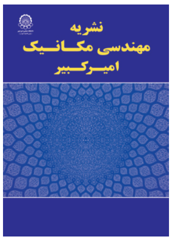

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Investigation of Effective Factors on Strain Distribution in Round Section Roll Forming Process Using Design of Experiments

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ABSTRACT: Geometric defects of roll forming process are affected by amount and situation of strain distribution. In this work, simulation of round section roll forming process has been conducted using the finite element method. Effective factors on the strain distribution have been investigated. Roller diameter, distance between the stations and line speed of the sheet as input parameters and maximum longitudinal strain and strain distribution uniformity across the sheet were considered as the response functions. Design of experiments was conducted using the central composite design. They were executed by finite element method and then values were extracted for response functions. Effects of the input parameters on the response functions were investigated using the analysis of variance. The results of tests were indicated and discussed by the main and interactions effects diagrams. The results demonstrated that by increasing stations distance and roller diameter, maximum longitudinal strain is reduced. On the other hand, by considering analysis of variance, the line speed of sheet and roller diameter affected the transverse strain distribution, but the distance between the stations has no effect on the transverse strain distribution.

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1- Introduction

Roll forming is a continuous process for forming sheets, strips or coiled metal stocks into long shapes of essentially uniform cross-section. However, cold roll forming in its present form is a relatively young forming process. It was not widespread until the demand for better and faster methods of producing sheet metal parts was recognized. Some studies are conducted in this field [1-16].

In this study, design of experiments is conducted using the Central Composite Design (CCD). Effects of the input parameters on the response functions are investigated using the analysis of variance.

2- Design and process analysis

In this study, data from seam welded pipe production line was used with two-inch diameters and 3 mm thickness of sheet that was produced by roll forming process and using compressive molds and guide molds. This process was simulated by commercially available finite element software ABAQUS/Explicit 6.11. Considering that sample product has a symmetry plane, to reduce the analysis time, half of section was modeled. The model includes a pair of cylindrical rolls zero station, five pairs of rolls and four guides roll in main stations. Considering Coulomb model, friction coefficient is intended constant equal to μ=0.2. In this work, the rolls are modeled as rigid bodies because they have negligible deformation. The strip considered as deformable and meshed using four nodes thin shell elements (S4R).

3- Design and performing the experiments

CCD was used to design experiments by Minitab software. In the present work, three factors of the cold roll forming process that are effective and controllable in the experiments, were considered as inputs parameters. They are roll diameter (A), distance between the stations (B) and line speed of the sheet (C). The maximum and minimum magnitudes of the input parameters are shown in Table 1.

Table 1. Maximum and minimum magnitude of the input parameters in CCD

Parameter	Minimum	Maximum
Roll diameter(mm)	55	90
Distance of station(mm)	530	600
Line speed(m/mm)	30	35

Based on CCD, five levels of the parameters are specified that are given in Table 2. Design of the experiments using the CCD is shown in Table 3. Design of the experiments using the CCD was done in 20 states.

Table 2. Levels of parameters

Parameter		Level				
		1	2	3	4	5
Roll diameter (mm)	A	43	55	72.5	90	102
Distance of station (mm)	B	506	530	565	600	623
Line speed (m/mm)	C	28.2	30	32.5	35	37

4- Elicit strain functions

In this work, to extract Maximum Longitudinal Strain (MLS), an element was defined within 73 mm center of the strip and at each station maximum plastic strain was extracted. Then sum of five stations will be calculated eventually and investigated as MLS. In Figure 1, MLS was imposed to the edge of the sheet.

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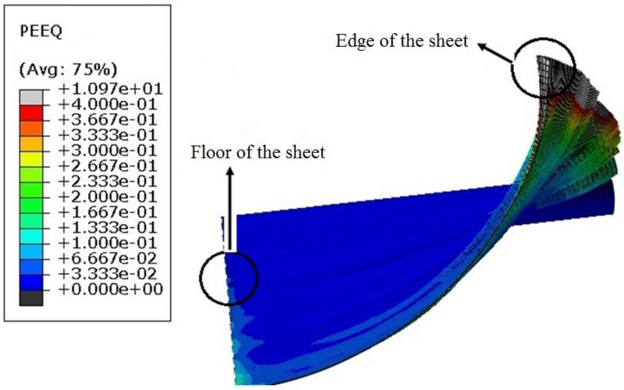

Figure 1. Longitudinal strain at the edges and bottom sheets rounded by the process

Strain Distribution Uniformity (SDU) is another parameter studied in the paper. Because of longitudinal bow, camber and twist are the most frequent defects in narrow roll formed products. Longitudinal bow is caused by non-uniformity of transversal elongation and shrinkage of the strip. However, these defects can be reduced by using proper conditions.

5- Results and Discussion

To investigate effects of factors on the maximum longitudinal strain, Analysis of variance is used by the statistic P-Value to determine the influence of factors on the functions. According to P-values and diagrams main effects, we can say that the roller diameter and distance between stations have significant effects on the MLS. By increasing the distance between the stations or the roller diameter, MLS decreases. But it can be said that the line speed has less effect than other factors on the MLS. Diagram of interaction effects on MLS is shown in Figure 2.

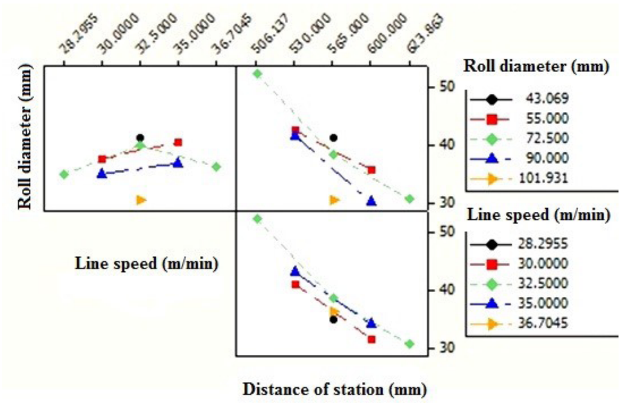

Figure 2. Diagram of factors interactions on the MLS

The results of analysis of variance for SDU indicate that the roll diameter and linear speed have significant effects while the distance between the stations is ineffective.
With regards to the main effects diagram it will be determined that the effect of each factor on the non-uniformity of strain parameter is very low. In other words, the range of variation for uniformity of strain is negligible. Diagram of interaction effects on SDU is shown in Figure 3.

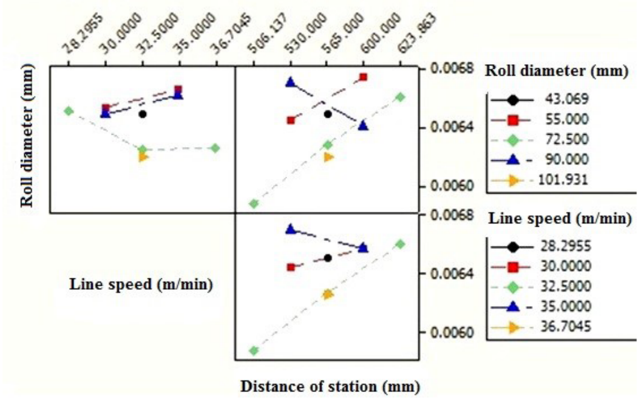

Figure 3. Diagram of factors interactions on the SDU

6- Conclusions

The results demonstrated that by increasing distance stations and roller diameter, the maximum longitudinal strain is reduced. On the other hand, by considering analysis of variance, the line speed of sheet and roller diameter affected the transverse strain distribution, but the distance between the stations is ineffective on the transverse strain distribution.

References

[1] Salmani Tehrani, M., Nikfroz, M., (2009). “The effect of geometrical parameters on the angle of twist sections roll forming asymmetric channel simulation using Finite Element.” *Journal of Advanced Design and Manufacturing Technology* 2(3).

[2] Binti Mohd saffe, S. N., Nagamachi, T., (2014). “Residual stress around cut end of hat steel channel by roll forming “ Procedia Engineering 81: 5.

[3] Moslemi naeini, H., Azizi tafti, R., Tjdari, M., (2011). “Using artificial neural networks for estimation of spring back in cold roll forming.” *Amikabir journal of mechanical engineering* 42(3).

[4] Bhattacharyya, D., Smith, P., yee, C.H., Collins, I.F., (1984). “The development of longitudinal strain in cold roll forming and its influence on product straightness.” *First international con. on tech. of plasticity*, Tokyo, The japan Sock. for tech of plasticity: 5.

[5] Paralikas, J. (2009). “Investigation of the effects of main roll forming process parameters on quality for a V-section profile form AHSS.” *international journal of advance technology* 44: 14.

[6] Zeng, G. (2009). “Optimization design of roll profiles for cold roll forming based on response surface method.” *Materials and Designs* 30: 8.

[7] Salmani Tehrani, M., Bahrami, M., (2010). “Investigate numerical and analytical of the round tube roll forming.” *Journal of Advanced Design and Manufacturing Technology* 3(2).

[8] Dadgar asl, Y., Tajdari, M., Moslemi naeini, H., (2015). “prediction of required torque in cold roll forming process OS a channel section using artificial neural network.” *modares mechanical engineering* 15(7).

[9] Mohamadi, M., Moslemi naeini, H., Kasaei, M.M., Salmani tehrani, M., (2014). “investigation of twist

defect floor of profiles with variable area in flexible roll forming process." *modares mechanical engineering* 14(6).

[10] Minjin oh., M. K. l., N., (2010). "robust design of roll formed slide rial using response surface method." *journal of mechanical science and technology* 24(12).

[11] Safdarian, R., Moslemi naeini, H., (2015). "the effects of parameters on the cold roll forming of channel section." *journal of thin-walled structures* 92: 6.

[12] Abvabi, A., Rolfe, B., Hodgson, P.D., (2015). "the influence of residual stress on a roll forming process." *international journal of mechanical science*.

[13] Halmos, G. T. (2006). *roll forming handbook*, Taylor & Francis.

[14] Moslemi naeini, H., Tajdari, M., Mazdak, S., (2007). "the optimal angle of the blades in the shape and its effect on sheet rolled in the cold roll forming process." *fifteenth annual conference of mechanical engineering*, Amirkabir university of technology.

[15] Alimirzaloo, V. (2011). *optimization of compressor blade final forging in air engine*. Mechanical Engineering, Amirkabir University. Ph.D.

[16] McClure, C. K., Li, H., (1995). "roll forming simulation using finite element analysis." *Manufacturing review* 8(2): 8.

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