نشریه مهندسی مکانیک امیرکبیر

Amirkabir Journal of Mechanical Engineering

Amirkabir Journal of Mechanical Engineering, 49(4) (2018) 273-274
DOI: 10.22060/mej.2017.10280.4820

Appropriate Flower Pattern for Cold Roll Forming of Hat Channel Section

R. Safdarian[1], H. Moslemi Naeini[2]*, M. Salmani Tehrani[3]

[1] Department of Mechanical Engineering, Behbahan Khatam Alanbia University of Technology, Behbahan, Iran
[2] Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran
[3] Department of Mechanical Engineering, Esfahan University of Technology, Esfahan, Iran

ABSTRACT: Cold roll forming process is a process that a strip passes through a collection of rotary rolls to be converted to a desired profile. Hat channel section is one of the roll forming products that has many applications in various industries especially in automotive industry. In the present study proper flower pattern for production of hat channel section is determined. Proper flower pattern in the cold roll forming process can prevent some defects such as bowing and wrinkling. Flower pattern of hat channel section was predicted by ABAQUS 3D simulation. Longitudinal strain is one of the results of simulation which was used as a criterion for product quality evaluation. Results of simulations were verified by experimental tests for first forming stand of hat channel section which were done in the present study. In the experimental part of present study, effect of roll angle was investigated on the bow defect of product. Experimental and numerical results of this study have a good agreement. Numerical and experimental of this study showed that bow defect increases by increasing bending angle.

Review History:
Received: 9 February 2015
Revised: 6 October 2015
Accepted: 6 October 2015
Available Online: 2 November 2015

Keywords:
Cold Roll Forming
Hat Channel Section
Flower Pattern
Bow
Longitudinal Strain

1- Introduction

In the cold roll-forming process, a long metal strip is deformed progressively through a series of rotating rolls in several stands. Because of large number of parameters which affect product quality, this process is complex. There are numbers of published experimental and numerical studies of the roll-forming process. Some defects of cold roll forming products were studied by Onaetal. [1]. They did some experimental tests on the cold roll forming of non-symmetric channel section. Fewtrell et al. [2] did some experimental investigations of operating conditions of cold roll forming in order to gain a scientific understanding of the process. Panton et al. [3] 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. Panton et al. [4] investigated longitudinal, transverse and shear strains in the roll forming of channel section. Lindgren [5] used finite element analysis to investigate the effect of bending angle and material strength on the longitudinal strain and deformation length of channel section. Finite element software of Metafor was used by Rossi et al. [6] to model the cold roll forming of channel profiles made of high- strength and stainless steels. The numerical results, expressed in terms of corner strength enhancement versus radius-to-thickness ratio, were compared against an existing predictive model. Wiebenga et al. [7] used robust optimization techniques to determine the optimal process settings of adjustable tools in the final roll forming stand. Advanced high strength steel (AHSS) was used in the roll forming of V-section profile and results showed a significant amount of longitudinal bow and springback in the final product.

In this paper, numerical and experimental methods are used to investigate the effect of some forming parameters in the cold roll forming of channel section. Bowing defect which is one of the main defects in the roll forming products is investigated experimentally and numerically. In this study an appropriate flower pattern is presented for hat channel section.

2- Methodology

As mentioned above, in this study effects of some parameters such as roll angle were investigated experimentally. The materials used in this study were steel sheets of St14. Mechanical properties of St14 steel was measured by tensile test based on the ASTM-E8 standard. Finite element method was used for prediction of appropriate flower pattern for hat channel section production in the cold roll forming. Numerical investigation of cold roll forming was done using a commercially available finite element code Abaqus/Explicit6.10. The model consists of two forming stands that the first stand is used as a belt feeder to the second stand. Rolls were modeled as analytical rigid parts, because of their negligible deformation. The sheet strip was modeled as a deformable part using four node Kirchhoff thin shell elements (S4R). Since the channel section is symmetric, just half of section was modeled.

Corresponding author, E-mail: moslemi@modares.ac.ir

3- Results and Discussion

One of the main defects in the cold roll forming products is bowing. Bow is the variation from a straight line in the vertical plane of a roll formed piece. Effect of bending angle on the bow defect was investigated in this study. Four different roll forming stands with angles of 15˚, 30˚ and 45˚ were used for this purpose. Forming stand of roll forming mill was changed to investigate the effect of other roll forming angles (15˚, 30˚ and 45˚) on the product quality. For better understanding of roll forming angle effect on the bow defect, Cordiant measuring machine (CMM) was used to measure this defect in the samples which was formed with different roll angles. Bow defect of experimental samples and FEM results are compared for three roll forming angles of 15˚, 30˚ and 45˚. Maximum values of bow defect (Δ) of experimental samples are compared with the FEM results for three angles of 15º, 30º and 45º in Table1. Error values of this table show that numerical method has a good accuracy for bow prediction of cold roll forming products.

After verification of numerical model, different models for production of hat channel section were simulated in the ABAQUS and appropriate flower pattern was selected. The criterion for this selection is longitudinal strain in the edge of channel section.

Table 1. Comparison of bow maximum value of FEM and experimental samplesc

Forming Angle (degree)	Δ-FEM (mm)	Δ-Expriment (mm)	Error (%)
15	-0.583	-0.524	10.12
30	-15.79	-15.58	1.3
45	-31.05	-29.41	5.28

4- Conclusions

In this study the effects of some roll forming parameters of channel section were investigated on the edge longitudinal strain and bow defect of samples. Experimental and numerical results of this study show that bow defect increases with bending angle enhancement. Numerical and experimental results comparison shows that numerical results have good agreement with experiments. Therefore, appropriate flower pattern for cold roll forming of hat channel section was suggested using numerical simulation.

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Please cite this article using:

R. Safdarian, H. Moslemi Naeini, M. Salmani Tehrani, Appropriate Flower Pattern for Cold Roll Forming of Hat Channel Section, *Amirkabir J. Mech. Eng.*, 49(4) (2018) 773-784.

DOI: 10.22060/mej.2017.10280.4820