

Improved Modeling Method of the 3MA System for Detecting Mechanical Properties of Cold Rolled Steels

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The 3MA system developed by Fraunhofer IZFP is an integrated ferromagnetic material microstructure and stress analyzer that contains four electromagnetic non-destructive testing methods: tangential magnetic field harmonic analysis (HA), Barkhausen noise (BN), incremental permeability (IP) and multi-frequency eddy current (EC) testing. However, the stepwise regression method in the 3MA system cannot find the best model, and has the following disadvantages: (1) introducing irrelevant variables; (2) causing the model overfitting. In order to solve this problem, the following work has been done: 1. The random noise is used as independent variables (IVs) with stepwise regression to illustrate the problems of the stepwise regression method. 2. The electromagnetic parameters of cold rolled strips were collected by 3MA system in order to detect the mechanical properties. Mechanical properties detected include yield strength (Rp), tensile strength (Rm) and elongation (A). Comparison of the modeling results of stepwise regression methods with Lasso, ElasticNet, XGBoost, LightGBM, Kernel ridge regression (KRR) has been done. The results show that the root mean square error (RMSE) of the above regression methods is smaller than the stepwise regression method. 3. Other regression methods including partial least squares (PLS), principal component regression (PCR) and robust regression were also investigated, using RMSE and mean absolute percentage error (MAPE) to evaluate the models' predictions. 4. This paper proposes a stacking model based on Lasso, ElasticNet, XGBoost, LightGBM and KRR, which improved the detection accuracy of mechanical properties. Keywords: 3MA system, mechanical properties, cold rolled steels, modeling method, stacking model.