1-1-2014

Analysis of thin strip profile during asymmetrical cold rolling with roll crossing and shifting mill

Abdulrahman Aljabri
University of Wollongong, ada507@uowmail.edu.au

Zhengyi Jiang
University of Wollongong, jiang@uow.edu.au

Dongbin Wei
University of Wollongong, dwei@uow.edu.au

Analysis of thin strip profile during asymmetrical cold rolling with roll crossing and shifting mill

Abstract

Strip profile control during rolling is required to assure the dimensional quality of rolled thin strip is acceptable for customers. Throughout rolling, the strip profile is controlled by using the advanced shape control rolling mill, such as the combination of work roll crossing and shifting during asymmetrical rolling, the one of the valuable methods to control the strip profile quality in rolling process. In this paper, the influences of cold rolling parameters such as the crossing angle and axial shifting value of work rolls on the strip profile are analysed. The strip shape control is discussed under both symmetrical and asymmetrical rolling conditions. The obtained results are appropriate to control the rolled thin strip profile in practice. (2014) Trans Tech Publications, Switzerland.

Keywords

thin, analysis, rolling, cold, roll, mill, asymmetrical, during, profile, shifting, strip, crossing

Publication Details

Aljabri, A., Jiang, Z. & Wei, D. (2014). Analysis of thin strip profile during asymmetrical cold rolling with roll crossing and shifting mill. Advanced Materials Research, 894 212-216.

Analysis of Thin Strip Profile during Asymmetrical Cold Rolling with Roll Crossing and Shifting Mill

Abdulrahman Aljabri[1, a], Zhengyi Jiang[2, b] and Dongbin Wei[3, c]

[1, 2, 3] School of Mechanical, Materials and Mechatronic Engineering, University of Wollongong, Wollongong NSW 2522, Australia

[a]ada507@uowmail.edu, [b]jiang@uow.edu.au, [c]dwei@uow.edu.au

Keywords: Asymmetrical rolling; work roll crossing; work roll shifting; strip profile; thin strip; cold rolling

Abstract. Strip profile control during rolling is required to assure the dimensional quality of rolled thin strip is acceptable for customers**.** Throughout rolling, the strip profile is controlled by using the advanced shape control rolling mill, such as the combination of work roll crossing and shifting during asymmetrical rolling, the one of the valuable methods to control the strip profile quality in rolling process. In this paper, the influences of cold rolling parameters such as the crossing angle and axial shifting value of work rolls on the strip profile are analysed. The strip shape control is discussed under both symmetrical and asymmetrical rolling conditions. The obtained results are appropriate to control the rolled thin strip profile in practice.

Introduction

The market requirements for higher quality and increasingly thinner strip have recently encouraged the development and manufacturing of thin gage for producing thinner strip with good shape and profile. As a result, rolling researchers have developed a variety of advanced control shape rolling mills [1-4] to improve the strip shape and profile. By using these advanced rolling mills, the strip profile is controlled by varying the shape of the gap between work rolls of a rolling mill which is known as the roll gap profile [3] . Such roll gap profile control can be carried out on mills equipped with work roll crossing, and in combination of roll axial shifting and asymmetrical rolling.

The combination of multiple shape control systems, such as pair cross and work roll shifting (PCS) [4] and the work rolls crossing and shifting (RCS) [2] can provide more than one benefits of the strip profile control technology, for example, the roll crossing mill provides thickness distribution control while the roll shifting improves the bending roll effect, to reduce the edge drop of the strip, and to maintain the uniform wear and thermal crown of the working rolls [5]. Simultaneously, asymmetrical rolling can make the rolling force decreases dramatically, so the edge drop reduces as well as the strip crown becomes small. These mills are appropriate to control the strip shape, profile and flatness when the rolling process is applied to the rolling of thick strip, and the control of the strip shape, profile and flatness no longer present a serious challenge to rolling mill operation for relatively thick products. Researchers have studied the effects of rolling parameters on the strip shape and profile [6-8]. The ability of the work roll crossing and shifting mill on crown control and its effect on rolling mechanics are discussed [9-11]. Up to now, there is no established research on the analysis of strip profile for thin strip during asymmetrical cold rolling with roll crossing and shifting mill. In this work, the effects of the work roll crossing angle and axial shifting parameters on the strip shape and profile in asymmetrical cold rolling of thin strip were experimentally investigated.

Asymmetrical cold rolling shown in Fig. 1 (a) is a roll configuration where operates different peripheral velocities ($V_1$and V_2) between two rolls due to the variance in diameters (R_1 and R_2). In comparison, the traditional rolling process (symmetrical) is a deformation process wherein both work rolls operate at the same velocity (V_u and V_d) and are both upper and down work roll equal in diameters (R_{wu} and R_{wd}) as shown in Fig 1. (b). Asymmetrical rolling produces a cross shear region between the backward-slip zone and the forward-slip zone as shown in Fig.1 (a). This leads to a 30-40% reduction in the rolling force and results in the ability to be able to greatly reduce the thickness of strip that can be rolled [12].

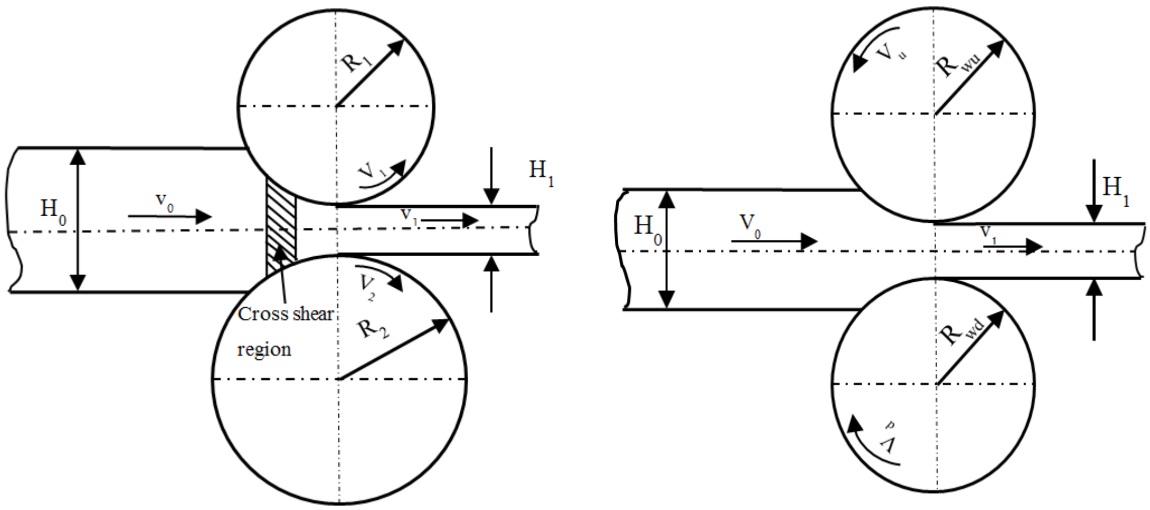


Fig. 1 Strip rolling process (a) asymmetrical rolling, (b) symmetrical rolling

Experiment of asymmetrical cold rolling of thin strip

Extensive tests were carried out on a 4-high Hille 100 rolling mill revamped for the purpose of research with a work roll crossing and shifting system. The confirmatory tests were performed by modifying an ordinary cold rolling mill to work roll crossing and shifting system. The specification for the test mill is given in Table 1. To implement an experimental process for cold steel rolling, low carbon steel strips 0.5-0.55 mm thick, 80-120 mm wide and 400 mm long were mainly rolled under dry condition with a roll speed of 10 rpm (0.033 m/s). During implementation no bending force was applied to the rolls, nor was tension applied to the strip specimens.

Table 1 Specification for the 4-high asymmetric rolling

Mill system	Work roll crossing and shifting
Cross angle	0°, 0.5°, 1.0°
Shifting value	0-16 mm
Upper work roll	Diameter = 63mm, length = 250 mm
Down work roll	Diameter = 76mm, length = 250 mm
Backup roll	Diameter = 228mm, length = 250 mm

Results and discussion

Strip shape control. The comparison of the exit strip profile in asymmetrical rolling and symmetrical rolling (standard 4-high) is shown in Fig. 2. It can be seen that if the symmetrical rolling process with crossing angle is carried out, the edge buckle is observed. However, the strip surface is roughly flat under asymmetrical rolling with crossing angle. This is due to the existing of the cross shear region in the roll bite, which makes the rolling force reduce significantly, and the crossing angle changes the roll gap distribution that leads to the strip thickness distribution in the width direction be constant.

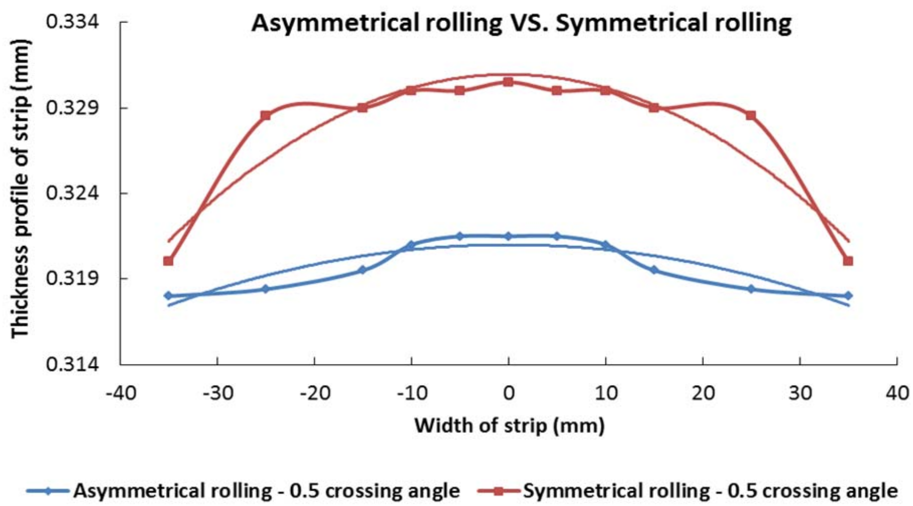
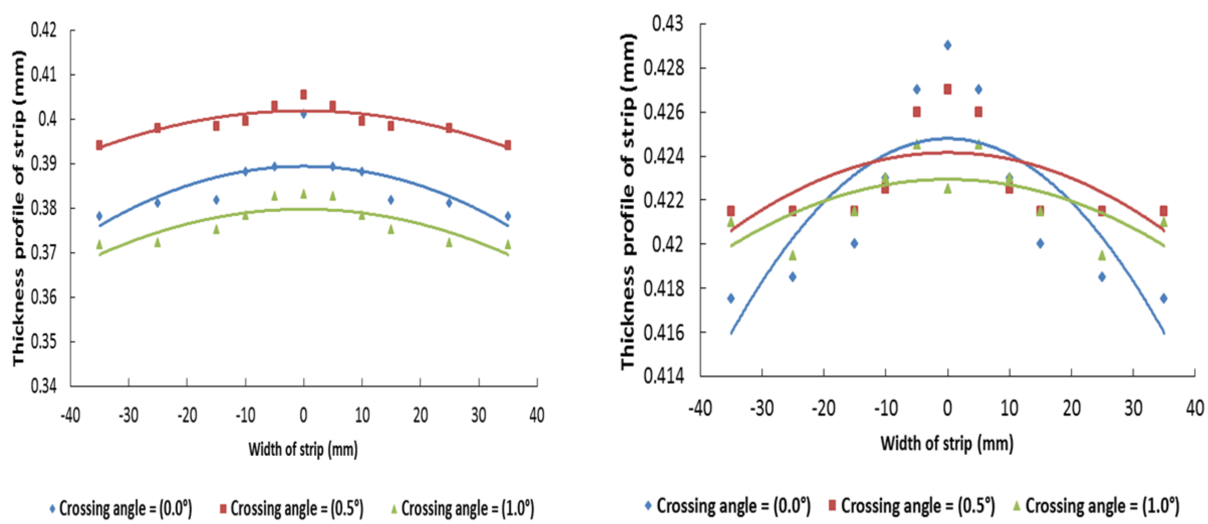


Fig. 2 Strip profile in asymmetrical and symmetrical rolling

Thin strip profile with crossing angle. Fig. 3 shows the effects of the work roll crossing angle in asymmetrical rolling with different strip widths. It is clear that the strip thickness profile along the width direction improved significantly as the cross angle increases and reaches 1.0º with asymmetrical rolling for both strip widths, but more improved with wider strip. This proves that the work roll crossing system has a capability to adjust the roll gape profile causing the roll gap distribution to be uniformed. Simultaneously, asymmetrical rolling makes the rolling force decrease dramatically, so the strip profile is significantly improved.



(a) (b)

Fig. 3 Exit strip profile for different crossing angle in a symmetrical rolling. (a) 80 mm width of strip and (b) 100 mm width of strip

Thin strip profile with a combination of work rolls crossing and shifting. It was found that as the work roll crossing and shifting rolling mill used as a multiple shape control system provides high efficiency profile control devices. The influence of the work rolls crossing and shifting on strip profile under asymmetrical rolling condition was analysed as shown in Fig. 4. It can be seen that the strip profile changes toward flat shape when changing the work roll axial shifting value, and the strip profile becomes more improvement when the crossing angle increases. This could be a result of modifying the roll gap profile by crossing angle and simultaneously the roll bending improves as the shift amount of roll stroke increases.

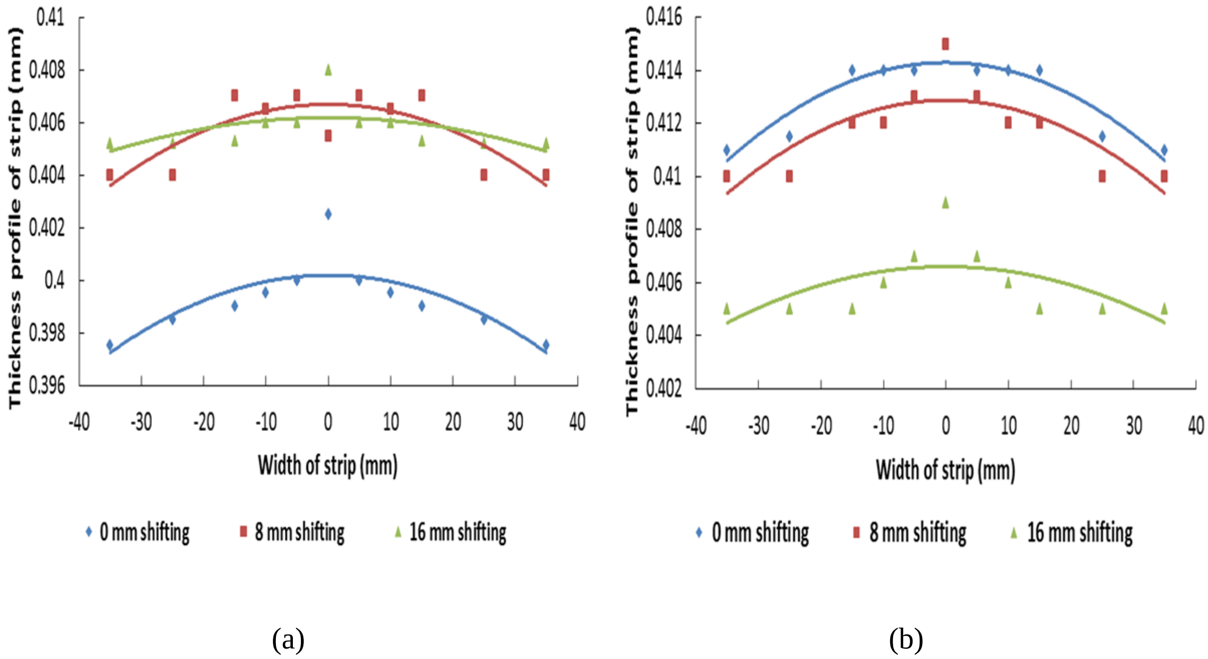


Fig. 4 Strip profile for different crossing angle and shifting values in a symmetrical rolling. (a) 0.5º crossing angle and (b) 1.0º crossing angle

Summary

The exit strip profile for cold rolling of thin strip was systematically estimated considering the work roll crossing, axial work roll shifting and the combination of the work rolls crossing and shifting using a 4-high asymmetrical rolling mill. Experimental results show that the work roll crossing angle provides improved strip shape by modifying the roll gap distribution caused by load variation. The strip profile is nearly flat under asymmetrical rolling with an increase of crossing angle and axial shifting value. The practical application has demonstrated that the combination of the work rolls crossing and shifting during asymmetrical rolling can effectively improve the strip profile.

Acknowledgments

The authors gratefully acknowledge the Australian Research Council (ARC) funding support for this research. The authors would also thank Mr. Joe Abbott's assistance in the experimental work. The first author is grateful to the Ministry of Higher Education under King Abdullah Scholarships Program for the financial support towards his PhD study.

References

[1] N. Kiyoshi, et al., *High reduction rolling technology on pair cross mill*. Nippon Steel Technology Report No.75, 1997: p. 9-23.

[2] V.B. Ginzburg and M. Azzam, *Selection of optimum strip profile and flatness technology for rolling mills.* Iron And Steel Engineering, 1997. 74: p. 30-37.

[3] V.B. Ginzburg, *Roll crossing and shifting system*. 1997, Danieli United, A Division of Danieli Corporation; intenational Rolling Mill Consultants, Inc. : USA. p. 1-18.

[4] Y. Miyai, R. Shimizu, and T. Kawasaki, *Modernization and operation of NKK's Keihin hot strip mill.* Iron and Steel Engineer, 1991. Nov: p. 35-40.

[5] Y. Qiulin and F. Kuan-Chen, *Method for controlling axial shifting rolls*. 1995, The University of Toledo: Canda. p. 1-17.

[6] Z.Y. Jiang, et al., *strip shape analysis of asymmetrical cold rolling of thin strip.* Advanced Material Research, 2010. 97-101: p. 81-84.

[7] Z.Y. Jiang, D.B. Wei, and A.K. Tieu, *Analysis of cold rolling of ultra thin strip.* Journal of Materials Processing Technology, 2009. 209: p. 4584-4589.

[8] Z.Y. Jiang, H.T. Zhu, and A.K. Tieu, *Analysis of asymmetrical rolling for cold rolling due to roll edge contact.* Key Engineering Materials, 2004. 274-276: p. 715-720.

[9] S. Omori, et al., *Analysis of rolling load generated by pair crossed rolling mill.* Ironmaking & Steelmaking, 2004. 31: p. 71-80.

[10] M. Kitahama, et al., *Profile Control of hot rolled strip by work roll shifting (K-WRS) mill.* Iron and Steel Engineering, 1987: p. 34-42.

[11] A. Aljabri, et al., *Thin strip profile control capability of roll crossing and shifting in cold rolling mill.* Material Science Forum, 2013. 773-774: p. 70-78.

[12] D. Pan and D.H. Sansome, *An experimental study of the effect of rolll-speed mismatch on the rolling load during the cold rolling of thin strip.* Journal of Mechanical Working Technology, 1982. 6: p. 361-377.