*Journal of Applied and Computational Sciences in mechanics, Vol. 30, No. 2, 2019*

# Geometry Effects of Asymmetrical Channel Sections on Common Defects in the Roll Forming Process

Yaser Tajik[1], Hasan Moslemi Naeini[2],
Roohollah Azizi Tafti[3], Davood Akbari[4], Mehdi Kasaei[5]

## 1. Introduction

Roll-forming is the process of continuously shaping strips by means of a series of progressive forming rolls in order to achieve a required cross-section (Figure 1).

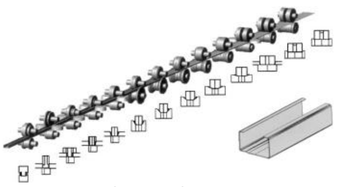

**Fig. 1. A schematic of a roll-forming process**

Roll-forming processes are often used to manufacture thin-walled products. They can be used to satisfy industry demand for products with asymmetrical-channel sections. In Figure 2, an asymmetrical-channel section with its dimensional characteristics is shown.

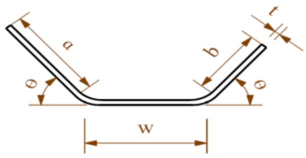


**Fig. 2. An asymmetrical-channel section**

Twist and longitudinal bow which are common defects in roll-formed asymmetrical channel sections affect the appearance and functionality of the product. Therefore, it is very important to understand the reason of occurring these defects and knowing the influence of effective variables on them. In this study, the common defects of asymmetrical channel sections were studied by finite element analysis. Effects of the geometrical properties were investigated on the above defects. Some experiments were performed on an industrial roll-forming machine to verify the accuracy of the finite element model. The finite element results showed that with the increase of the strip thickness, the longitudinal bow initially increases and then decreases. Furthermore, the increase of the flange width decreases the longitudinal bow. However, the web width has no significant effect on the longitudinal bow. Moreover, the average residual longitudinal strains of both flange edges can be used as a criterion to assess the longitudinal bow; a higher average strain leads to a higher bow. The twist angle decreases with the increase of the strip thickness or the web width. However, the twist angle increases with the increase of the flange width.

## 2. Finite-element analysis

In order to investigate the occurrence of defects, the roll-forming process was analyzed using the ABAQUS finite-element package (version 6.13). A sensitivity study was conducted to find the optimum mesh size whose results were logically accurate and its computational time was not too long. A roll-forming line including two stands was modeled. The first stand with cylindrical rolls was used to support the strip before entering the second stand, whose rolls bent the strip to a fold angle of 30$^{\circ}$ (Figure 3).

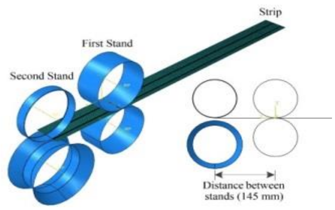


**Fig. 3. The modeled roll-forming line with two stands**

## 3. Experimental Details

In order to verify the finite-element model, some experimental trials were performed. Afterwards, the experimental-measurement results were compared with the results of the finite-element analysis. The strips used in the experiments were made of mild steel (St12) with plastic true-stress–strain curves obtained by the standard tensile test according to ASTM E8. Figure 4 illustrates an industrial roll-forming machine used in the experiments.

**Fig. 4. Roll-forming machine used in the experiments**

## 4. Effect of the strip thickness

The strip thickness effects on the longitudinal bow and average of residual strains on both flange edges are shown in Figure 5. It is observed that with the increase of the strip thickness, both longitudinal bow height and the average strain increase initially and then decrease. Therefore, in thin strips whose thickness is less than 1 mm, the influence of the plastic deformation of flange edges is higher than the increase of the bending stiffness.

[1] PhD. Student, Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran.
[2] Corresponding Author: Professor, Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran.
[3] Assistant Professor, Department of Mechanical Engineering, Yazd University, Yazd, Iran.
[4] Assistant Professor, Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran.
[5] Assistant Professor, Department of Mechanical Engineering, Faculty of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran.

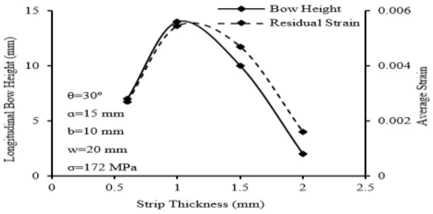


**Fig. 5. Effects of the strip thickness on the longitudinal bow and the average of residual strains**

Effects of the strip thickness on the twist angle and the effective torque are shown in Figure 6. It is observed that with the increase of the strip thickness, the twist angle decreases while the effective torque increases. Therefore, the effect of the torsional stiffness is higher than the influence of the effective torque and the twist angel decreases with the strip thickness.

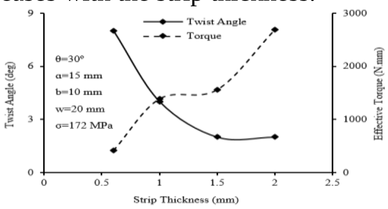


**Fig. 6. Effects of the strip thickness on the twist angle and the effective torque**

## 5. Effect of the web width

The web width effects on the longitudinal bow and average strain are shown in Figure 7. It is observed that the web width has no significant effect on the longitudinal bow height and the average of residual strains.

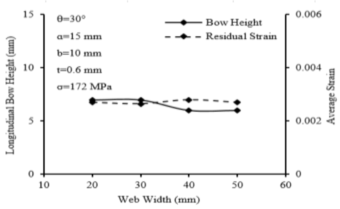


**Fig. 7. Effects of the web width on the longitudinal bow height and the average strain.**

The web width effects on the twist angle and the effective torque are shown in Figure 8. According to Figure 8, opposite to the effective torque, the twist angle decreases with the web width. Therefore, the influence of the torsional stiffness is higher than that of the effective torque on the twist angel when the width of web increases.

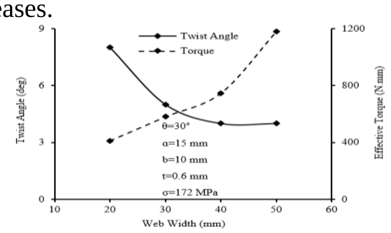


**Fig. 8. Effects of the web width on the twist angle and the effective torque**

## 6. Effect of the flange width

The effects of the long flange width on the longitudinal bow and the average strain are shown in Figure 9. It is observed that both longitudinal bow height and average strain decrease with the increase of the long flange width.

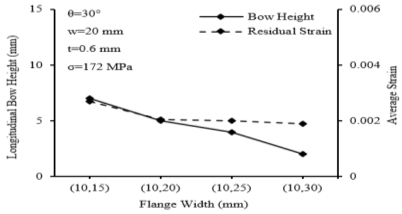


**Fig. 9. Effects of the flanges width on the longitudinal bow height and the average of residual strains**

The long flange width effects on the twist angle and the effective torque are shown in Figure 10. It is observed that both effective torque and twist angle increase with the increase of the long flange width. Therefore, the influence of the effective torque on the twist angel is higher than that of the torsional stiffness when the width of flange increases.

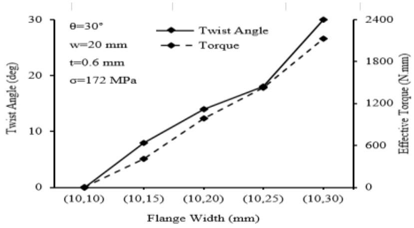


**Fig. 10. Effects of the flanges width on the twist angle and the effective torque**

## 7. Conclusion

This study investigated common defects occur in roll formed asymmetrical channels. Finite element analysis was employed to study effects of the strip thickness, the web width, and the flange width on defects during the forming process. Finite element results were verified by comparison with the results of experiments performed on an industrial roll forming machine. The main achievements of this study are as follows:

1- While roll-forming the asymmetrical-channel sections, the strip is not deformed symmetrically and the long flange edge comes into contact with the roll before the short one. Therefore, the force is applied to the long flange before the short one while a larger force is applied to the long flange compared to the short one. This asymmetrical application of forces to the flanges results in a torsional torque which may lead to a twist distortion from the long flange toward the short one.

2- The twist angle decreases with the increase of the strip thickness, decrease of the long flange width, or increase of the web width for the studied asymmetrical channel sections.

3. Variations of the longitudinal bow height are similar to average residual longitudinal strains of both flange edges. So, it can be used as a criterion to assess the longitudinal bow.