = \ell_1 - g + \ell_2 - 2\times g + \ell_3 - g + 2\times K_{Ai} = 30 - 1.5 + 25 - 2\times 1.5 + 20 - 1.5 - 2\times 0.48 = 75 - 6 - 0.96 = 69 - 0.96 = 68.04mm \quad (7)$$

Sample no.6 (Z Support)

For the sample no. 6 the drawing was calculated on neutral fiber.

$$L_6 = \ell_1 + \ell_2 + \ell_3 + \ell_\varphi = 30 - 2\times g + 25 - 4\times g + 20 - 2\times g + 2\times\frac{\pi\times 90^0}{180^0}\times (r+0.45\times g) = 75 - 8\times 1.5 + \pi\times (1.5+0.45\times 1.5) = 75 - 12 + 3.14\times 2.175 = 63 + 6.8295 - 69.8295mm \quad (8)$$

Sample no.7 (Z Support)

The drawing for sample no. 7 was calculated on neutral fiber using the coefficients K_{Ei} obtained from the table.

$$L_7 = \ell_1 + \ell_2 + \ell_3 + K_{E3} = 30 + 25 + 20 - 2\times 2.65 = 75 - 5.3 = 69.7mm \quad (9)$$

Sample no.8 (Z Support)

The drawing for sample no. 8 was calculated by the bending machine software.

$$L_8 = \ell_1 - g + \ell_2 - 2\times g + \ell_3 - g + 2\times K_{soft} = 30 - 1.5 + 25 - 2\times 1.5 + 20 - 1.5 + 2\times 0.99 = 75 - 6 + 1.98 = 70.98mm \quad (10)$$

For the component "U Support" (Fig. 6) the 4 types of samples depending on the drawing calculated.

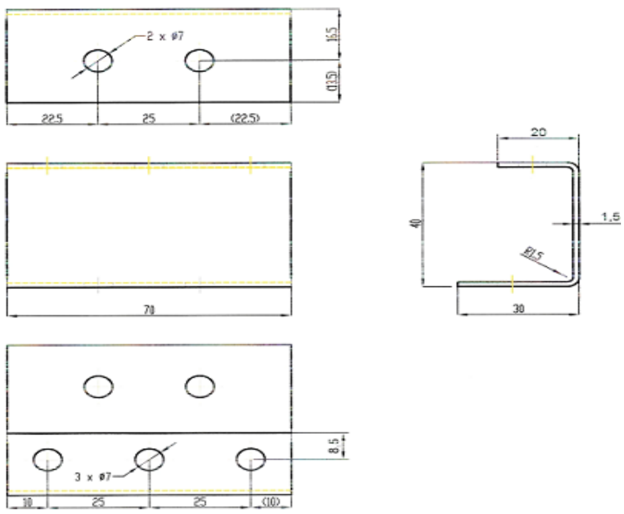

Figure 6: Sample no. 9, 10, 11, 12 (U Support)

Sample no.9 (U Support)

The drawing (the geometry in plane of the piece) was calculated using the bending coefficient K_{Ai}.

$$L_9 = \ell_1 - g + \ell_2 - 2\times g + \ell_3 - g + 2\times K_{Ai} = 30 - \\ -1.5 + 40 - 2\times 1.5 + 20 - 1.5 - 2\times 0.48 = 90 - 6 - \\ -0.96 = 84 - 0.96 = 83.04mm \quad (11)$$

Sample no.10 (U Support)

For the sample no. 10 the drawing was mathematically calculated on neutral fiber.

$$L_{10} = \ell_1 + \ell_2 + \ell_3 + \ell_\varphi = 30 - 2\times g + 40 - 4\times g + 20 - 2\times g + \\ 2\times \frac{\pi\times 90^0}{180^0}\times(r + 0.45\times g) = 90 - 8\times 1.5 + \pi\times(1.5 + 0.45\times 1.5) \\ = 90 - 12 + 3.14\times 2.175 = 78 + 6.8295 - 84.8295mm \quad (12)$$

Sample no.11 (U Support)

The drawing for sample no. 11 was mathematically calculated on neutral fiber using the coefficients K_{Ei} obtained from the table.

$$L_{11} = \ell_1 + \ell_2 + \ell_3 + K_{E3} = 30 + 40 + 20 - 2\times 2.65 = \\ = 90 - 5.3 = 84.7mm \quad (13)$$

Sample no.12 (U Support)

The drawing for sample no. 12 was calculated by the bending machine software.

$$L_{12} = \ell_1 - g + \ell_2 - 2\times g + \ell_3 - g + 2\times K_{soft} = 30 - \\ -1.5 + 40 - 2\times 1.5 + 20 - 1.5 + 2\times 0.24 = 90 - 6 + \\ + 0.48 = 84.48mm \quad (14)$$

2.3. Bending semi-manufactures materials

The drawings (semi-manufactured materials) have been bent using a hydraulic bending digital press machine:
a) Hydraulic bending digital press machine type SAFAN in the first stage;
b) Hydraulic bending digital press machine type ERM 30135.in the second part of the research.
Bending is made with pair tools type punch and die (stencil). When the punch is descending into the material that is being distorted, due to bending strength, it produces a curbing of the semi-manufactured material in the stencil (bottoming) [7]. Compared to free bending, bending using stencil with a V or U path, is much more precise (Fig. 7) [9].

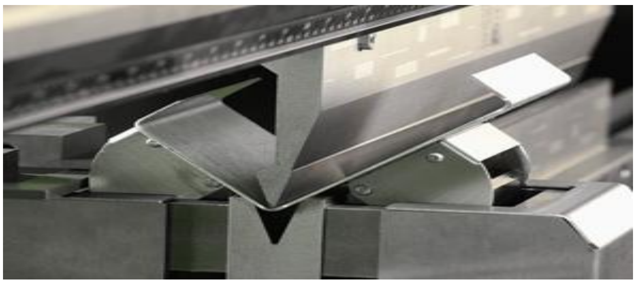

Figure 7: A die with V-shaped channel

The tools used for the bending process were chosen according to the type of material, the thickness of the metal sheet and the configuration of the component, which positively influenced the quality and precision of the execution. Fields of elastic and plastic deformation produced of the bending. The plastic and elastic deformation of the semi-manufactured material is produced only in the area near the bending line [12]. For the calculation of the drawings was taken into consideration the type of the punch and the die used. It was selected a punch with the radius of the bending R=1.5 mm and a die with an opening V=10 mm [10]. The choice of the die is based on the thickness of the material and the length of the metal piece. The bending machine"s manual indicates the calculation for the die opening [11]:

$$V = 8\times g = 8\times 1.5 = 12mm \quad (15)$$

In this case the choice of the die with the opening V=10mm is favorable.
The introduction of bending parameters, the drawing of the profile of the bending the parts and the specification of the tools for profiling is presented in Fig. 8, Fig. 9 and Fig.10.

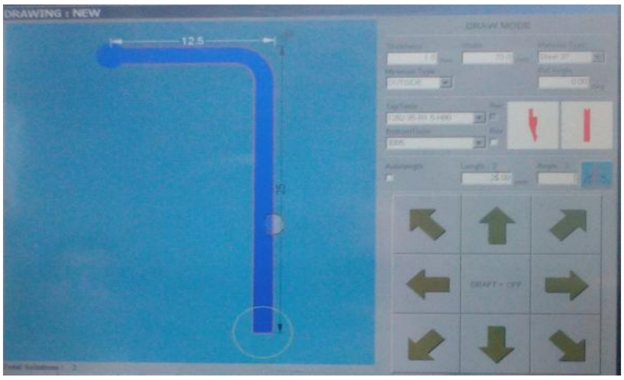

Figure 8: Bending program for"L Support"

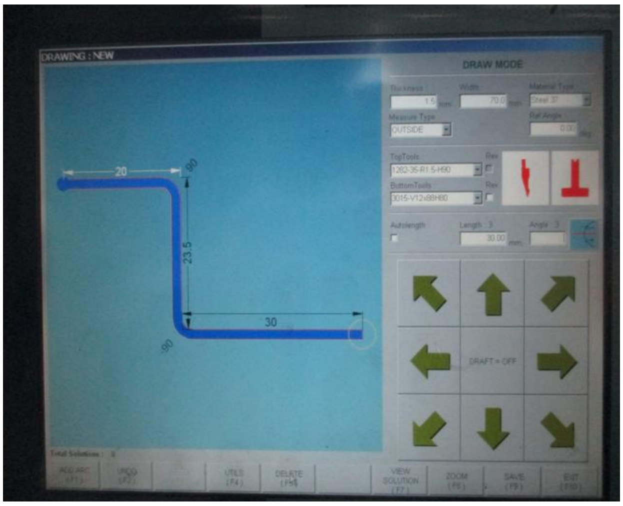

Figure 9: Bending program for"Z Support"

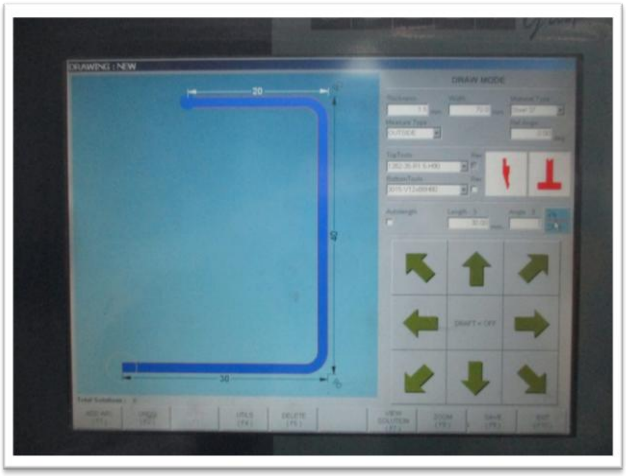

Figure 10: Bending program for"U Support"

The data determined in this paper has been centralized in the table I.

Table I: The drawings calculated in four ways

Sample name	Drawing calculated with K_{Ai} (mm)	Drawing calculated on neutral fiber (mm)	Drawing Calculated on neutral fiber with K_{Ei} (mm)	Drawing calculated by the bending machine software (mm)
Sample no.1 L Suport	34.02			
Sample no.2 L Support		34.91475		
Sample no.3 L Support			3.85	
Sample no.4 L Support				34.74
Sample no.5 Z Support	68.04			
Sample no.6 Z Support		69.8295		
Sample no.7 Z Support			69.7	
Sample no.8 Z Support				70.98
Sample no.9 U Support	83.04			
Sample no.10 U Support		84.8295		
Sample no.11 U Support			84.7	
Sample no.12 U Support				84.48

III. .CONCLUSION

There are differences between the drawings (the single part determined by evidence and measurements and the ones calculated along the neutral fibre can be found differences that increase gradually, depending on the complexity of the bent component and the number of bendings.

The calculation of the drawings is important because it contains also the deformations created during the bending process. Using bending coefficients obtained by research, enables the easy calculation of the drawing for their design and as well for their manufacturing. These coefficients (K_i) can directly be introduced in the software through the control panel. The bending coefficients Ki must counterbalance the deviations in the final levels of the metallic components, due to multiple variables that can negatively influence their execution.

Comparing the four variants of the drawings it was chose the one that is closest to the optimum, which is the subject of another research.

REFERENCES

[1] Angelescu C., Ciucur D., Dobrotă N., Gavrilă I., Ghiţă P.T., Popescu C., Târhoacă C., Economie, Editura Economică, Bucureşti, 2000.
[2] Bacirov I. C., Juran J.M., A MAN for history quality - Quality Assurance, number 74, S.U.A., 2013.
[3] Olaru M., Managementul calităţii, suport de curs, Bucureşti, 2009.
[4] Baron T., Calitate şi fiabilitate, Editura Tehnică, Bucureşti, 1988.
[5] Tempea I., Dugăeşescu I., Neacşa M., MECANISME Noţiuni teoretice şi teme de proiect rezolvate, Editura PRINTECH, Bucureşti, 2006.
[6] TRUMPF GmbH + Co., Workbook – Fundamentals TC 500R and TC 200R, Edition 03/99, Ditzingen, 1999.
[7] Lucreţiu R., Sheet – Bending, Biblioteca digitală, Bucureşti, 2011.
[8] Color-metal.ro/îndoirea-tablelor.
[9] www.sm-tech.ro/boschert-gizelis.htm.
[10] www.eurostampsrl.it/en/offer-request
[11] "MANUAL FOR THE USE AND MAINTENANCE OF YOUR MACHINE" – Manual Synchro
[12] Stăncioiu A., Popescu Gh., Girniceanu Gh., Fiability & Durability, nr.2/2009, Editura "Academica Brâncuşi", Târgu Jiu, 2009.