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Soft Sensing Modeling of Rotor Displacements Based on Continuous Hidden Markov Model

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In the traditional magnetic bearings, displacement sensors are used to estimate position of rotors, which increase size and cost of magnetic bearings, and decrease its dynamic performance. The soft sensing technology can not only solve the problems above, but also eliminate the mutual coupling of motion equations, which makes the design of controller easier. As a result, soft sensing technology for high speed and high precision occasion arouses wide public attention. Currently, a variety of soft sensing methods have been proposed, however, there are still some problems need to be solved, such as complexity of structure, strict requirements for controllers, excessive reliance on precise mathematical model, and so on. Thus, a soft sensing modeling based on continuous hidden Markov model (CHMM) is proposed in this paper. It has no additional signal input and signal processing circuits. Furthermore, it has higher prediction accuracy and shorter computing time than other machine learning soft sensing methods. Firstly, the structure and operation principle of a 3-degree-of-freedom hybrid magnetic bearing (3-DOF-HMB) are described, and the nonlinear mathematical model of the 3-DOF-HMB in large air-gap is derived by using equivalent magnetic circuit method. Secondly, combining the well prediction ability of CHMM, a position prediction model is built by collecting representative current-displacement data, meanwhile, basic Baum-Welch parameters revaluation formula is improved to optimize parameters of the CHMM prediction model. Then, a soft sensing credibility evaluation index is proposed for real-time monitoring. Finally, mean squared error (MSE) is taken as model evaluation index to compare the predictive ability of proposed CHMM and other soft sensing methods. The simulation results show that the MSE value of the CHMM prediction model is obviously smaller than that of other soft sensing models. The effectiveness of the proposed soft sensing method based on CHMM is verified by experiments.

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