Journal of Chemical Technology and Metallurgy, 50, 6, 2015, 613-616

TEMPERATURE FIELD OF STRIPES UNDER HOT ROLLING

Sergey M. Belskiy[1], Svetla Yankova[2], Vyacheslav B. Chuprov[1],

K.V. Bakhaev[1], Aleksandr O. Stoyakin[1]

[1] *Lipetsk State Technical University*
30 Moskovskaya, 398600 Lipetsk, Russia
E-mail: Belsky-55@yandex.ru; prokatka@stu.lipetsk.ru
[2] *University of Chemical Technology and Metallurgy*
8 Kl. Ohridski, 1756 Sofia, Bulgaria

Received 19 February 2015
Accepted 05 September 2015

ABSTRACT

The study of temperature distribution along width of stripes in the Hot Rolling Mills HRM 2000 line was carried out in collaboration of NLMK Hot Rolled Production specialists with students and lecturers of the Lipetsk State Technical University. This study was made using a portable thermal scanner BALTECH TR-1400. It was marked that the surface temperature increased from the right edge of the strip to the left in relation to rolling direction. The temperature distribution asymmetry along the width of the strip is one of the reasons for camber, wedging and flatness of hot-rolled strips.

Keywords: hot-rolled strip, temperature distribution across the width, camber, wedge, flatness.

INTRODUCTION

Consumer properties of hot rolled steel strips depend on many parameters, among which the most essential are stability of mechanical properties and microstructure of metal along the length and the width of the strips, the presence of surface defects, as well as the geometric parameters: longitudinal and transverse thickness, camber and wedge of a cross sectional profile [1 - 9]. These parameters are largely dependent on the temperature field distribution along the length and the width of the strips rolled in continuous hot rolling mills (HRM).

EXPERIMENTAL

The study of temperature distribution along stripes' width in the HRM 2000 line was carried out in a collaboration of NLMK Hot Rolled Production specialists with students and lecturers of the Lipetsk State Technical University (LSTU). The investigations were conducted in the framework of the additional professional education, jointly developed by LSTU and OJSC "NLMK"(Novolipetsk Steel), for students of target groups with guaranteed work placement at OJSC "NLMK".

The study was made using a portable thermal scanner BALTECH TR-1400 with a measuring range -20 ~ +1200°C and an accuracy of ±5°C (±0,5 % of the measured temperature) in the following points: from the top of stands № 3 - 5 (points P1 - P3, Fig.1), from the walkway before the finishing mill (point P4, Fig.1), from the walkway after the last stand of finishing mill (point P5, Fig. 1) and from the place of setting of strip coiling temperature pyrometers (point P6, Fig. 1). The distance from the scanner to the strip surface depending on the place of measurement was from 3 to 6 m.

The HRM 2000 pyrometers are installed after the stand № 5, after finishing mill and before coiler № 1. The temperatures measured by pyrometers along strips' center line are recorded and stored on the servers of the metal tracking system (MTS).

The software part of the thermal scanner BALTECH TR-1400 allows specialists to correct strips surface temperature «offline» changing the value of emissivity. This

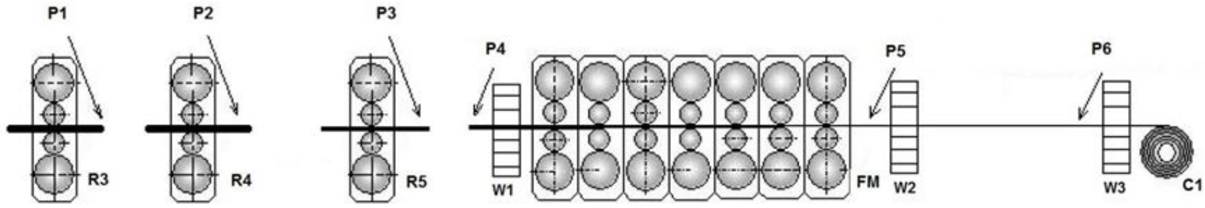

Fig. 1. Temperature field measuring points (P1 - P6) of the rolled strips (R3 - R5 – roughing stands № 3 - 5; FM – finishing mill; C1 – coiler №1; W1 - W2 – walkways before and after finishing mill, W3 – walkway before coiler № 1).

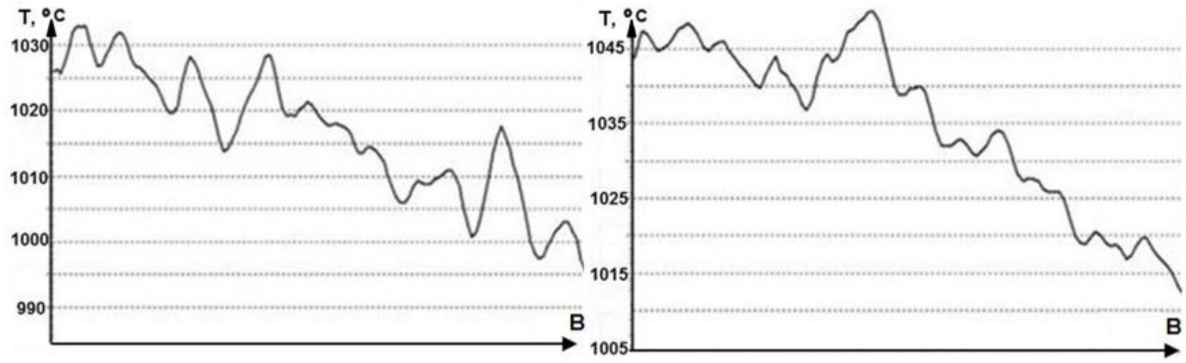

Fig. 2. Typical temperature distribution along the strip width after roughing stand № 5 (B – strip width).

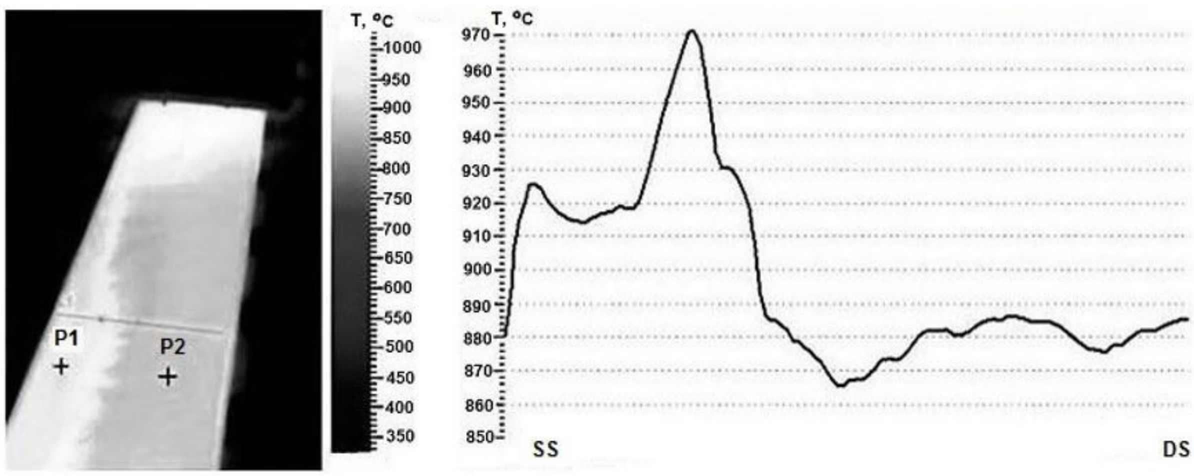

Fig. 3. IR image and temperature distribution along the width of the middle part of the strip before finishing mill (P1 - strip area without coarse scale; P2 - strip area with rough scale).

technique was used to synchronize the temperatures of the strips central parts measured by a portable thermal scanner and ones which were stored in the MTS servers. The research was conducted within a single year. The reheating furnace number, the number of strip in the sequence of rolling and the actual time of measurement were used to identify the strips.

After processing the data set and analysis of the results the conclusions were drawn, some of them are shown below.

The temperature field of the strip surface after stand № 5 is characterized by definite temperature decrease from the left edge to the right (down the HRM) and the presence of longitudinal temperature striation. Surface temperature decrease from the left edge to the right is determined by the position of the right edge of the slab during the discharge from the reheating furnace. It is closer to the flap of the furnace and therefore becomes cooler. Longitudinal temperature striation is caused by the effect of water descaling in nozzles overlap places.

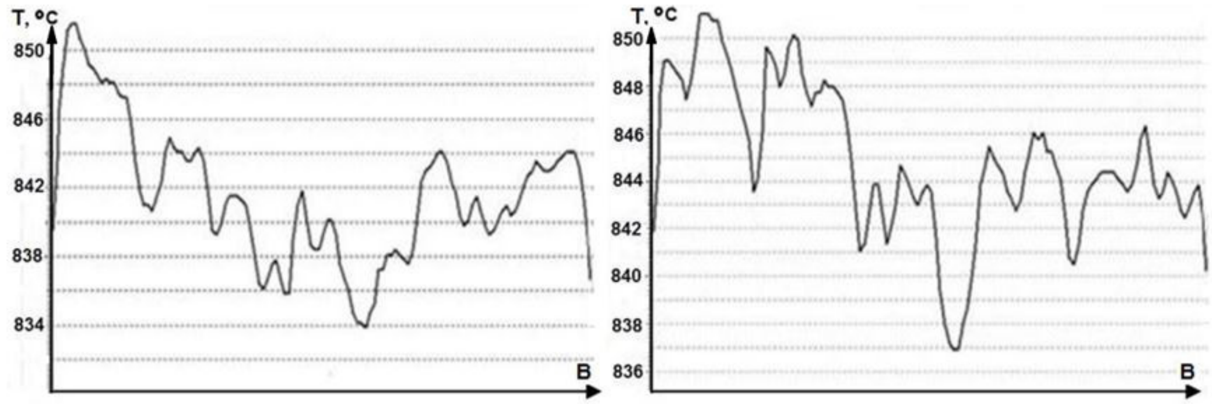

Fig. 4. Typical temperature distribution along the strip width after stand № 12.

Two examples of the surface temperature distribution across the strip after stand № 5 are presented in Fig. 2.

There is an intensive formation of scale before the finishing mill, on the intermediate roller table, and therefore about 60 % of thermal images taken in this area, were not subject to analysis (Fig. 3). It is seen in the thermograms suitable for analysis that the temperature wedge of the head part of the strips leaving from roughing stands is substantially aligned, but in process of approach the finishing mill of tail parts of some strips the service side temperature becomes even higher than that of the drive side. The temperature equalization and the change of the temperature wedge direction can be explained by the design of the heat keeping mechanism above intermediate roller table and the air flow direction in the intermediate roller table area.

After the finishing mill the temperature imbalance becomes less defined, although some heredity persists. The example of typical temperature distribution along the strip width after finishing mill is shown in Fig. 4.

The joint analysis of the thermal field and flatness before coiling is of interest. After passing the strips accelerated cooling area the temperature distribution along the width is uneven: the temperature on the service side, as a rule, is lower than the temperature on the drive side. Depending on steel type the temperature gradient ranges from 5 - 10°C for structural steels to 10 - 15°C for electro-technical steels. This feature may be associated with the work of water crosscut blowing of the accelerated strips cooling mechanism.

The comparison was made between the flatness of finished hot-rolled strips with their temperature profiles during coiling (Fig. 5).

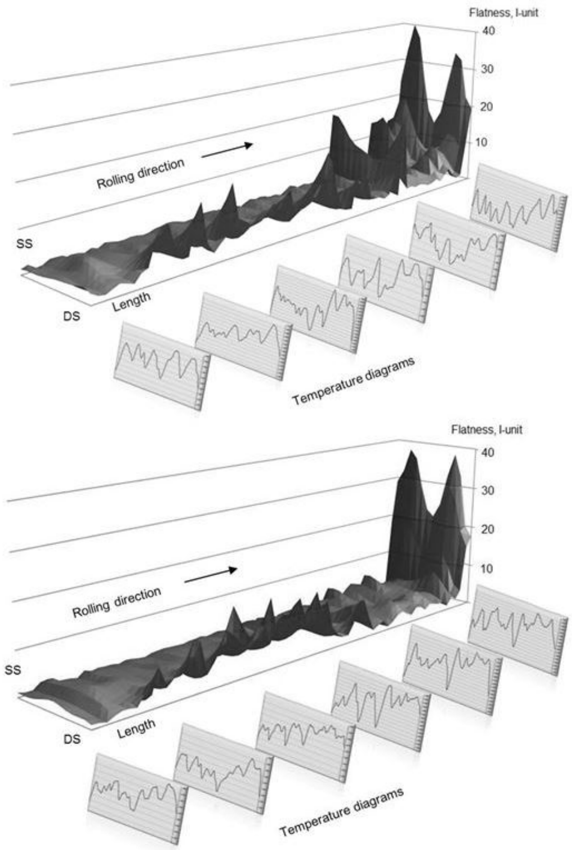

Fig. 5. Comparison of the diagrams of flatness and coiling temperature distribution across the width of the rolled strip.

The multifunctional device RM-312 installed after finishing mill measures the change of the hot strip flatness. It is written as a graph and stored on MTS servers. It can be seen in thermograms that the temperature increases in the place of waves formation at the drive side. This fact can be explained as follows: the cooling water falling on the surface of the strip rolls faster off the wavy sections than off the flat ones, as a result the strip on the drive side is cooled less intensively.

RESULTS AND DISCUSSION

The study of the thermal field distribution of hot-rolled strips in HRM 2000 line established the next features:

1. The temperature fields of the rolled strips surfaces after roughing stands have temperature wedge along the width which decreases from the left edge to the right and are characterized by presence of longitudinal temperature striation.
2. The temperature wedge of the head part of the strips leaving from the roughing stands is substantially aligned before finishing mill.
3. After the finishing mill the temperature imbalance becomes less defined, but some heredity persists.
4. On the run out roller table strips temperature increases in the area of wave formation.

The first feature is explained by position of the slab in front of the flap of the reheating furnace - the slab side that is closer to the flop is cooler than the opposite side longitudinal temperature striation is caused by the effect of water descaling in nozzles overlap places.

The second feature can be explained by the design of the heat keeping mechanism above intermediate roller table and the air flow direction in the intermediate roller table area.

The third feature is explained by non uniform heat production in the strips deformation zones during strips rolling in the finishing mill.

The reason for the fourth feature is that the cooling water falling on the strips surface rolls faster off the wavy areas than off the flat ones, so the wavy strip zones are cooled less intensively than the flat ones.

CONCLUSIONS

The studies of the thermal field distribution of hot rolled strips in HRM 2000 line established the reasons for features of the temperature field distribution of hot rolled strips in different areas of the rolling mill. A comparative analysis of flatness charts and temperature field distribution charts of rolled strips was carried out.

According to the executed research some recommendations were developed for adjusting the roughing stands at the HRM 2000 to reduce the cross sectional profile wedge of hot rolled strips, and the master's thesis was defended.

Besides, students got experience in research and study of real processes of rolling of hot strips on operating HRM.

REFERENCES

1. S.L. Kotsar, A.D. Belyansky, Yu.A. Mukhin, Technology of sheet-rolling production, Moscow, Metallurgy, 1997, (in Russian).
2. V.N. Shinkin, Mathematical modeling of processes of large-diameter pipes production for the main pipe ducts, Bulletin of Saratov STU, 2011, 62, iss. 4, 69-74, (in Russian).
3. S.M. Belskiy, S.I. Mazur, Yu.A. Mukhin, A.I. Goncharov, Influence of the cross-section of hot-rolled steel on the flatness of cold-rolled strip, Steel in Translation, 43, 5, 2013, 313-316.
4. V.N. Shinkin, Criterion of opposite bending of free part of a sheet on a SMS MEER large diameter pipe press, Rolling, 9, 2012, 21-26, (in Russian).
5. V.N. Shinkin, V.I. Mokrousov, Criterion of gas and oil pipelines' tubes rupture in case of defect "rolled out scorch with scratch", Rolling, 12, 2012, 19-24, (in Russian).
6. Yu.A. Mukhin, S.I. Mazur, S.M. Belskiy, A.V. Shunin, Hot rolling with reverse temperature wedge and stability of structure and mechanical properties of the rolled strips, Rolling, 11, 2013, 15-18, (in Russian).
7. V.N. Shinkin, A.P. Kolikov, Modeling of processes of expanding and hydraulic tests of large diameter pipes for main pipelines, Rolling, 10, 2011, 12-19, (in Russian).
8. V.N. Shinkin, A.P. Kolikov, Elasto-plastic change of metal on a edge-bending press when forming large-diameter tubes, Steel, 6, 2011, 53-56, (in Russian).
9. V.N. Shinkin, A.P. Kolikov, V.I. Mokrousov, Criterion of destruction of large-diameter pipes in case of unfusing of the welded seam and intrinsic pressure, Rolling, 2, 2012, 14-16, (in Russian).