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RESEARCH AND DEVELOPMENT PROSPECTS OF THE QUALITY OF METTALIC PRODUCTS ACHIEVED ON CNC MACHINES

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***Abstract**: 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. 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. The paper proposes research and studies on determining the drawings of metal parts with the thickness between 0.8 and 6 mm. It is considered that other variables such: the vibrations of the machines, their usage and the variable temperature during the process of punching and bending, may influence the quality and precision of the products. The wearing of the tools, the tolerance between the active surfaces of the bending tools, the roughness of the sheet metals represent other measures that cause deviations of size for the bent component, but they are not the purpose of this research.*
***Keywords**: quality, conformity, bent metallic components, digital control machines, the drawing (the single parts).*

1. INTRODUCTION

The contemporary global market is extremely dynamic because the volume of demand and supply is fluctuating rapidly. The 1980 year has started with a new vision on the global market as the companies worldwide were in an increasingly harder globalized competition. In the early 1990s, the world economic system has enabled the introduction of ISO 9000 standards and the training of real professionals of quality, which had a powerful impact in the commercial trades between countries [1].
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. They target consumers with similar preferences and needs, even if they are separated geographically by thousands of kilometers. Globalization does not consist only in trades, it also defines a significant leap in quantity and quality for the entire international economic order [2].
The 3rd millennium offers a new image of the global market, more specifically a market that belongs to the consumers due to the abundance of offers in the last decades. Producers are confronting with consumers that have a different way of thinking. Starting with the emergency of satisfying the dynamic and unlimited needs of the consumers, the producers came up with new alternatives regarding the economic utility of goods in their network, specifically a prioritized approach for the quality of goods. The contemporary market must offer products that can adapt to the client's needs, which means bigger investments and longtime commitments.
The quality of products and services represents an important economic benchmark. The concept of quality economic goods can be defined as an approach for maximizing the consumer satisfaction and showing the extent of utility of the product, service and information.
This paper offers specific answers for multiple issues originated due to the quality of economic goods used within companies. By solving the problems that companies are generally facing, means discovering methods and ways of improving the qualities of goods. Finally, the quality of economic goods reflects the way to excellence as a comparison with poor quality.

2. TECHNICAL REQUIREMENTS

The study and research conducted and presented in this paper, focuses on the bending of the metal parts of steel sheet type OL37 with 1.5 mm thickness with digital control machines. 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 [3]. These variables are not included in the software used for the computer aided design and manufacturing.
The purpose of the research is to determine the optimum bending coefficient, depending on the thickness and the chemical composition of the material, the bending complexity and other variables that can affect the quality and precision of the bent components.
The bending coefficients established by experimental attempts and measurements, are highlighted in tables, being able to be introduced in the computer aided design program (CAD - Computer Aided Design) as well as in the computer aided manufacturing (CAM - Computer Aided Manufacturing), directly through the operator (worker).

2.1. Semi-manufactured cutting

The samples presented in the paper have been obtained within a company that produces ironworks, equipped with digital control machines. The semi-manufactured cutting is obtained with two digital control machines:
1. Hydraulic guillotine scissors type CNC HVR 3100x10;
2. Stamping machine TC 200R.

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_i) obtained, has been included in the calculation of the drawing as seen in Fig1, Fig 2, Fig 3.

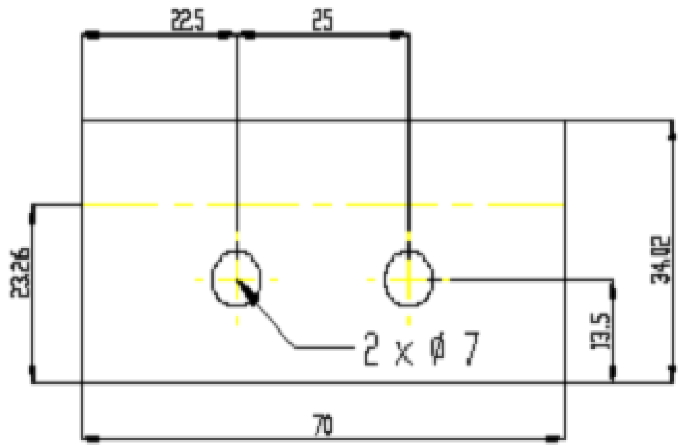

Figure 1: The drawing of the sample no.1 (L Support)

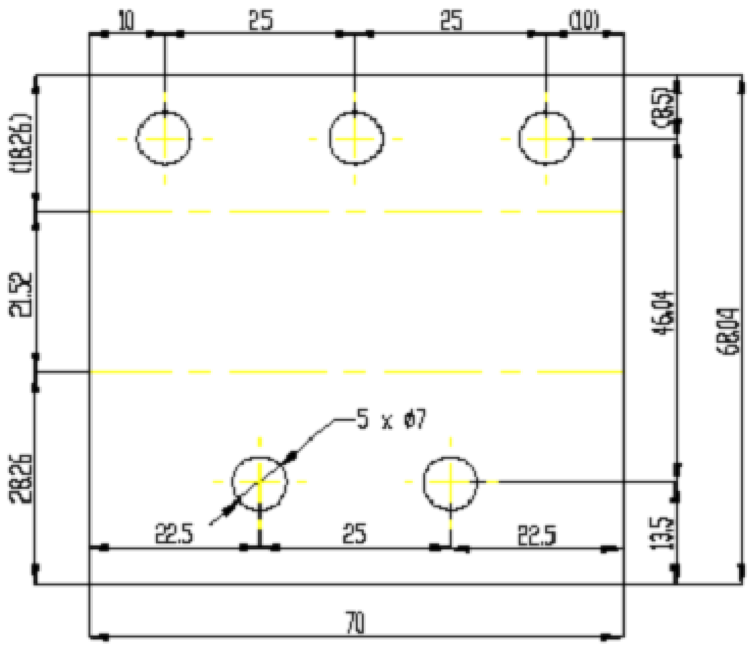

Figure 2: The drawing of the sample no. 2 (Z Support)

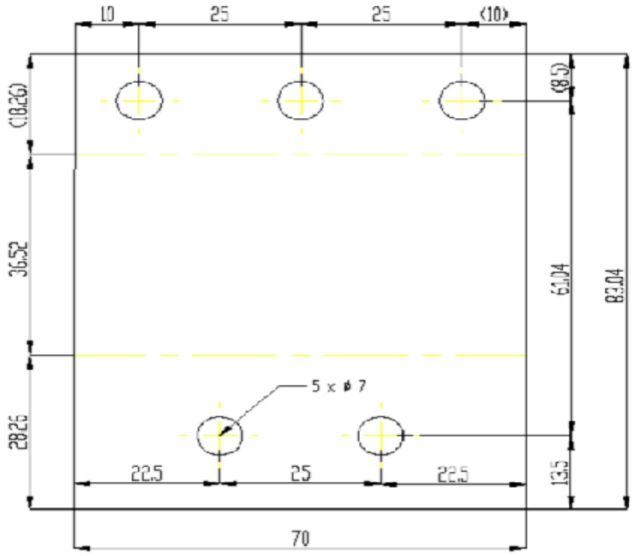

Figure 3: The drawing of the sample no.3 (U Support)

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 [4].

2.2. Bending semi-manufactures materials

The drawings (semi-manufactured materials) have been bent using a hydraulic bending digital press machine type Safan. 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) [5].
Compared to free bending, bending using stencil with a V or U path, is much more precise.[6].

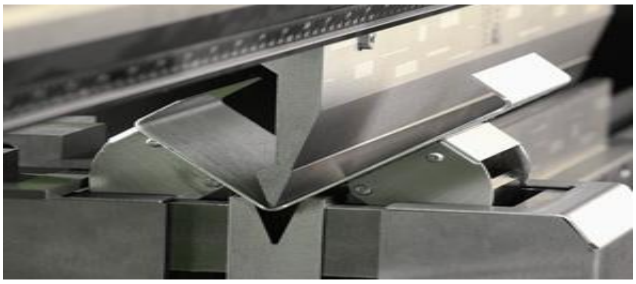

Figure 4: A die with V-shaped channel

The bending process causes changes in the form and size of the semi-manufactured material which, under the action of an exterior force that has a tangential action on the material, is curving it in the bending line area (Fig 5) [7]. The plastic and elastic deformation of the semi-manufactured material is produced only in the area near the bending line.

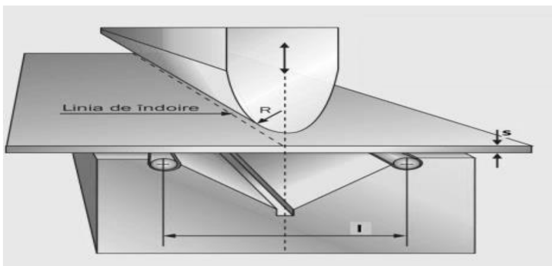

Figure 5: The formation of the folding line under the action of the punch

If the exterior force, which has tangential action on the surface of the semi-manufactured material that is being distorted, exceeds the limit of elasticity of the material, then it produces a plastic deformation (the plasticity of material E_p is not a constant value). Plastic cold deformation is produced at low temperatures of recrystallization or restoration of the metal structure and it is followed by the cold hardening process (lengthening of the crystal grains). This phenomenon leads to an increase in strength of the plastic deformation and a decrease in plasticity. The maximum density of atoms in the crystalline structure of the plastic cold deformed area determines an irreversible movement of the atoms (gliding course) on new points of balance, this way forming levels of gliding between the modified area and the unmodified one. Virtually, the symmetry layout between the deformed area and the undeformed one modifies its position, in symmetry with the undeformed area, forming the twinning layout (new symmetry layout) Fig 6 [8].

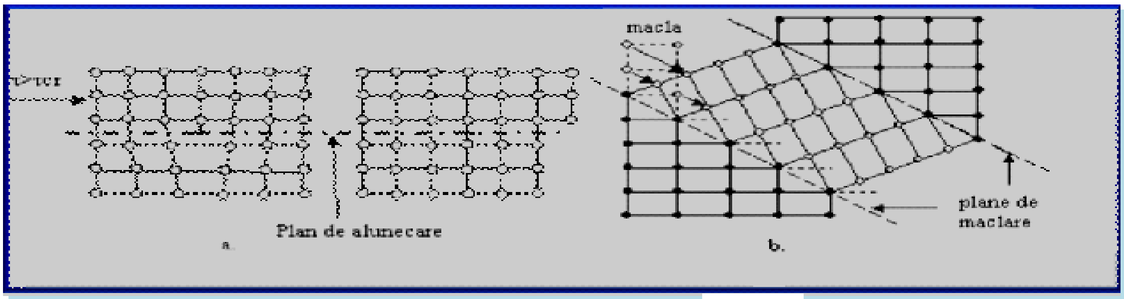

Figure 6: Plastic deformation **-** a. sliding plane; b. twinning (moving atoms)

The deformation forces produce a bending of the material and the creation of uneven tension throughout the whole thickness of the material. On the outside, expansion deformations emerge (lengthening of the exterior fibres) and on the inside, the interior fibres shorten due to compression phenomenon. Deformations reduce as the thickness of the semi-manufactured material is penetrated until it reaches the neutral area where the force is annulled, the neutral fibre remains unreformed maintaining its original length. Regarding the median axis of the semi-manufactured material, the neutral layer area is moved towards the interior of the curvature. Besides the lengthening and compression stress, in the structure of the bent semi-manufactured material there are formed radial stress of compression as an effect of the pressure from the peripheral layers onto the interior layers, the maximum value is reached in the neutral layout area [5].
After we remove the forces that caused the bending of the component, a phenomenon of expansion takes place, named springing or springback [5]. The elastic deformation that joined the plastic deformation (the coexistence law between the two types of deformation) during the bending process, disappears after the deformation force stops. The relaxation phenomenon takes place joined by the return to another radius (R_f) other than the bending radius (R_0) of the semi-manufactured material that was subjected to deformation Fig.7 [9]. The bending angle after the material returns to the original status (a_x) is lower than the original bending angle (a_0).

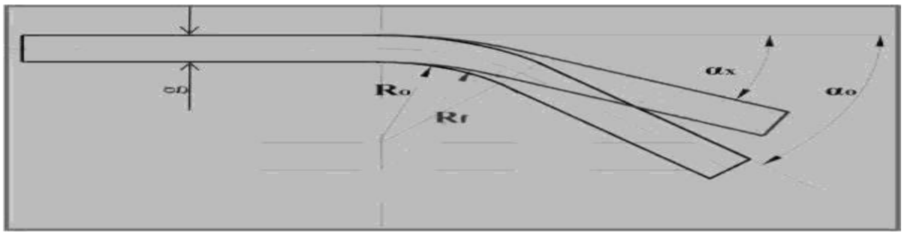

Figure 7 Elastic relaxation of the sample after bending

The value of the elastic expansion angle is influenced by: the thickness of the material, the bending radius, the physical and chemical properties of the material, the value of the bending angle and the bending method used. When determining the size of the tools used for the bending process, the adjustment of the elastic extension is necessary.

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

The deformations produced in the bent area are complex because they are influenced by the existence of many variables. 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 fibres parallel with the neutral axis are produced [5]. Calculation of the drawing of the single part is performed based on the length of the neutral fiber Fig.8 [5]. The formulas have been used for calculations, according to the relations (1) and (2).

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

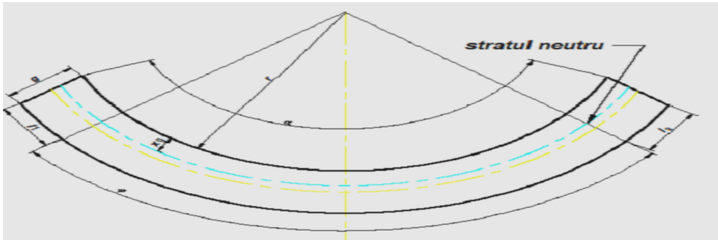

Figure 8: The length of the neutral fiber

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

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

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 obtained by folding with the folding C.N. machine are represented in Fig. 9 and Fig. 10.

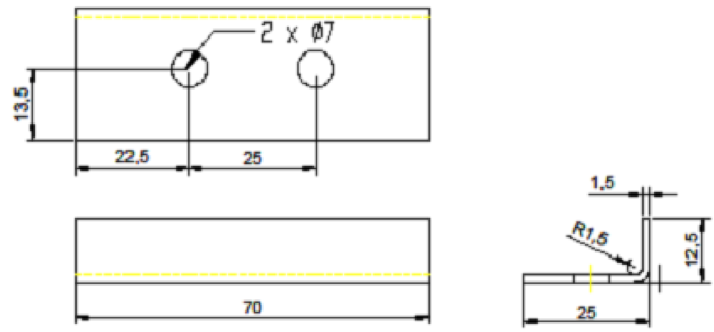

Figure 9: Sample no. 1 (L Support)

Sample no.1 (L Support)

$$L_1 = \ell_1 + \ell_2 + \ell_\varphi = 25 - 2\times g + 12.5 - 2\times g + \frac{\pi \times 90^0}{180^0}(r + x \times g) = 25 - 2\times 1.5 + 12.5 - 2\times 1.5 +$$
$$+ \frac{\pi \times 90^0}{180^0}(1.5 + 0.45\times 1.5) = 31.5 + 1.57\times 2.175 = 31.5 + 3.41475 \cong 34.9148 mm \qquad (3)$$

The following data was considered: $\varphi = 90^0$; $r = 1.5mm$; $x = 0.45$[9]; $g = 1.5mm$

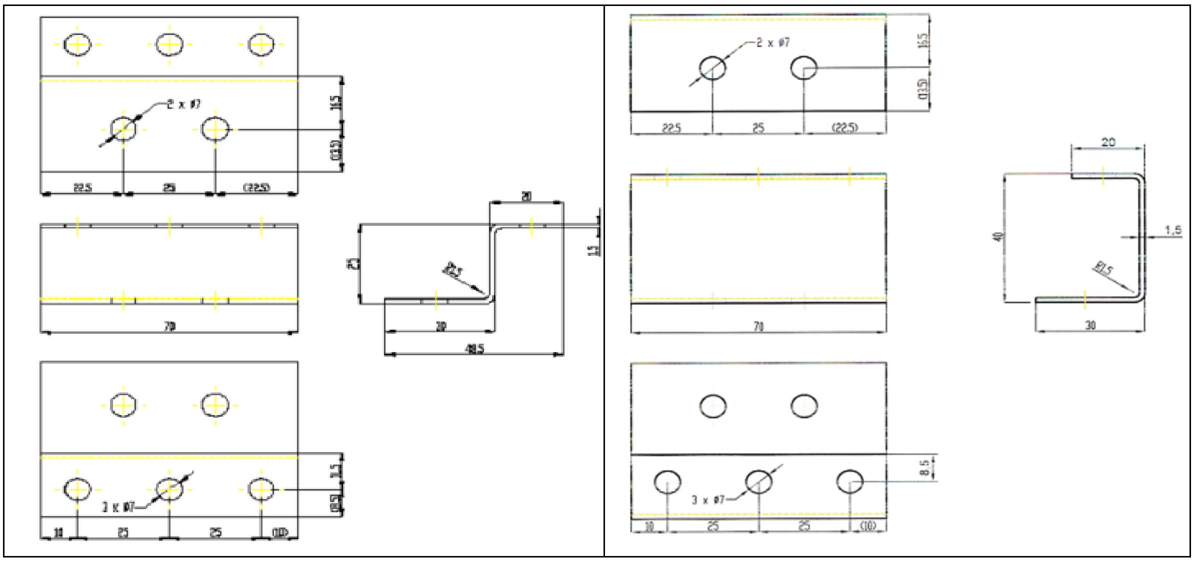

Figure 10: Sample no. 2 (Z Support) and sample no. 3 (U Support)

Sample no.2 (Z Support)

$$L_2 = \ell_1 + \ell_2 + \ell_3 + 2\times\ell_\varphi = 30 - 2\times g + 25 - 4\times g + 20 - 2\times g + 2\times\frac{\pi\times 90^0}{180^0}(r + x\times g) =$$

$$= 30 - 2\times 1.5 + 25 - 4\times 1.5 + 20 - 2\times 1.5 + 2\times\frac{\pi\times 90^0}{180^0}(1.5 + 0.45\times 1.5) = 27 + 19 + 17 +$$

$$+ 3.14\times 2.175 = 63 + 6.8295 = 69.8295 mm \quad (4)$$

Sample no.3 (U Support)

$$L_3 = \ell_1 + \ell_2 + \ell_3 + 2\times\ell_\varphi = 30 - 2\times g + 40 - 4\times g + 20 - 2\times g + 2\times\frac{\pi\times 90^0}{180^0}(r + x\times g) =$$

$$= 30 - 2\times 1.5 + 40 - 4\times 1.5 + 20 - 2\times 1.5 + 2\times\frac{\pi\times 90^0}{180^0}(1.5 + 0.45\times 1.5) = 27 + 34 + 17 +$$

$$+ 3.14\times 2.175 = 78 + 6.8295 = 84.8295 mm \quad (5)$$

The dates were determined in this paper, have been centralized in table 1.

Table 1: Unfolded samples calculated and determined by tests

Sample name	Unfolded sample calculated on neutral fiber	Unfolded sample determined by tests and measurements
Sample no.1- L support	34.9148 mm	34.02 mm
Sample no.2- Z support	69.8295 mm	68.04 mm
Sample no.3- U support	84.8295 mm	83.04 mm

3. CONCLUSION

Between the drawing (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.

Using bending coefficients obtained by research, enables the easy calculation of the drawing for their design and as well for their manufacturing. These coefficients ($K_î$) can directly be introduced in the software through the control panel. Quality implies cost reduction in the production process especially in waste control, nonconformity, solutions for inconsistent components, restorations and other issues that can appear during the manufacturing process. The calculation of the drawing of the single part becomes important because it must include also the deformations appeared after the bending process. 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.

For metal parts of steel sheet OL37 and thickness (g) =1.5 mm, the bending coefficient $K_î$ obtained from the research is $K_î$ = - 0.48 mm/bending.

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