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Development and application of a neural network based coating weight control system for a hot-dip galvanizing line

Key words: Neural network; Hot-dip galvanizing line (HDGL); Coating weight control

Corresponding author: Zai-sheng PAN
E-mail: panzs@zju.edu.cn
ORCID: https://orcid.org/0000-0003-1273-2519

Motivations

The HDGL system has some complicated characteristics, which lead to the difficulty in coating weight control:

1. The X-ray coating gauge is installed far away from the air knife, leading to a large time-varying measurement lag.

2. Various disturbances in the control system may influence the model precision and have negative effect on the control performance.

3. Strong nonlinear relationship exists between the controlled variable and the manipulated variables. It is quite difficult to establish an accurate model covering all the operating points.

4. Due to the nature of air knife, the settling time of air pressure is much longer than that of air knife gap, which is driven by a motor, resulting in the unsynchronized regulation problem when air pressure and air knife gap need to be regulated simultaneously.

Main idea

Neural network (NN) is incorporated in both feed forward control (FFC) and feedback control (FBC). It is not only strong in reflecting the nonlinear characteristic of a real plant, but also good at addressing the time-variant large measurement delay problem with a bias update module.

Methods

1. FFC begins to regulate the MVs (air pressure and air knife gap) once the line speed changes significantly or a new strip with different target coating weight setup approaches. It can dramatically shorten the coating weight transition time when the target coating weight changes and reduce the control variance when the line speed changes.
2. This predictive value derived by NN, instead of the measured coating weight, is used as feedback, so that the large time-variant measurement delay is addressed. In addition, the predictive coating weight is adjusted through an on-line bias-update algorithm.

Major results

1. Our model is closer to the practical system with a small modeling error, especially when bias update is used.

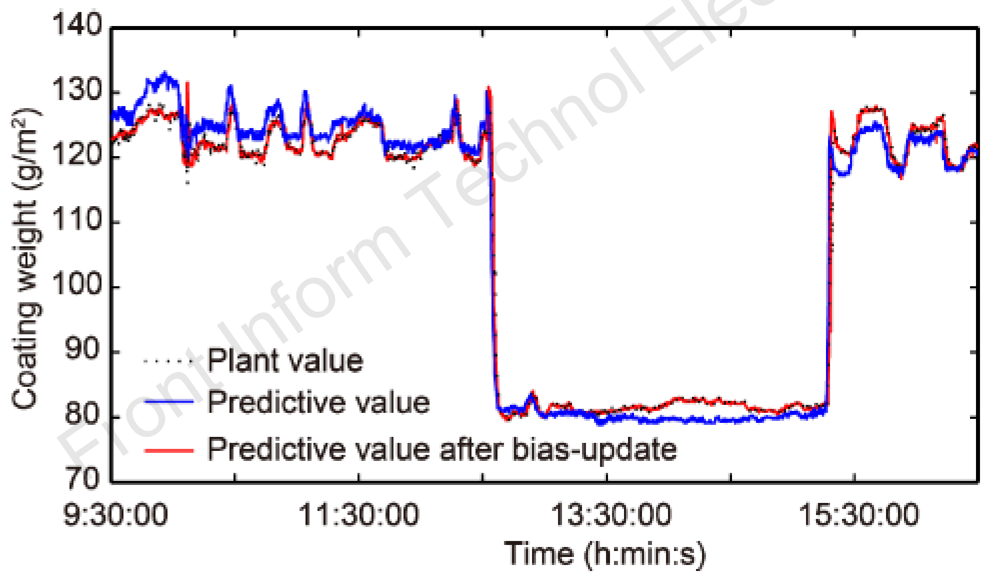
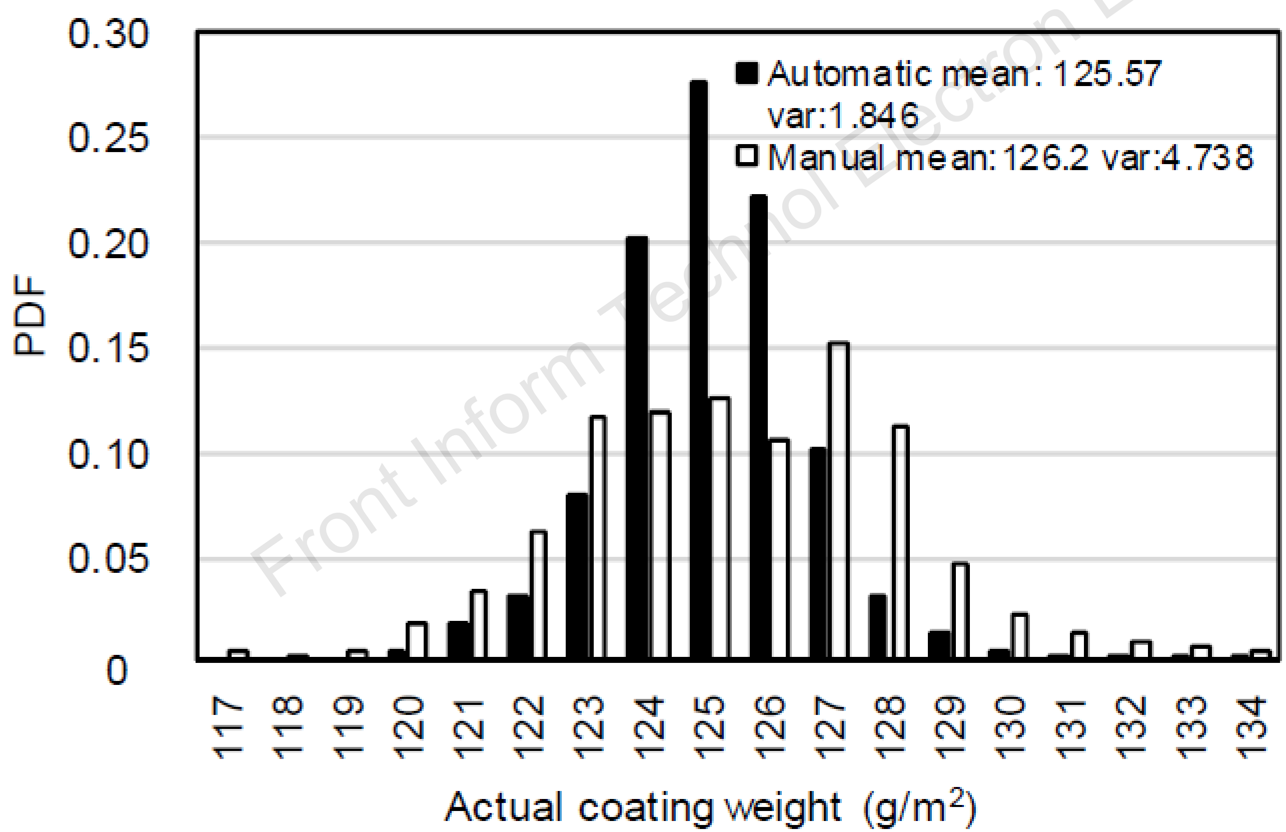


Fig. 8 Comparison of the predictive coating weight before and after bias-update (References to color refer to the online version of this figure)

Major results

2. Production variance is reduced.



Major results

3. Zinc is saved.

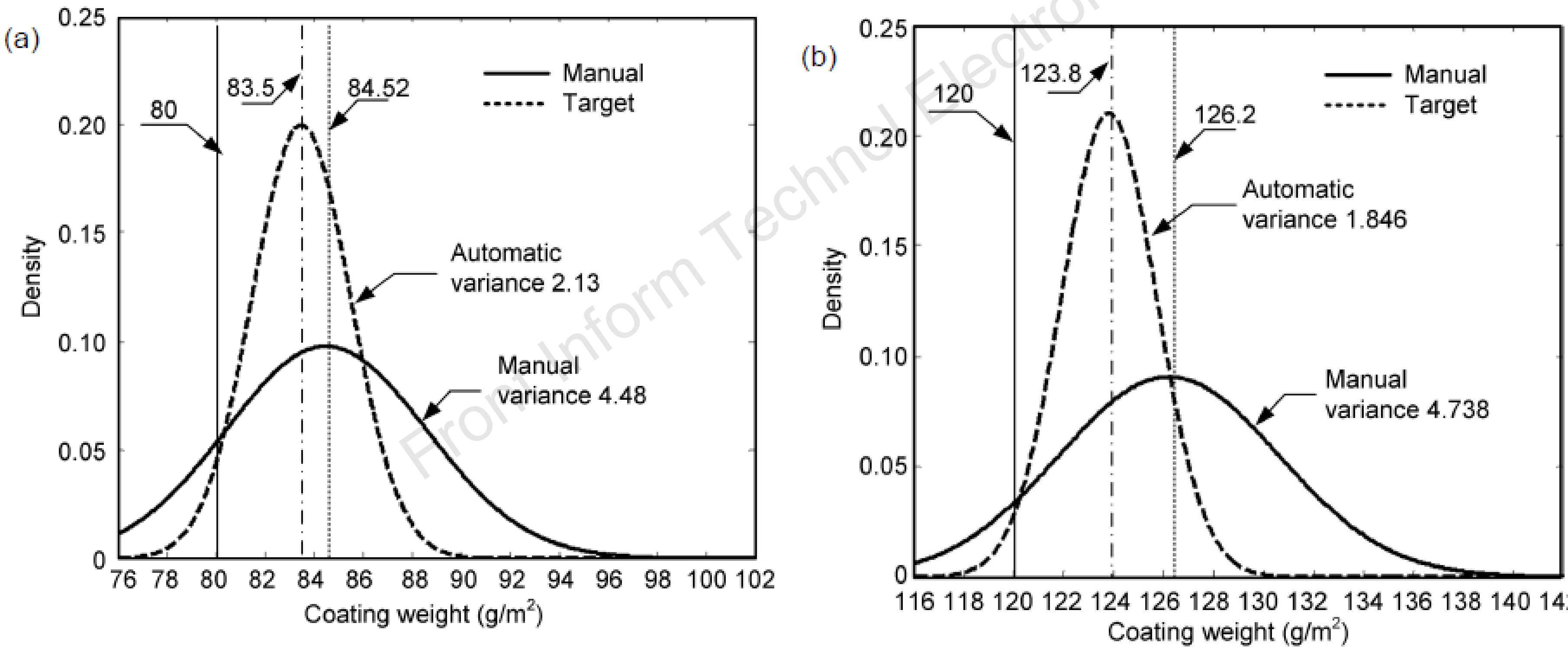


Fig. 11 Analysis on the zinc saving of Z80 (a) and Z120 (b)

Conclusions

1. A novel neural-network-based coating weight control approach is proposed for HDGL. The system consists of an FFC, an FBC, which is composed by a neural network predictive model, a bias update module, and a real-time optimizer. Through this framework, four types of control difficulty, including strong nonlinear, large time-variant delay, strong disturbance, and unsynchronized regulation of two MVs, are addressed.

2. The long-term industrial application results have shown the effectiveness and efficiency of the proposed method. Both the variance of coating weight and the transition time are significantly reduced.