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[1.] Tihomir Grishev VASILEV

RECONSTRUCTION OF ROLL FORMING MACHINE OF THIN-WALLED STEEL PROFILES

[1.] Nikola Vaptsarov Naval Academy, Varna, BULGARIA

Abstract: In order to make reconstruction of the roll forming machine is necessary to define the number of required deformation passages, the distances between the deforming rolls and the sequence of formation of the profile. By analyzing the geometrical parameters characteristic of the method of roll forming a boundary condition defined which serves as basis for creation of the sequence of formation of the profile. The need to search for new approach for the design of deformation transitions required by the complexity of the source account and the impossibility of applying the standard approaches. After theoretically were considered restrictions on the design of appropriate passages proceed to the design of new sets of deformation rollers, which are adapted to the existing roll forming machine. In the outcome of the theoretical and practical work achieved satisfactory results on the produced profile quality.
Keywords: cold roll forming, sheet metal profile, roll forming machine, machine design

1. INTRODUCTION

The cold roll forming is a highly productive process for producing of various types thin-walled steel profiles unlimited length by sequentially superimposing the deformation sections of a number of passages [2]. Minimal distance between two deformation sets is limited by condition to a minimum deformation work spent on longitudinal plastic deformations [1, 3]:

$$L=\sqrt{\frac{8.a^{3}.\Delta\Theta}{3.t}} \qquad (1)$$

where: a – Flange length, mm; ΔΘ – Bending angle, deg; t – Thickness of the material, mm; L – Distance between two deformation sets, mm;

The basic parameters that influence the length *L* shown in Figure 1. The number of necessary passes is determined by the geometrical condition to prevent plastic deformations or the parameter *dL/L* shown in Figures 1 and 2, need to be smaller than the value of elastic elongation limit.

One of the methods by which determines the minimum number of passes is using deformation angle ψ [3] Figure 2. The value of ψ depends on the sensitivity of the material to be plastically deformed, as an average value taken in the range $1.4^{\circ} \div 1.5^{\circ}$.

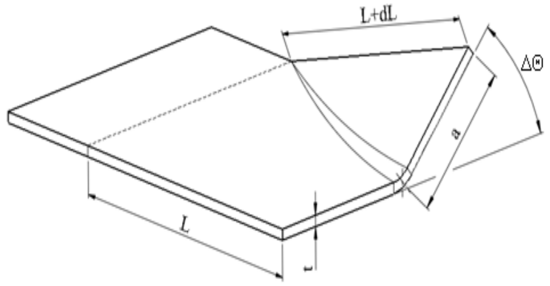

Figure 1. Basic parameters of roll forming process

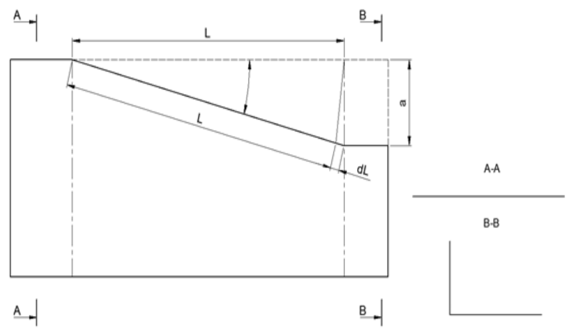

Figure 2. Determination of deformation angle ψ and elongation *dL*

From Figure 2 we can write the following relation [3, 5]:

$$\cot g(\psi)=\frac{L}{a} \qquad (2)$$

If the value of *L* is represented by the number of necessary passes *L=l(n-1)* we have:

$$\cot g(\psi) = \frac{l.(n-1)}{a} \quad (3)$$

where: n – Number of passes, pcs; l – Distance between two passes, mm;
For number of passes [5]:

$$n = \cot g(\psi)\frac{a}{l} + 1 \quad (4)$$

The elastic elongation of a material can be represented by the relationship:

$$\varepsilon_0 = \frac{R_e}{E}.100,\% \quad (5)$$

where: ε_0– Elongation at yield strength, %; R_e – Yield strength of the material, MPa; E – Modulus of elasticity, MPa;
If adopted an axial deformation of the material only to the limit of elasticity have:

$$\varepsilon_0 = \frac{R_e}{E} = \frac{dL}{L} \quad (6)$$

From Figure 2 we can also write:

$$\cos(\psi) = \frac{L}{L+dL} \rightarrow \psi = a\cos\left(\frac{1}{\left(1+\frac{R_e}{E}\right)}\right) \quad (7)$$

To reach the plastic deformation in the cross-section of a profile is necessary to determine the maximum radius at which have the appearance of deformation exceeding the yield stress. The other hand the minimal radius at which stress is formed in excess of the tensile strength. Limit values of the radii provided that the neutral line is located equidistant from both surfaces are [6]:

$$r_{max} = \frac{t.E}{2.R_e}; \quad r_{min} = t.c; \quad (8)$$

where: c - Constant which depends on the deformed material properties and bending direction compared to rolling direction of sheet; When bending is transverse to sheet rolling direction for strain hardened materials C15-C25 $c=0.5$, while for longitudinal bending $c=1$ [6].

There are three methods of forming the radius: - deformation with a constant radius; - deforming at a constant arc length; deformation at different arc length and different radius. The most commonly used method according to [3] is constant arc length deformation, as research has shown the existence of the lowest residual stresses.

In the design process of the passes is necessary to define the maximum distance *b* from the end of the profile in this section to the same point on the profile in the previous section (Figure 3).

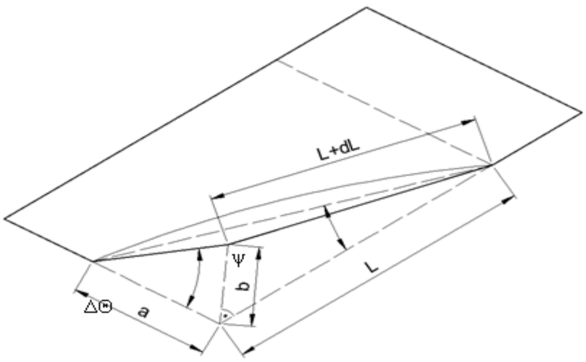

Figure 3. Scheme for determination of some distance *b*

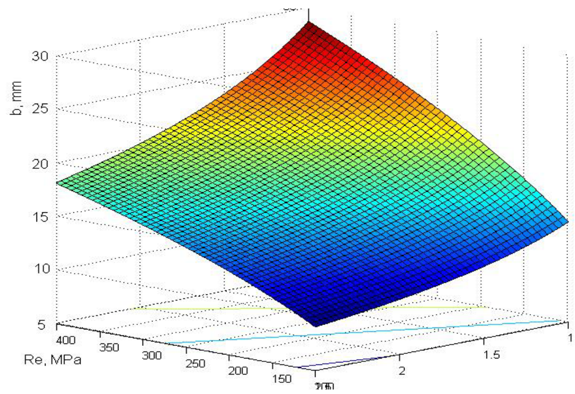

Figure 4. Influence on the distance *b* from the yield strength *Re* and modulus of elasticity *E* in situation *L=315 mm*

From geometric parameters shown in Figure 3 can be written:

$$(L+dL)^2 = L^2 + b^2 \quad (9)$$

After substitution of the equation (6) to (9) to the distance *b* we have:

$$b = L.\sqrt{\frac{2.R_e}{E} + \frac{R_e^{\ 2}}{E^2}} \quad (10)$$

The influence on the yield strength and modulus of elasticity over the distance *b* shown in Figure 4.

2. PRACTICAL WORK

The objective of this study was to design a deformable rolls for a specific profile to be mounted on an existing machine. From a financial perspective it is appropriate to be added minimum number of new elements. Figure 5 shows the profile for which is necessary to develop a new set of deformable rolls, the dimensions are shown with approximate values.

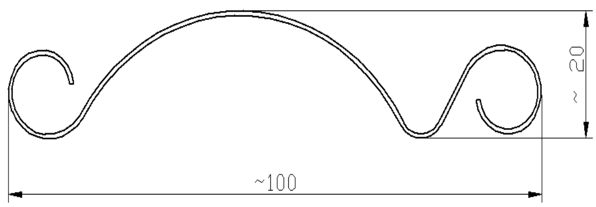

Figure 5. Cross section of the starting profile

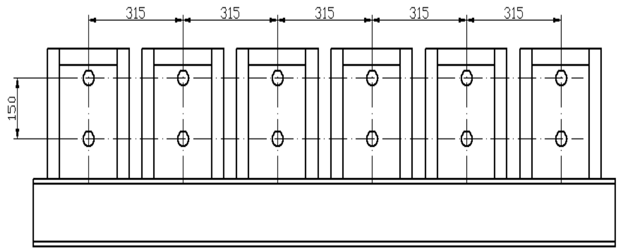

Figure 6. Dimensions scheme of the existing machine before reconstruction

Next important elements are the structural dimensions of the existing roll forming machine. The machine has six roller pairs located wheelbase of *315 mm* in the longitudinal direction and *150 mm* in height between the shafts of each pair.

For profile material will be used galvanized low carbon steel in EN10025 - S185 (WNº1.0035 in EN10027-2) with thickness 0.5 mm. Minimum yield strength of the material for these thicknesses is Re≥185MPa. For the design process will be used most unfavorable limit values of the mechanical performance.

After known output size profile and presents the main dependencies and limitations should be set restrictive conditions necessary for the design of individual passages.

The profile which is necessary to produce is a complicated, it can not be used dependences of (1) to (4), it necessary to considered another method expressed by relations (9) and (10). For yield strength $Re = 185MPa$, elastic modulus $E = 200\ GPa$ and a distance between rollers $l = 315\ mm$ have a maximum distance $b = 13.55\ mm$.

For maximum radius beyond which no occurrence of plastic deformation replacing $Re = 185MPa$, $E = 200\ GPa$ and $t = 0,5\ mm$ in (8) we have - $r_{max} = 270.3\ mm$ and $r_{min} = 0.5\ mm$.

After known limit values of the distance *b*, the minimum and maximum radius, proceed to the design of individual passages. In Figure 7 shows the stages of unfolding profile.

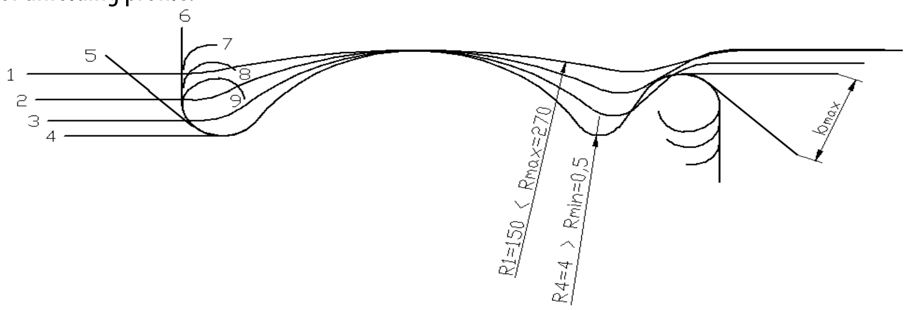

Figure 7. Stages of unfolding profile

Figure 8. Picture of reconstructed machine for the production of specialized profile

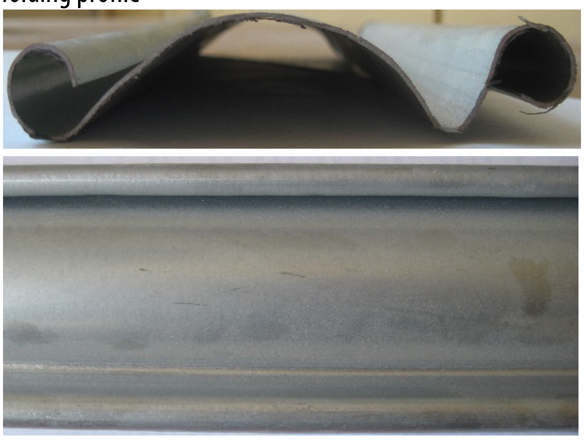

Figure 9. Pictures of the obtained profile in cross-section a) and b) above

Designed necessary passages which satisfy the requirement of the limit calculated above. Defined nine passes which requires the existing machine to add three more. According to the different cross-sections have been designed and the required roller sets which are monolithic rotary elements and the rest of their structural elements have been developed based on the existing elements of the machine.

3. CONCLUSIONS

From the analysis can be make the following conclusions:

- By analyzing existing dependencies on the cold roll forming of thin-walled steel profiles are defined boundary conditions for the design of passages required to produce a specific profile.
- By analyzing the geometrical model of profile (Figure 3) lead to dependence (10) by which can determine the maximum distance between two identical points of the profile, depending on the mechanical properties of the material and the distance between deforming steps .
- Designed required for the profile preparation passages based on information received from the theoretical analysis limitations.
- Plan has been developed to reconstruct the existing machine for cold roll forming of thin-walled steel profiles, after its reconstruction, have achieved the desired results. Performance profile required specifications.

Applied in this work approach for the design of complex thin-walled steel profile shows satisfactory results and may be using as the design of roll forming machines.

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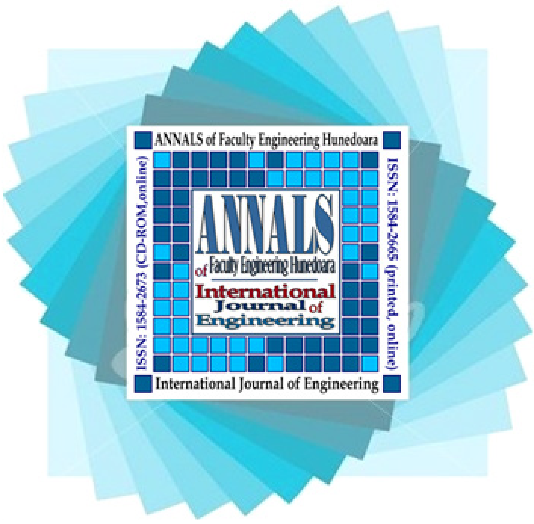

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