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Investigation of bow defect in roll forming

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Abstract Even though New materials are coming into the market Aluminum Alloy is still widely used in Aerospace, Automobile and defense industries. The main reason is these alloys are light weight, high strength and easy to recycle. Many traditional methods like punching, shearing and blanking has been widely used previously to deform these sheets in different industries. Meanwhile, roll forming which is die less processing method, has been used for manufacturing of parts for automobiles and aircrafts structure parts. In this paper, combination of numerical simulation and experimentation of Aluminum alloy 5052 for bow reduction has been studied for U-shape sections. From results it was concluded that the bow defect is significantly reduced by increasing the forming speed of forming rollers.

1. Introduction

Due to the increasing demand of improvement in automobile industries make new ways for the manufacturing processes which is having safety of labors, energy efficient and low threads to environment. With the emergence of new alloys makes these process more interesting for all area of automotive and structural application. New aluminum alloy can achieve the same strength as well as effectively reduce the material thickness while having perfect corrosion resistance. Demand of new materials forming technique has been widely increased in the market, so the insiders pay close attention to new technology. Roll forming is the method for these alloys to deform into its final shape with smooth surface and good tolerance. Roll forming is a series of mechanical process, in which a sheet of different thickness and different materials are undergoes with plastic deformation to achieve its desired finals shape. This process consists of two main types cold and hot roll forming. In cold roll forming the sheet is deform at room temperature while in hot roll forming the sheet is preheated to some temperature and then undergoes the deformation process. It is widely used in automobile and construction industries where sheet is to be deform in specific shapes.

Roll forming production line is more effective and the process is continuous which also make it has a higher economy. The length of the sheet can be adjusted without to having to replace the rolling tool. Compared with the stamping and bending process, roll forming is more flexible, especially for the small-scale production. Traditional molding and other produce any cross-sectional profiles, while punching and bending section to produce only relatively simple [1-6]. The most important advantage of cold-formed profiles is relatively uniform hardening properties and high surface quality, plated metal and enamel processed substantially without leaving scratches. Cross-section cold-formed steel is widely used in

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various industrial fields, especially automobile manufacturing and construction, the traditional cold-formed profiles or closed beam-like openings in high demand.

G.Nefuss and so on [7] have apply the elastic-plastic method to the roll forming simulation in 1996.The sheet is considered to be thin and the neutral layer is coons curve. In 1998, neixue [8] and so on used the computer to simulate the pipe and assume that there is only plane strain exist. From which they get the force and moment across the profile without considering the interaction of the rolls. In 2004, A.Alsamhan ,I.Pillinger and P.Hartely [9] applied remeshing techniques to the roll forming process with the sheet friction calculation. Zhang Dongjuan and Cui Zhenshan [10] had developed an analytical model for predicting the sheet spring back after U-bending based on the Hill's 48 yield criterion and plane strain condition. Also, three materials hardening –kinetic, isotropic and combined hardening has been used to consider the effect in the bending process. R.Safdarian and H.Moslemi Naeini [11] studied the effect of some roll forming parameters of channel section are investigated on the edge longitudinal strain and bow defect of products. The relationship between the parameters and defect have been recovered with simulation and experiment method. In previous study many researchers try to modify many parameters in order to minimize the bow defect in final profile of roll forming. However, there other method through which we can also minimize the bow defect. In our research study we are investigating the effect of roll speed on final profile of aluminum alloys. Results shows that the roll speed has significant effect on the final profile of forming sheet.

2. Experiments

2.1 Roll forming machine specifications

Experimental tests were performed on a cold roll forming machine with four stands. The roll stands are located at equal distance from each other while distance between two successive roll stands is 220mm. In detail, the roll stages were designed to produce different bending angle at each stage and the bending angles were 22.5^0 (1^{st} stage), 45^0 (2^{nd} stage), 67.5^0(3^{rd} stage) and 90^0 (4^{th} stage), respectively.

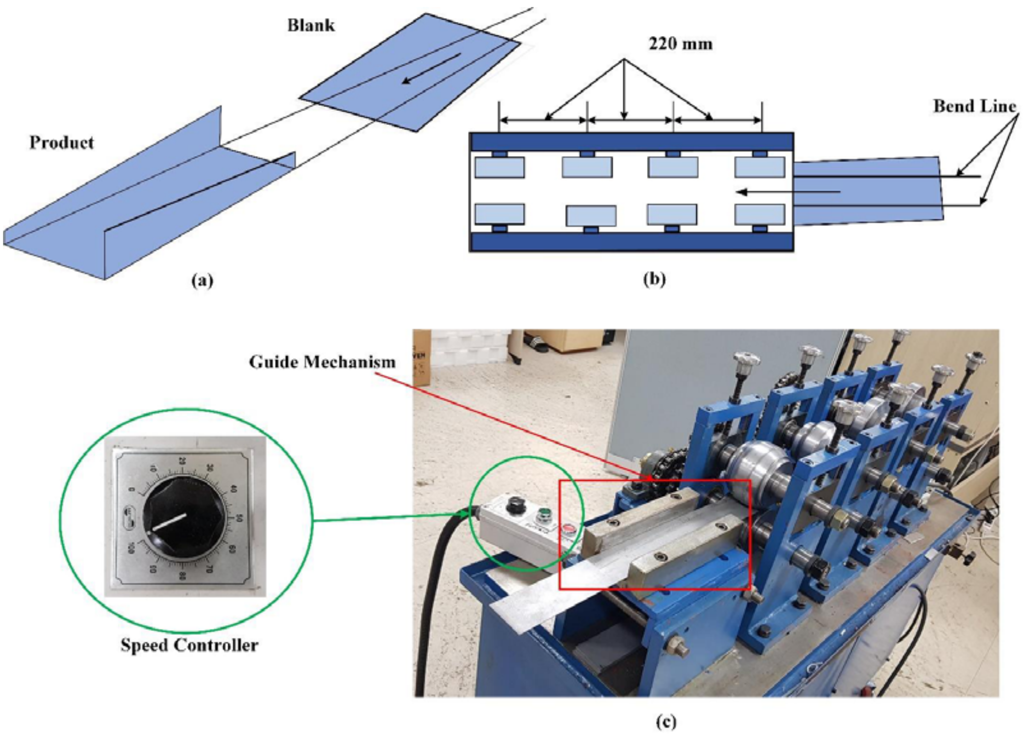

Fig. 1 Roll forming machine specification and guiding mechanism

Using this apparatus, we can deform sheet of different metals into U-channel sections. In some cases, in order to feed the initial strip aligned to the production line, a guide mechanism was used as shown in Fig. 1. Roll forming machine can be operate for different speed up to 100 mm/s according to our need of experiment as shown in above figure.

2.2 Measure of the roll forming defect and material specification

Roll forming is a complex deformation process, which involves large displacement, finite strain and the problems of contact and friction between strip and rolls. This process exhibits obvious geometry, physical and boundary nonliterary. The complex processes contain many defects like twist, spring back while most common among them is bow defect. Which is the longitudinal twist of deformed sheet after roll forming process as shown in Figure .2.

Table. 1 Material chemical and Mechanical properties

Material: AA5052								
Composition (wt. in %)	Si	Fe	Cu	Mg	Zn	Cr	Al	Mn
	0.05	0.2	0.03	3.2	0.12	0.23	balance	0.08
Mechanical Properties	Density (g/cc)	Poisson's ratio	Young's modulus (GPa)	Tensile strength (MPa)	Yield strength (MPa)	Strain hardening coefficient	Ductility (%)	-
	2.66	0.33	70.3	356	155	0.16	12	-

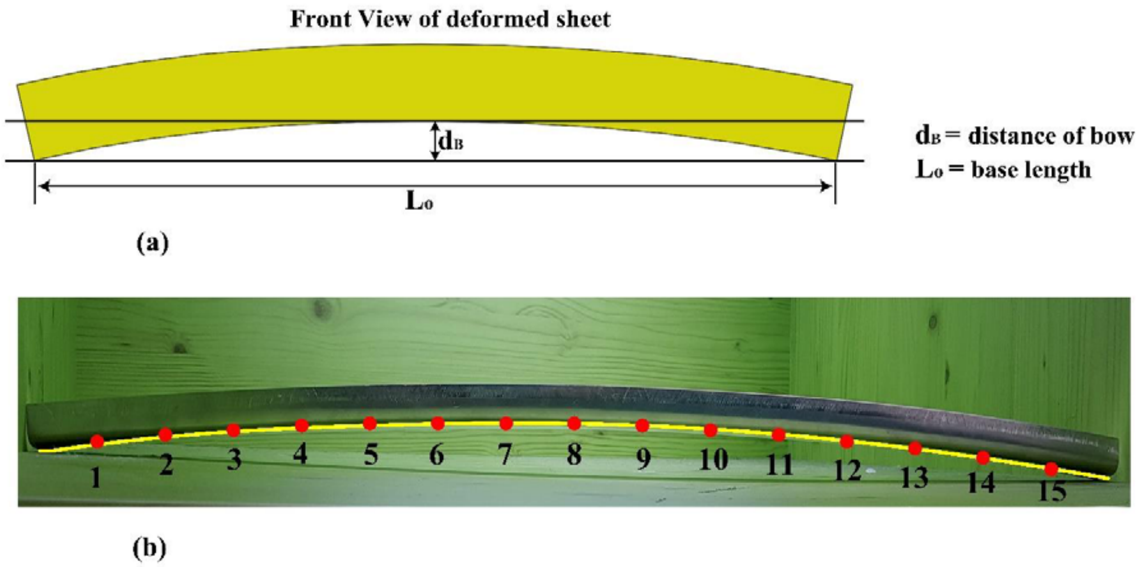

Fig. 2 Bow defect in aluminum roll forming

We are using a cost-effective method in which the bow defect is measure with the help of 15 different points on deformed sheet with equal distance from each other as shown. In the first step the sheet is place on the uniform surface, that all the vertices of the deform sheet touch the flat surface as shown in Figure. 2(a). In the next step two major quantities has been calculated, L_o which is the horizontal length of uniform surface (base line) and d_B is the vertical distance of bow from base line. The values of bow has been measured for 15 points on each sheet for three different roll speed.

In this study, Al6061 aluminum alloy was adopted as a testing material and the chemical composition and the material properties are summarized in Table 1. The Al6061 aluminum alloy specimen dimensions are: 700 mm length, 60 mm width and 1mm thick.

2.3 Finite element analysis of roll forming process

During the roll forming process, plastic strains are produced in different areas of the strip. Through these deformations, the strip is formed to make the desired shape. By investigating the effective stress distributions that occur on the strips, it is possible to determine how the bow is happened to strip deformations. Therefore, three models were simulated, according to experimental tests, using the ANSYS/LS_DYNA finite element software. Figure. 3 (a) shows the forming process model of a strip in a four-stand roll forming line.

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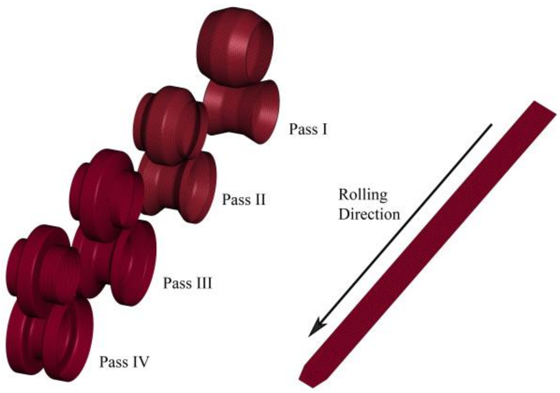
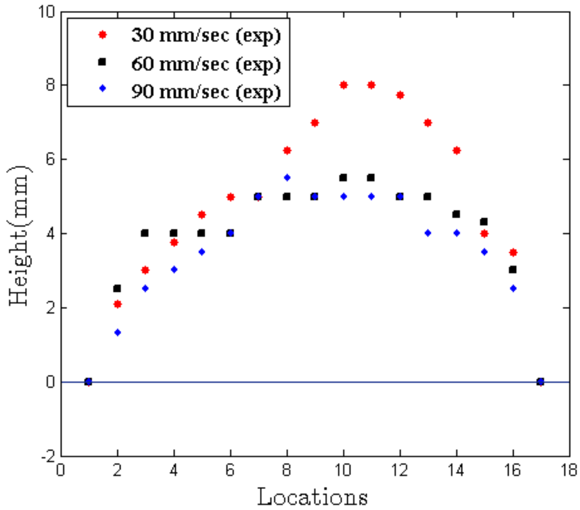
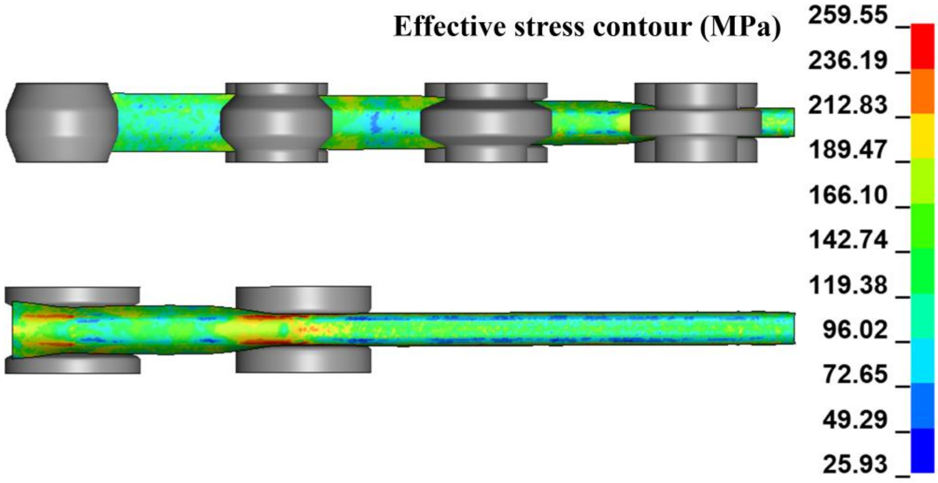


(a) FE model description



(b) bow measurement (mm) at different speeds



(c) Stress contour in formed profile

Figure 3. Finite element model (FEM) results of cold roll forming process for AA5052 material.

As shown in Figure 3 (c), all effective stress results were obtained on the strip length and its values is maximum at those points where the sheet passes the rolls. The bow defect values for 30, 60 and 90mm/sec roll speed are shown in Figure .3(b) which shows that the bow defect is symmetric in 90 mm/sec roll speed. In addition, at high roll speed, the bow height tends to be reduced than that of other two low roll speeds.

Conclusion

In this investigation, the effects of different roll speed on the amount of bow to produce a symmetrical U-shape section using the cold roll forming process were studied experimentally. Also, through the finite element method, the effect of roll speed for 30, 60 and 90mm/sec and effective stress distribution within the strips was studied by using FE model. Then, using the results from both simulation and experimentation, the effect of speed in bow was investigated. Which led to demonstrate the relationships

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between the bow at different roll speed for three AA5052 specimens. Results show that the bow value is inversely proportional to the roll speed during the roll forming process. By increasing the roll speed the bow defect is decreased by considerable amount, also the bow is more uniform and symmetric in high roll speed than compared to low speeds.

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