Proceedings of the 10th World Congress on Mechanical, Chemical, and Material Engineering (MCM'24)
Barcelona, Spain –August 22-24, 2024
Paper No. HTFF 225
DOI: 10.11159/htff24.225

Development of Numerical Model Based Deep Learning for the Temperature Prediction of the Hot Rolling Process

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Extended Abstract

In the hot rolling mill, the thermal history experienced by the strip during processing is one of the most important parameters influencing the product quality. Especially, for the hot rolling process, the temperature prediction is the key technology because the metallurgical properties of product are substantially affected by it.

During the several decades, the models for the temperature of the strip are demonstrated for the precise prediction on the basis of the finite difference models [1-4] and the finite element (FE) models [5-8] than on the basis of the elementary models which inherently involve many simplifying assumptions. However, a precise model such as a FE process model tends to require a large time for the calculation. In this paper, a numerical model based deep learning is presented for the prediction of the temperature distributions during the hot rolling.

The hot rolling process consists of reheating furnace, roughing mill, induction heater and finishing mill. There exist several reheating furnaces to heat the slab for the rolling temperature, the roughing mill to reduce the thickness, the induction heater for additional heating and the finishing mill to produce the product of desired thickness. For the hot rolling process, sound prediction of the temperature is vital for achieving the desired temperature because the metallurgical properties of product are substantially affected by it. In addition, by achieving the desired rolling temperature, we can ensure rolling stability.

In this paper, mathematical model is presented for the prediction of the temperature distributions during the rolling, the cooling, and the heating. The model consists of a model for the prediction of temperature distributions in bite zone, a model for the prediction of temperature distributions in the cooling regions and a model for the prediction of temperature distributions at the induction heater. The model in bite zone considers the energy terms of deformation, friction, and the heat transfer from the strip to the roll. The model in the cooling regions considers the radiation and the convection. The model of the induction heater considers the heat generation due to the induced eddy current.

From the combination of these mathematical models, the temperature distributions can be predicted in the whole regions between the exit of the reheating furnace and the exit of the finishing mill. Furthermore, by using the presented prediction model of the temperature, we can optimize the process conditions for the desired rolling temperature. The prediction accuracy of the proposed model is examined through comparison with actual data.

References

[1] A. Laasraoui and J. J. Jonas, “Prediction of temperature distribution, flow stress and microstructure during the multipass hot rolling of steel plate and strip”, Iron Steel Inst. Jpn. Int, 31, 1991, pp.95-105
[2] H. Yoshida, A. Yorifuji, S. Koseki, and M. Saeki, “Integrated mathematical simulation of temperatures, rolling loads and metallurgical properties in hot strip mills”, Iron Steel Inst. Jpn. Int., 31, 1991, pp.571-576
[3] B. K. Chen, P. F. Thomson, and S. K. Choi, “Temperature distribution in the roll-gap during flat rolling”, J. Mater. Proc. Technol. 30, 1992, pp.115-130
[4] W. C. Chen, I. V. Samarasekera, and E. B. Hawbolt, “Fundamental phenomena governing heat transfer during rolling”, Metallurgical Trans. 24A, 1993, pp.1307-1320
[5] S. M. Hwang, M. S. Joun, and Y. H. Kang, “Finite element analysis of temperatures, metal flow, and roll pressure in hot strip rolling”, ASME J. Eng. Ind. 115, 1993, pp.290-298

[6] M. Kiuchi, J. Yanagimoto, and E. Wakamatsu, “Thermal analysis of hot plate/sheet rolling”, Proc. 7th Int. Steel Rolling Conf., Chiba, Japan., 1998, pp.227-232
[7] C. G. Sun, C. S. Yun. J. S. Chung, and S. M. Hwang, “Investigation of thermo-mechanical behavior of a work roll and of roll life in hot strip rolling”, Met. Mater. Trans. 29A, 1998, pp.2407-2423
[8] S. M. Hwang, C. G. Sun, S. R. Ryoo, and W. J. Kwak, “An integrated FE process model for precision analysis of thermo-mechanical behaviors of rolls and strip in the hot strip rolling”, Comput.Methods Appl. Mech. Engrg. 191, 2002, pp.4015-4033