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Research Article

The Investigation of Effects of Roll Forming Parameters on Shape Defects of Channel Section

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Abstract

Cold roll forming is one of the complex forming processes which quality of products is highly dependent on the process parameters. In this study the effect of change in strip thickness and change of material of channel section are investigated on the edge longitudinal strain and bow defect of products. It is important to consider these parameters for roll forming process design. Longitudinal bow is one of the main defects in the cold roll forming products which is affected by the strip thickness increment. Experimental results of this study show that bow defect decreases with the strip thickness increasing. Results of present study show that peak of longitudinal strain in the edge of channel section increases with the strip thickness increases.

Keywords: *Longitudinal strain, bow defects, strips thickness.*

1. Introduction

In the cold roll-forming process, a long metal strip is deformed progressively through a series of rotating rolls in several stands, in order to achieve a required cross-section, with no reduction in the strip thickness, except in the localized bend regions. Being a progressive and continuous process, in which small amounts of forming are applied at each pass of rolls, cold roll forming is largely employed to bend a long strip of sheet blank into a desired cross- sectional profile via roller dies (R. Safdarian, *et al*, 2015).

There are numbers of published experimental and numerical studies of the roll-forming process. (Neffussi, *et al*, 1993) proposed a kinematical approach for predicting the optimal shape and the deformed length of a metal sheet during the cold roll forming before the first roll stand. The main drawback of this study is that only rigid- plastic behavior was considered. Some defects of cold roll forming products were studied by (Ona, *et al*, 2000). They did some experimental tests on the cold roll forming of non-symmetric channel section. They investigated the effect of asymmetry on the some defects such as wrinkling and torsion of non-symmetric channel section. In another study (Fewtrell, *et al*, 1990) did some experimental investigations of operating conditions of cold roll forming in order to gain a scientific understanding of the process. They investigated effective parameters in the cold roll forming process. These parameters were: distance between two continuous stations, rolls velocity and rolls axisym-metric. Fifty tests were done under varied operating conditions. Their results showed that product quality is achievable by control of forming parameters. (Panton, et al, 1992) proposed a new design method that described the variation of bend angle with distance along the strip both within the roll gap and in the unsupported region. They indicated that forming happened in three regions for asymmetry channel section. First region where the bend angle does not change, second region where the bend angle changes but the strip does not contact the roll and third region where the bend angle changes as a function of the roll geometry. Their results showed that severity of forming related to the maximum longitudinal strain in the strip, and this was a function of the maximum slope of the bend angle curve.

2. Methodologies

Experimental material and properties

Average mechanical properties of materials are summar-ized in Table 1. These mechanical properties are Yield Stress (YS), Ultimate Tensile Strength (UTS), work hardening exponent (n), work hardening coefficient and elongation. Hollomon's equation (σ¼ Kεn) was used to model the plastic behavior of sheet material.

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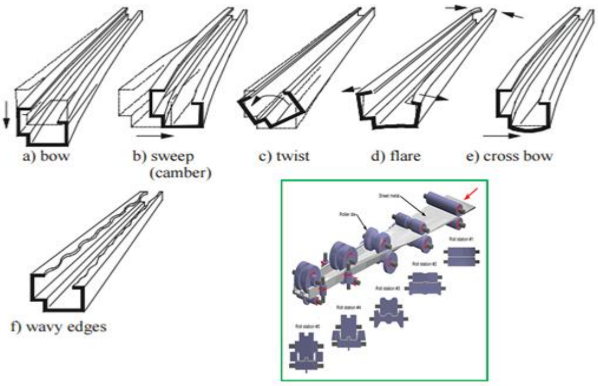

Fig. 1 Defects in Roll forming process (Daya Yesane, 2015)

Table 1 Average mechanical properties from tensile test

Sr. No.	Material	YS (N/mm2)	UTS (N/mm2)	Elongation (%)
1	Aluminum	276	310	12
2	En8	280	450	16
3	M.S.	350	560	14

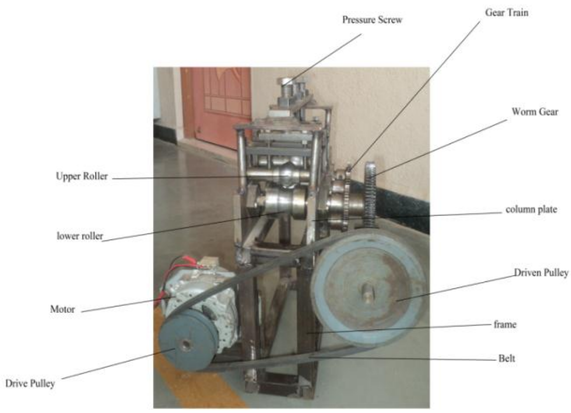

Fig. 2 Experimental setup for roll forming

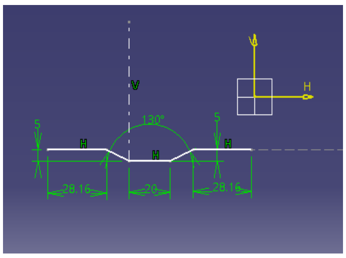

Fig. 3 First Stage of sheet drawing

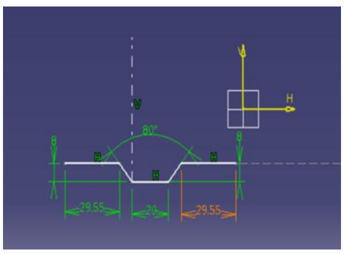

Fig. 4 Second Stage of sheet drawing

3. Results and discussion

3.1 Experimental Results for Aluminum Material

In experimental study, bowing angle, camber angle, product angle and deformation of material is measured using references taking on machine. Deformation is measured by using grid. Measured angles are compared with the design parameter and plotted the result.

Table 2 Experimental Results for Aluminum Material

Parameter	Design Parameter	Experimental Result (0.9mm)	Experimental Result (0.6mm)	Experimental Result (0.3mm)
Bowing angle	10	15	18	22
Camber angle	0	5	9	15
Product angle	60	59	61	63
Strip length	65	65.11	65.12	65.15

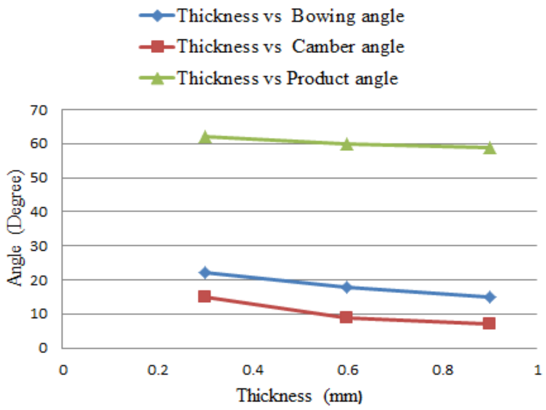

Fig. 5 Thickness vs Angle for Aluminum

Figure 5 shows that bowing angle is decreases with the increase in thickness. Camber angle is also inversely proportional to the thickness of material. Camber angle for aluminum increase 20.6% per mm. Product angle are slightly change with respect to thickness of material.

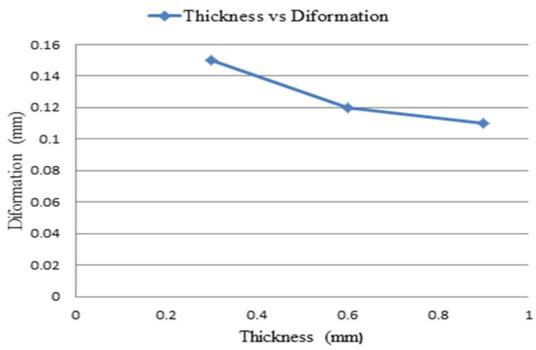

Fig. 6 Thickness vs deformation for Aluminum

Figure 6 shows that deformation of material decrease with increase in thickness of material. Deformation in material decreases by 20% for 0.6 mm thickness sheet with respect to 0.3mm thickness sheet.

3.2 Experimental results for En8 material

Table 3 Experimental Results for En8 Material

Parameter	Design Parameter	Experimental Result (0.9mm)	Experimental Result (0.6mm)	Experimental Result (0.3mm)
Bowing angle	10	17	21	25
Camber angle	0	7	9	16
Product angle	60	59	60	61
Strip length	65	65.15	65.17	65.19

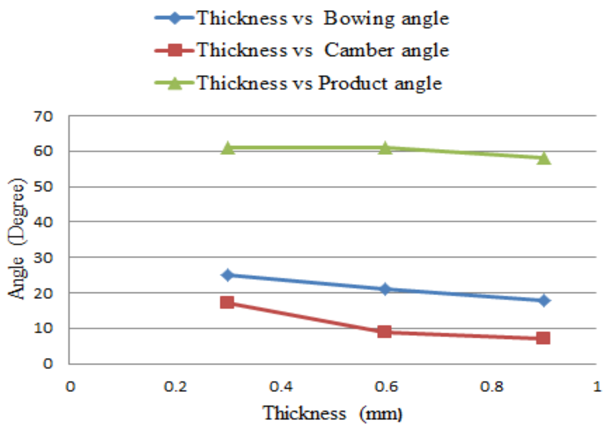

Fig. 7 Thickness vs Angle for En8 Material

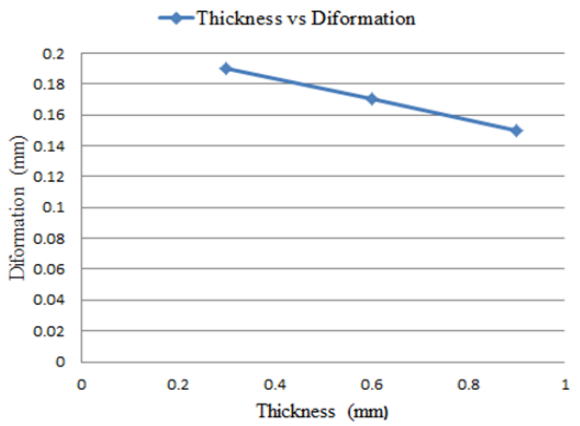

Fig. 8 Thickness vs deformation for En8 material

Figure 7 shows that bowing angle is decreases with the increase in thickness. Camber angle is also inversely proportional to the thickness of material. Camber angle for En8 material increase 9% per mm. Product angles are slightly change with respect to thickness of material. Figure 8 shows that deformation of material decrease with increase in thickness of material deformation in material decrease by 13.33% for 0.6 mm thickness sheet with respect to 0.3mm thickness.

3.3 Experimental results for mild steel

Table 4 Experimental results for Mild Steel

Parameter	Design Parameter	Experimental Result (0.9mm)	Experimental Result (0.6mm)	Experimental Result (0.3mm)
Bowing angle	10	11	13	16
Camber angle	0	5	6	07
Product angle	60	58	59	61
Strip length	65	65.08	65.10	65.13

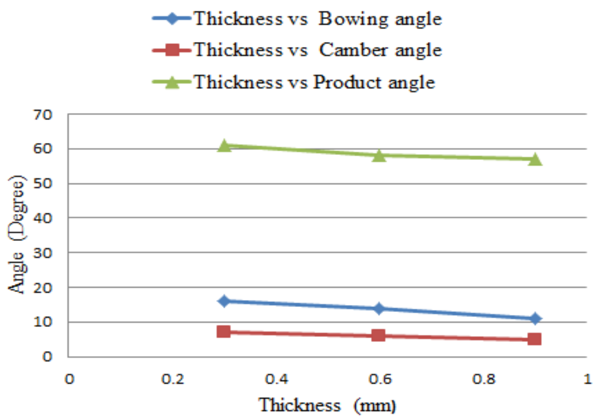

Fig. 9 Thickness vs Angle for Mild Steel

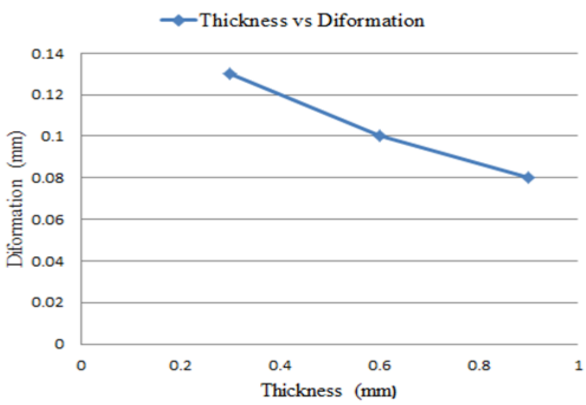

Fig. 10 Thickness vs deformation for Mild Steel

3.4 Experimental results for constant thickness

Table 5 Combine result of all material at 0.6 mm thickness sheet

Parameter	Design Parameter	Aluminum **(BHN- 75)**	En8 **(BHN-60)**	Mild steel **(BHN-130)**
Bowing angle	10	18	21	13
Camber angle	0	9	9	6
Product angle	60	61	50	59
Strip length	65	65.12	65.17	65.10

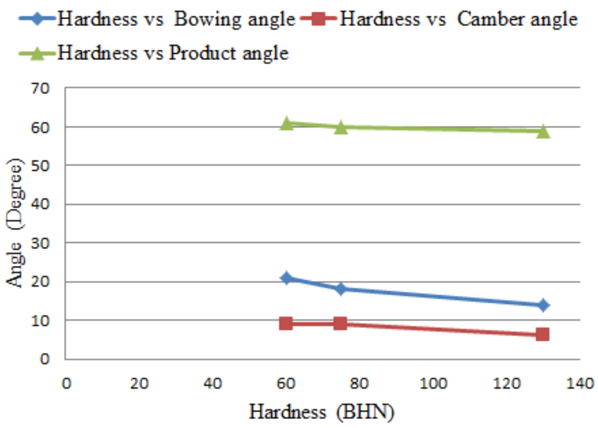

Fig 11 Hardness vs Angle

Figure 11 shows that for constant thickness bowing angle is decrease with increase in hardness of material. Maximum bowing angle for En8 material is 220 and minimum for Mild steel is 180. Camber angle is also inversely proportional to hardness of the material. Product angle for aluminum is 600 and for En8 material is 590. Figure 13 shows that deformation of material decrease with increase in hardness of material.

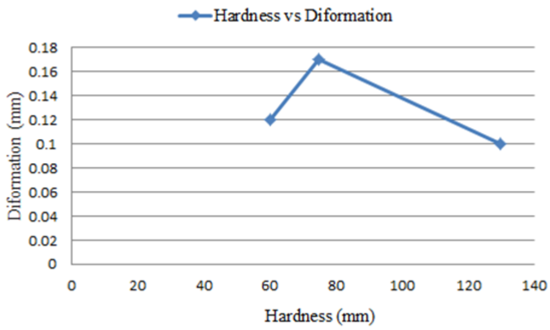

Fig 12 Hardness vs Deformation

Conclusions

In this study the effect of some roll forming parameters of channel section was investigated on the edge longitudinal strain and bow defect of samples.

1) Experimental results of this study show that bow defect increases with bending angle increasing. Results of present study show that peak of edge longitudinal strain in the channel section increases with the strip thickness increases.

2) Although roll angle increasing in each stand is useful and causes reduction in the number of roll forming stands, occurrence probability of some defects such as bow and fracture increase. Therefore, roll forming angle in the cold roll forming process should be selected an optimum value which prevent defect such as bow and fracture and also decrease the number of forming stands.

3) Bowing effect in different material shows different variation. Strip thickness has a very tangible effect on bowing reducing it can increase the strip forming length.

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