Journal of University of Science and Technology Beijing
Volume 14, Number 2, April 2007, Page 190

Materials

Study and application of crown feedback control in hot strip rolling

Xiaodong Wang[1)], *Anrui He*[1)], *Quan Yang*[1)], *Zhi Xie*[2)], *and Hongtao Yang*[2)]

1) National Engineering Research Center for Advanced Rolling Technology, University of Science and Technology Beijing, Beijing 100083, China
2) Anshan Iron and Steel Corporation, Anshan 114002, China
(Received 2006-06-22)

Abstract: Crown feedback control is one part of the automatic shape control (ASC) system. On the basis of large simulation researches conducted, a linear crown feedback control model was put forward and applied in actual strip rolling. According to its successful operation in the ASP1700 hot strip mill of Angang Group for one year and also from the statistical results of several crown measurements, it can be definitely said that this control model is highly effective and shows stable performance. The control effectiveness of different gauges of strips with the feedback control is found to increase by 10%-30% compared with that without feedback control.

Key words: hot rolled strip; crown; feedback control; automatic shape control; profiler

1. Introduction

Although there have been several researches related to strip shape control, yet most of those are concentrated on control methods and setup calculation, and no crown feedback control model that can be directly applied to hot rolling was put forward. R.M. Guo [1] stated that an online automatic shape control (ASC) system can be established through the deep understanding about strip rolling behavior based on shape theoretic models [2-9] suggested by predecessors. The simulation models can act as a bridge between theoretical and applicational models research, and it is used to prove the theoretical models. But these models did not involve a deep research with regard to the establishment of a close loop control system of crown feedback. The basic idea of strip shape control is that crown control is accomplished on upstream stands, whereas flatness control on downstream stands. X.L. Yao and Z.Y. Zhang *et al.* [10] put forward the strip crown prediction model, strip shape prediction model, and feedback control by simplifying and discretizing the models suggested by B. Cheng's elastic deformation theory of rolls. As no shape measuring apparatus was used, the real close loop control of strip shape was not achieved yet in the research mentioned above.

Therefore, the establishment of strip crown feedback control model (CFC) and its application to actual hot strip rolling have become one of the important tasks in ASC system research. One crown feedback control model that has been applied to the ASP1700 hot strip mill of Angang Group and its effectiveness are described in this article.

2. Principle of strip crown feedback control

Fig. 1 is the structural schematic graph of an online strip ASC system, which consists of a strip shape setup module, a bending force feed-forward control module, a crown feedback control module, and a flatness feedback control module. This system has been effectively applied to the ASP1700 hot strip mill. The strip crown value measured by a profiler is sent to the crown feedback control model, and then control variables are calculated based on certain arithmetic regulation. The aim of crown feedback control is to guarantee the strip crown within an economically reasonable range using the existing equipment. Hydraulic bending and shifting adaptors of work rolls were installed as the strip shape adjusting means from F3 to F6 in ASP1700. During crown feedback control, strips must be retained to be flat, that is, the difference value between the outlet and the inlet relative crown of every stand must be equal. The concept of relative crown is that strip crown is divided by strip thickness. The aim value of crown control is given at the exit of F6, the aim crowns at the exits of other stands can be calculated backward from F6 to F1. As the bending force adaptors were only installed on F3 to F6, bending of work rolls becomes the only controllable tool to control strip crown. The most ideal condition is that there is a profiler to measure the strip crown at the exit of every finishing stand and can achieve separate close loop control of each stand. But this situation is hardly realized for equipment layout because of the economic reason. Therefore, actual strip

Corresponding author: Xiaodong Wang, **E-mail:** x_d_wcumt@163.com

crown can only be measured by the profiler at the exit of F6, crown values at the exits of F3 to F5 can be calculated on the basis of the rule that relative crown should be retained as a constant. Thus the close loop control can be achieved. During strip shape setup calculations, the relative crown of every stand varies within a reasonable range, namely, satisfying Shohet discriminant [3], so that the flatness of a strip is not destroyed as shown in Fig. 2, in which CH/H and Ch/h represent the relative crowns at the entry and at the exit of the finishing stand, respectively. So this strategy is also used in crown feedback control. On the basis of Shohet rule, bending force is adjusted from F3 to F6. But the main adjusting values are loaded on F3 and F4, because the flatness of a strip is highly sensitive to the changes in the bending force of F5 and F6.

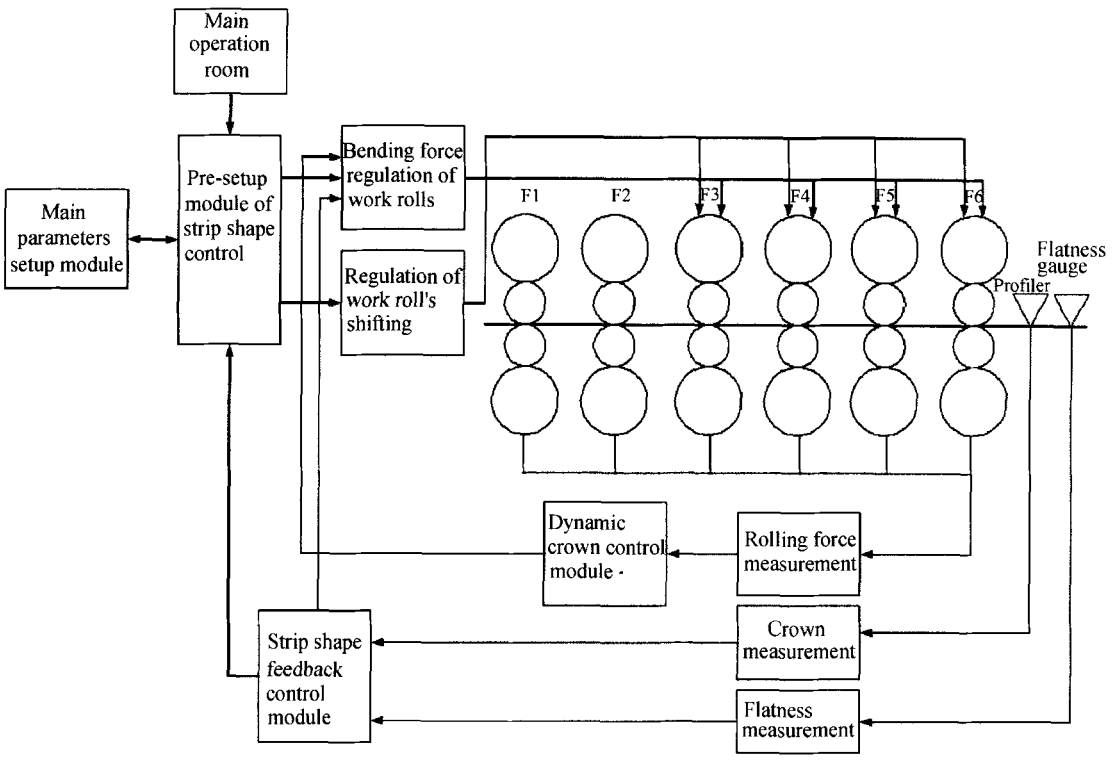

Fig. 1. Basic composition of automatic shape control system for hot rolled strip.

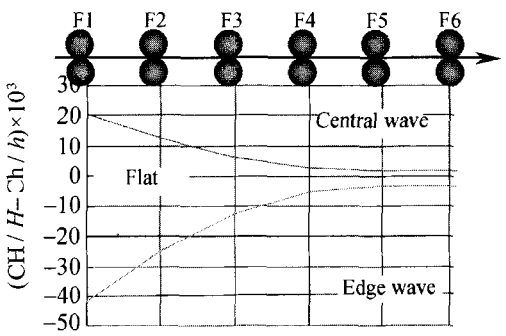

Fig. 2. Flatness dead area of strip shape control.

3. Profile measurement apparatus

One set X-ray profiler made by IMS Company was installed at the exit of the finishing train of an ASP1700 hot strip mill in Angang Group to measure the strip crown, and the schematic drawing is shown in Fig. 3. One or more X-ray sources were settled at the upper beam of the C frame, and a certain number of sensors were installed at the bottom beam. When the strip passes through the C frame, X-ray penetrates the strip and reaches the sensor. As the thickness is different at different width positions, the energy received by each sensor is different, and consequently, different electrical signals are produced and are sent to the signal-processing unit. So the thickness values at different positions on the cross section can be calculated using a computer, and then one crown value is given.

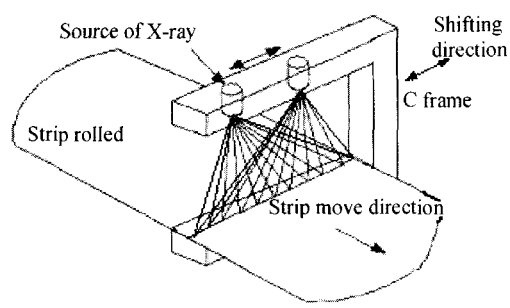

Fig. 3. Measurement scheme of the profiler.

As this profiler has only 28 measurement channels, one section profile cannot be measured one time, and the C frame must move along the direction of the strip width for obtaining the crown value during its measurement.

4. Crown feedback control model

On the basis of several product data, the deep resear-