Improvement on accuracy of coiling temperature at tail of strip during U-type cooling process

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Abstract. Water flow and number of valves turned on were analyzed in order to find out the reason of low coiling temperature at tail of strip during U-type cooling process. Result of research showed that actual value of number of valves turned on in micro zone at tail of strip was not consistent with the corresponding calculated value of valves turned on. Then actual value of water flow at tail of strip was not consistent with the corresponding calculated value of water flow. That was the reason of low coiling temperature at tail of strip during U-type cooling process. The improvement measure was compensation adjustment for response time of valves. After improving, actual value of number of valves turned on in micro zone was consistent with the corresponding calculated value of valves turned on and high accuracy of coiling temperature at tail of strip was obtained.

Introduction

Microstructure, mechanical property, physical property and machinability of hot rolling strip are affected greatly by coiling temperature [1-4]. Temperature drops slower at middle part of strip than head or tail during coiling process. So microstructure and mechanical property between head/tail and middle part of strip are inhomogeneous. Using U-type cooling process, the difference of microstructure and mechanical property between head/tail and middle part of strip can be eliminated, the uniformity of microstructure and mechanical property in the whole strip can be improved [5].

Coiling temperature at tail of strip is lower than target temperature sometimes when hot rolling strip is cooled during U-type cooling process, causing poor accuracy of coiling temperature. In this study, water flow and number of valves turned on for strip during U-type cooling process were analyzed. Then reasons of low coiling temperature at tail of strip during U-type cooling were obtained and the corresponding solutions for this problem were given.

Equipment of laminar cooling

Layout of laminar cooling device is shown in Fig. 1. Laminar cooling zone includes micro zone and trim zone. There are 20 groups of valves in micro zone and 2 groups of valves in trim zone. Ever group of upper or lower micro zone valves consists of 4 valves and ever group of upper or lower trim zone valves consists of 8 valves.

Laminar cooling control system adjusts water flow by turning on or off valves of headers [6].

Strip is cooled from finish rolling temperature at exit of finishing mill to required coiling temperature during laminar cooling process [7]. Control system of laminar cooling includes basic automation system and process automation system [8]. U-type cooling process can be executed by laminar cooling device [9].

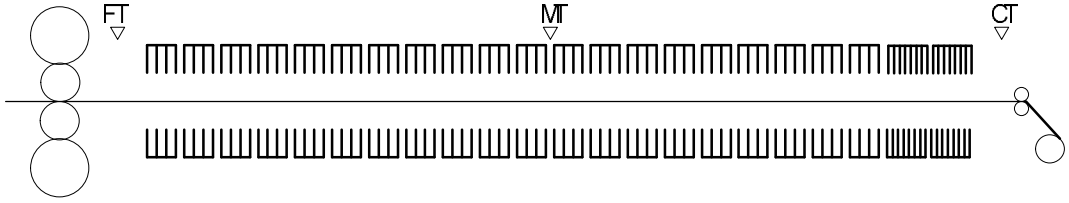

Fig.1 Layout of laminar cooling device

Reason analysis of low coiling temperature at tail of strip during U-type cooling process

Coiling temperature at tail of strip is lower than target temperature sometimes when hot rolling strip is cooled during U-type cooling process. Poor coiling temperature of strip during U-type cooling process is shown in Fig. 2. The technological parameters of strip in Fig. 2 are shown in Table 1.

Table 1 Technological parameters of strip during U-type cooling process

Steel grade	Thickness, mm	Target coiling temperature at middle part of strip, ˚C	Length of head part of strip, m	Target coiling temperature at head part of strip, ˚C	Length of tail part of strip, m	Target coiling temperature at tail part of strip, ˚C
SPHCQC-P	4.5	680	50	710	30	710

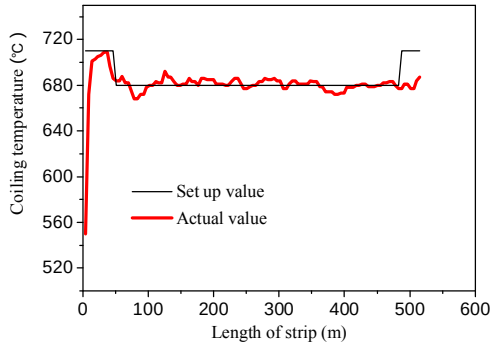

Fig.2 Coiling temperature

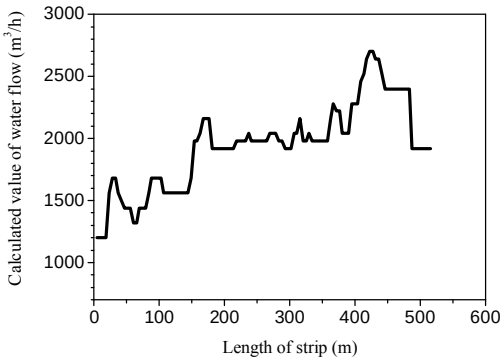

Fig.3 Calculated value of water flow

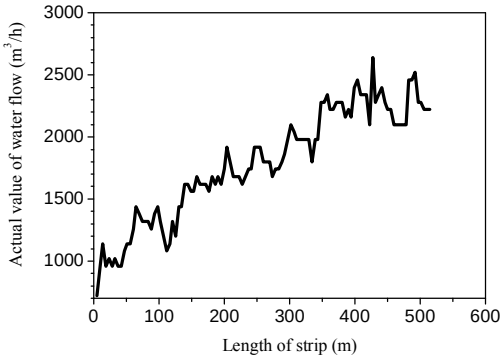

Fig.4 Actual value of water flow

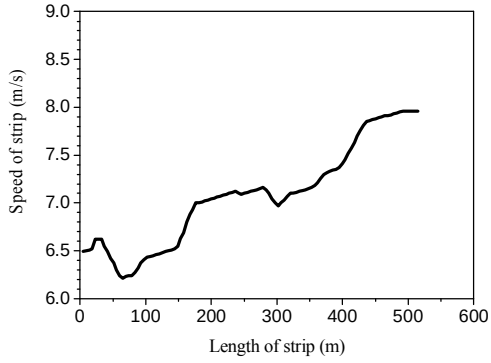

Fig.5 Speed of strip

Water flow, running speed of strip and number of valves turned on in micro zone were obtained from cooling log. Calculated value of water flow along strip length direction is shown in Fig. 3. Actual value of water flow along strip length direction is shown in Fig. 4. From Fig.3 and Fig.4, it can be seen that water flow is increasing along strip length direction. Running speed of strip is shown in Fig. 5. It can be seen from Fig. 5 that speed of strip during cooling is increasing. Water flow increases when speed of strip becomes faster. It is necessary to obtain a constant target coiling temperature.

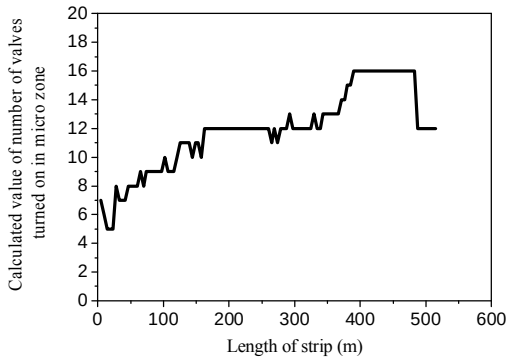

Fig.6 Calculated value of number of valves turned on in micro zone

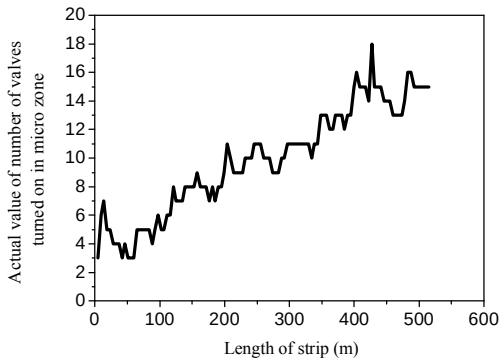

Fig.7 Actual value of number of valves turned on in micro zone

The increasing water flow is closely related to number of valves turned on. Calculated value of number of valves turned on in micro zone is shown in Fig. 6. Actual value of number of valves turned on in micro zone is shown in Fig. 7. From Fig.6 and Fig.7, it can be seen that number of valves turned on for strip during cooling is increasing. It also attributes to the increasing speed of strip.

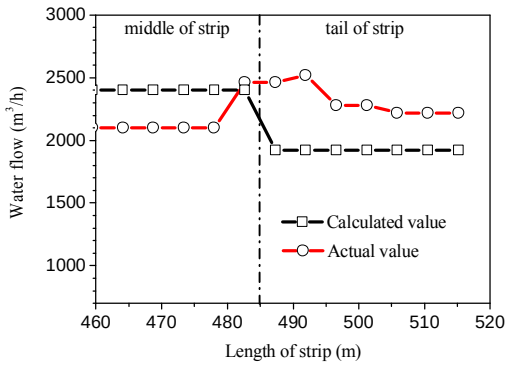

Fig.8 Comparison between calculated value and actual value of water flow for strip tail

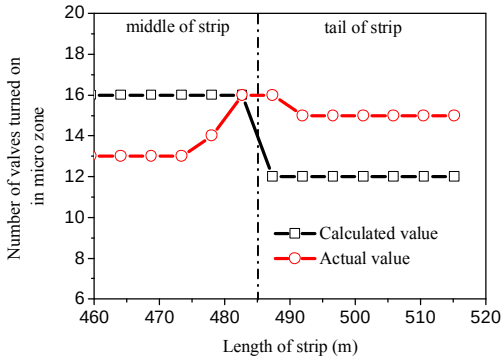

Fig.9 Comparison between calculated value and actual value of number of valves turned on in micro zone for strip tail

Fig.8 can be obtained by comparing calculated value of water flow for strip tail in Fig.3 with actual value of water flow for strip tail in Fig.4. Fig.9 also can be obtained by comparing calculated value of number of valves turned on in micro zone in Fig.6 with actual value of number of valves turned on in micro zone in Fig.7. Target coiling temperature at tail of strip is higher than middle part of strip during U-type cooling process. So water flow for strip tail should be less than water flow for middle part of strip. From Fig.8 it can be seen that calculated value of water flow for strip tail is less than calculated value of water flow for middle part of strip. It is correct. But actual value

of water flow at tail of strip is not consistent with the corresponding calculated value of water flow. Actual value of water flow for strip tail is greater than actual value of water flow for middle part of strip. That is the reason of low coiling temperature at tail of strip during U-type cooling process.

From Fig.8 and Fig.9 it can be seen that calculated value of water flow shows the same tendency of changes with calculated value of number of valves turned on in micro zone and actual value of water flow shows the same tendency of changes with actual value of number of valves turned on in micro zone. In fact calculated value of water flow depends on calculated value of number of valves turned on in micro zone and actual value of water flow depends on actual value of number of valves turned on in micro zone. In U-type cooling process, water flow for strip tail is less than water flow for middle part of strip. So number of valves turned on in micro zone for strip tail should be less than for middle part. According to Fig.9 calculated value of number of valves turned on in micro zone for strip tail is less than for middle part. It is correct. But actual value of number of valves turned on in micro zone at tail of strip is not consistent with the corresponding calculated value. Actual value of number of valves turned on in micro zone for strip tail is greater than for middle part of strip. That is the reason of greater actual water flow at tail of strip.

Method of improvement

Water flow for strip tail should be less than for middle part in order to obtain higher coiling temperature at tail of strip than middle part. That is to say, number of valves turned on in micro zone for strip tail should be less than for middle part. Calculated value of number of valves turned on in micro zone for strip tail is not wrong. But actual value of number of valves turned on in micro zone at tail of strip is not consistent with the corresponding calculated value. It means the corresponding valves do not turn off in time when strip tail enters into cooling zone.

Required water flow is calculated according to target coiling temperature by level two control system of laminar cooling device and required number of valves turned on/off is calculated according to water flow. Then the message of turning on/off valves is sent from level two system to level one system. This procedure needs a short period of time. This time is response time of valve. As time of valves turned/off lags behind actual need, the improvement measure is compensation adjustment for response time of valves. Then actual value of number of valves turned on in micro zone at tail of strip is consistent with the corresponding calculated value and actual value of water flow at tail of strip is consistent with the corresponding calculated value.

Coiling temperature of strip tail after improving

Perfect coiling temperature of strip tail is obtained after adjusting compensation time of valves. Accuracy of coiling temperature at tail of strip during U-type cooling process is improved. Coiling temperature of strip after improving is shown in Fig.10. The technological parameters of strip in Fig.10 are shown in Table 2.

Table 2 Technological parameters of strip during U-type cooling process

Steel grade	Thickness, mm	Target coiling temperature at middle part of strip, ˚C	Length of head part of strip, m	Target coiling temperature at head part of strip, ˚C	Length of tail part of strip, m	Target coiling temperature at tail part of strip, ˚C
SPHC	5	680	60	720	40	710

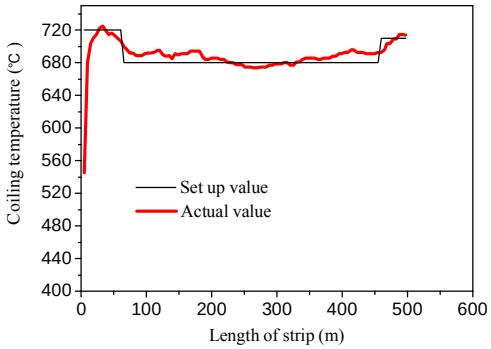

Fig.10 Coiling temperature

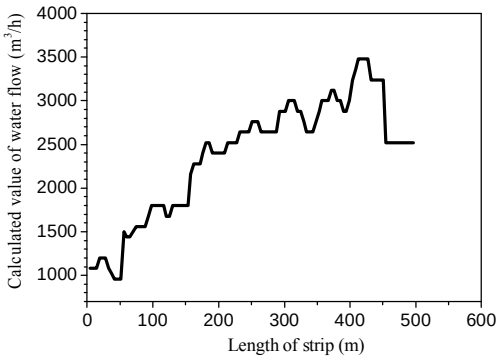

Fig.11 Calculated value of water flow

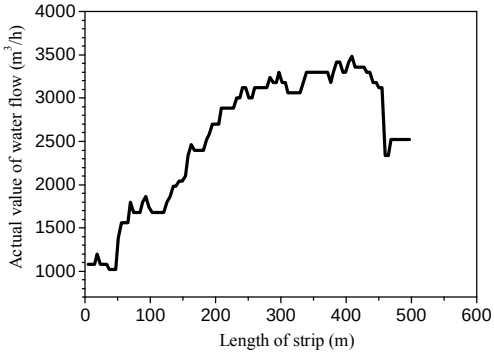

Fig.12 Actual value of water flow

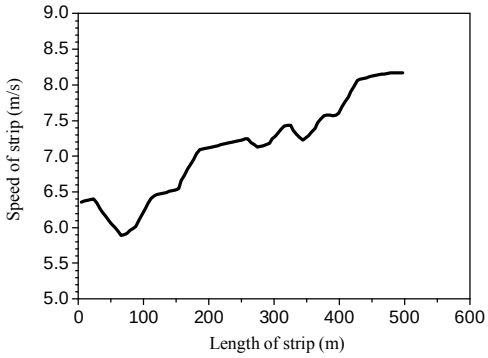

Fig.13 Speed of strip

Water flow, running speed of strip and number of valves turned on in micro zone were obtained from cooling log. Calculated value of water flow along strip length direction is shown in Fig. 11. Actual value of water flow along strip length direction is shown in Fig. 12. Running speed of strip is shown in Fig. 13. From Fig.11, Fig.12 and Fig.13, it can be seen that calculated water flow and actual water flow increase with the increase of running speed of strip. In U-type cooling process, coiling temperature at tail of strip should be higher than middle part of strip. So at tail of strip, water flow decreases.

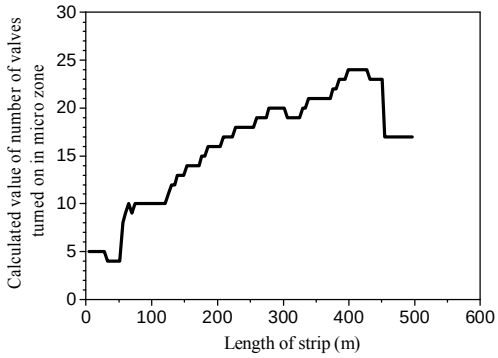

Fig.14 Calculated value of number of valves turned on in micro zone

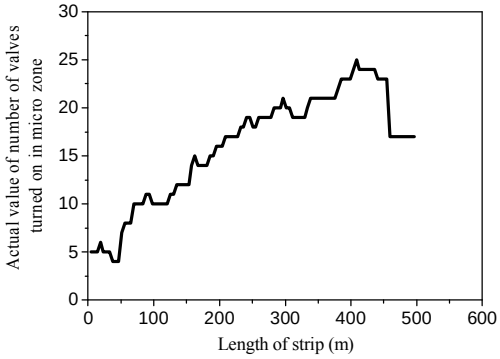

Fig.15 Actual value of number of valves turned on in micro zone

Calculated value of number of valves turned on in micro zone is shown in Fig. 14. Actual value of number of valves turned on in micro zone is shown in Fig. 15. From Fig. 14 and Fig. 15, it can be

seen that number of valves turned on for strip during cooling is increasing. It also attributes to the increasing speed of strip. At tail of strip, number of valves turned on in micro zone decreases due to requirement of U-type cooling process.

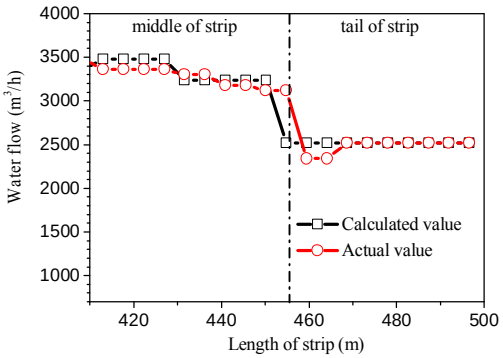

Fig.16 Comparison between calculated value and actual value of water flow for strip tail

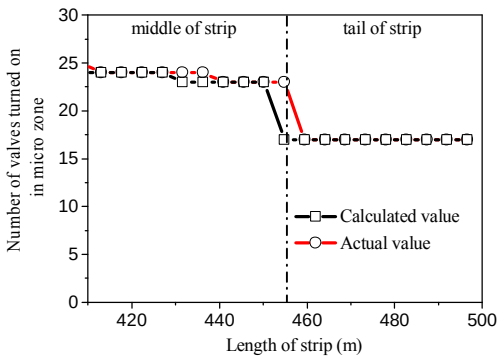

Fig.17 Comparison between calculated value and actual value of number of valves turned on in micro zone for strip tail

Fig.16 can be obtained by comparing calculated value of water flow for strip tail in Fig.11 with actual value of water flow for strip tail in Fig.12. Fig.17 also can be obtained by comparing calculated value of number of valves turned on in micro zone in Fig.14 with actual value of number of valves turned on in micro zone in Fig.15. After adjusting compensation for response time of valves, required number of valves turned off is calculated according to the difference between target coiling temperature of strip tail and target coiling temperature of middle part of strip and these valves are turned off in time. Actual value of number of valves turned on in micro zone at tail of strip is consistent with the corresponding calculated value. This is shown in Fig.17. Actual value of water flow at tail of strip is consistent with the corresponding calculated value. This is shown in Fig.16. Perfect coiling temperature of strip tail is obtained after adjusting compensation time of valves. This is shown in Fig.10.

Conclusions

(1) Actual value of number of valves turned on in micro zone at tail of strip is not consistent with the corresponding calculated value of valves turned on. Actual value of water flow at tail of strip is not consistent with the corresponding calculated value of water flow. These are the reasons of low coiling temperature at tail of strip during U-type cooling process.

(2) The improvement measure of low coiling temperature at tail of strip is compensation adjustment for response time of valves.

(3) After improving, actual value of number of valves turned on in micro zone is consistent with the corresponding calculated value and high accuracy of coiling temperature at tail of strip is obtained.

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