A NEW AGC ALGORITHM FOR HIGH STRENGTH STEEL IN TANDEM COLD ROLLING*

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Abstract
Cold rolled high strength steel are playing a very important role in reducing automobile weight for energy saving and environment protection. In recent year, more and more high strength steel were manufacturing in steel company. But there are some problems in the cold rolling process for high strength steel products. Periodic thickness deviation especially in strip head or tail is an important one in these problems. In this paper, the reason of periodic thickness deviation was analysed and a new AGC algorithm called Property FFC for high strength steel in tandem cold rolling was developed. The application of this new algorithm shows that it can reduce the thickness deviation.
Keywords: AGC; high strength steel; cold rolling; thickness deviation

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1 INTRODUCTION

Thickness accuracy is one of the most important quality index for strip steel. Automatic gauge control in tandem cold rolling is integrated strategy, including feed-forward control, feedback control, supervisory control, tension control and mass flow control.

With the development of light weight vehicles, high strength and ultra-high strength steel is widely used. Strength grade and production proportion of high strength steel are improved continually. High alloy element of high strength steel and non-uniform cooling temperature of hot rolled coil can cause property fluctuation of cold-rolled material, especially in strip head and tail. Strip steel with high property fluctuation can cause much thickness deviation in tandem cold rolling. For some steel grade, serious thickness deviation is caused in strip head and tail. So high property fluctuation affect the cold rolling product rate. In order to improve thickness accuracy, this paper study a new feed-forward control (FFC) method and corresponding technology for strip steel with high property fluctuation, which can improve product rate of high strength steel and reduce the tolerance length in strip head or tail.

2 NEW PROPERTY FFC TECHNOLOGY

2.1 Property feed-forward control method

A property feed-forward thickness control method in tandem cold mill comprises selecting one or more stands as virtual indirect measuring instruments for the strip property, in which the stand S_1 must be used as a virtual indirect measuring instruments for the strip property; calculating the deformation resistance fluctuation of supplied materials, providing a load cell on the stands that are selected as the indirect measuring instruments for the strip property and obtaining the deformation resistance fluctuation of the supplied materials of the stand Si. Finally the feed-forward adjustment amounts of each stand are calculated. The presented technology measures the deformation resistance of strip sections of the supplied materials on the selected stand and performs the feed-forward thickness control through deformation resistance force measured indirectly. The influence of the property fluctuation of hot-rolled finished products on the precision of the cold rolling thickness control is avoided. The presented technology improves the precision of thickness control and reduces the thickness fluctuation of the of cold-rolled products.

A property feed-forward thickness control method in tandem cold mill comprises the following steps:

Step 1, selecting one stand as virtual measuring instrument for strip property. Stand S1 is selected as virtual measuring instrument. A thickness gauge is provided at the entry of S_1.

Step 2, calculating the value of the deformation resistance fluctuation of supplied materials. providing a load cell on the stands that are selected as the indirect measuring instruments for the strip performance, measuring the rolling force deviation ΔP_i on the stand Si caused by the deformation resistance fluctuation, then calculating deformation resistance value

Δk_i of supplied material according to the following formula (1):

$$\Delta k_i = \frac{\Delta P_i}{Q_i} \quad (1)$$

where Q_i is the influence coefficient of the deformation resistance on the rolling force on the stand S_i.

step 3, calculating the feed-forward adjustment amount Δy_i for each stand S_i according to the selection as follows,

1) if the stand Si is selected as the virtual indirect measuring instrument for strip property, calculating the feed-forward adjustment amount .Δy_i for the stand S_i according to the formula (2):

$$\Delta y_i = \frac{\Delta h_i \times F_i}{C_{pi}} \quad \textbf{(2)}$$

where Δhi is the thickness deviation of the strip at the entry of the stand Si measured by the thickness gauge. If there is no thickness gauge provided at the entry of the stand S_i, the feed-forward adjustment amount for the stand S_i will not be calculated; C_{pi} is the longitudinal rigidity of the stand S_i; Fi is the influence coefficient of the thickness of the strip at the entry of the stand S_i on the rolling force of the stand S_i.

2) if the stand S_i is not selected as the virtual indirect measuring instrument of strip performance, the value of deformation resistance fluctuation of this stand is that of the up-stream nearest stand, that is $\Delta k_i = \Delta k_{i-1}$, then calculating the feed-forward adjustment amount Δy_i for the stand Si according to the formula (3):

$$\Delta y_i = \frac{\Delta k_i \times Q_i + \Delta h_i \times F_i}{C_{pi}} \quad \textbf{(3)}$$

where Δh_i is the thickness deviation of the strip at the entry of the stand Si measured by the thickness gauge. If there is no thickness gauge provided at the entry of the stand S_i, then $\Delta h_i = 0$. C_{pi} is the longitudinal rigidity of the stand Si; Fi is the influence coefficient of the thickness of the strip at the entry of the stand S_i on the rolling force of the stand S_i.

2.2 The application of the property feed-forward control

if the stand S_1 with thickness gauge at the entry is selected as a virtual measuring instrument of strip property, calculating the deformation resistance fluctuation of supplied material at stand S_1 according to the formula (1), that is as follow

$$\Delta k_1 = \frac{\Delta P_1}{Q_1} \quad \textbf{(4)}$$

Because the stand S_2 and S_3 are not selected as a virtual measuring instrument of strip property, the deformation resistance fluctuation of supplied material at stand S_2 and S_3 is as follow

$$\Delta k_3 = \Delta k_2 = \Delta k_1$$

Calculating the feed-forward adjustment amount Δy_2 and Δy_3 according to the formula (3), that are as follow

$$\Delta y_2 = \frac{\Delta k_2 \times Q_2 + \Delta h_2 \times F_2}{C_{p2}} \quad \textbf{(5)}$$

$$\Delta y_3 = \frac{\Delta k_3 \times Q_3}{C_{p3}} \quad \textbf{(6)}$$

Where Δh_2 is thickness deviation measure by thickness gauge at the entry of the stand S_2. Thickness gauge is not provided at the entry of the stand S_3.

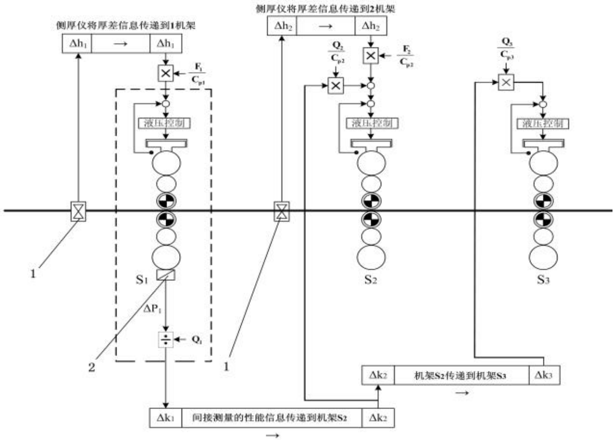

Fig.1 The application of the property feed-forward control

In Fig.1 the property feed-forward control for high strength steel calculates deformation resistance fluctuation precisely via rolling force deviation on the stand S_1. Deformation resistance fluctuation at stand S_1 is shifted to stand S_2 or S_3, output the feed-forward adjustment amount at stand S_2 and S_3.

The property feed-forward control can trace deformation resistance fluctuation precisely in the length. Not only precise thickness but also precise deformation resistance fluctuation at stand S_2 are obtained, so property feed-forward control at S_2 can be carried out.

The property feed-forward control for high strength steel on stand S2 is similar as on stand S_3. Deformation resistance fluctuation via rolling force deviation on the stand S_1 is shifted to stand S_3, the property feed-forward control for high strength steel on the stand S_3 is carried out. Thickness gauge is not provided at the entry of the stand S_3.

Because the property feed-forward control for high strength steel on the stand S_2 and S_3 is carried out and traces deformation resistance fluctuation precisely in the length, thickness deviation caused by property fluctuation is decreased.

3 ONLINE RESULTS AND ANALYSIS

The property feed-forward control for high strength steel is switched on for three coils and switched off for three coils. In Fig.2 thickness deviation is decreased when property FFC is switched on.

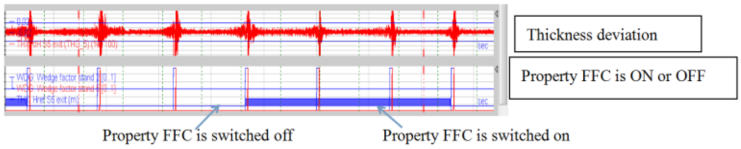

Fig.2 Comparison of property FFC switched on and off

4 CONCLUSION

Through the analysis of thickness deviation in strip head and tail and AGC theory, property FFC is proposed.

The property feed-forward control technology on second and third stand is made. Differential control optimization is carried out for different steel grades and based on the length of strip head and tail. The property feed-forward control program is applied and runs stably in the field. It can decrease the thickness deviation and the length beyond tolerance in strip head and tail. Good control results are obtained.

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