

Analytical Polynomial Models of Nonlinear Magnetic Flux Linkage for SR Motor



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Introduction

To model the nonlinear characteristic of the flux linkage for the switched reluctance motor, a modified flux linkage analytical model and a fast model based on an original polynomial model which fits the ψ - θ curve at different phase currents is proposed by analyzed the error percentage curve of the original model in this paper. The coefficient of the polynomial is studied for a fast model in order to increase the speed of solving the modeling problems. The electromagnetic torques of switched reluctance motor is calculated by the modified model and the fast model, which are matched well with the finite element analysis method. Then, the simulation model is built based on the modified model with MATLAB. Finally, an experimental platform is established to validate the proposed models. Compared the results of the experiment with that of the simulation operated under the angle position control mode, it verifies that the nonlinear model of flux linkage and torque are creditable.

Modeling Based on the Analytical Polynomial (1)

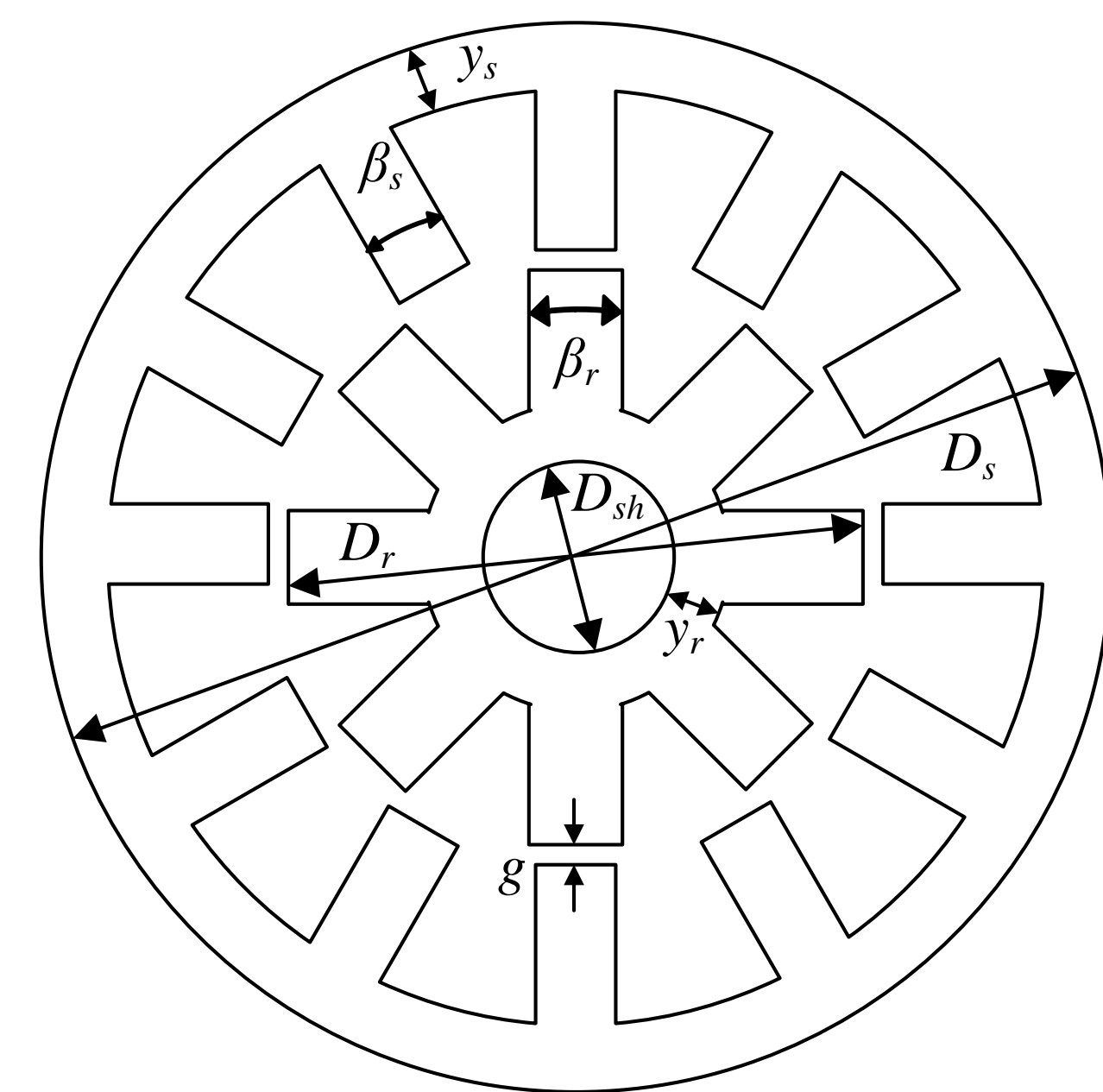


Table I Parameters of the Prototype

Parameter	Value
Number of stator poles N_s	12
Number of rotor poles N_r	8
Stator outer diameter D_s	110.00mm
Stator yoke width y_s	6.75mm
Stator pole arc angle β_s	15°
Rotor outer diameter D_r	58.30mm
Rotor yoke width y_r	7.10mm
Rotor pole arc angle β_r	16°
Shaft diameter D_{sh}	14.20mm
Air gap g	0.30mm
Stack length L_s	85.20mm

Fig. 1. The Sectional View of SRM

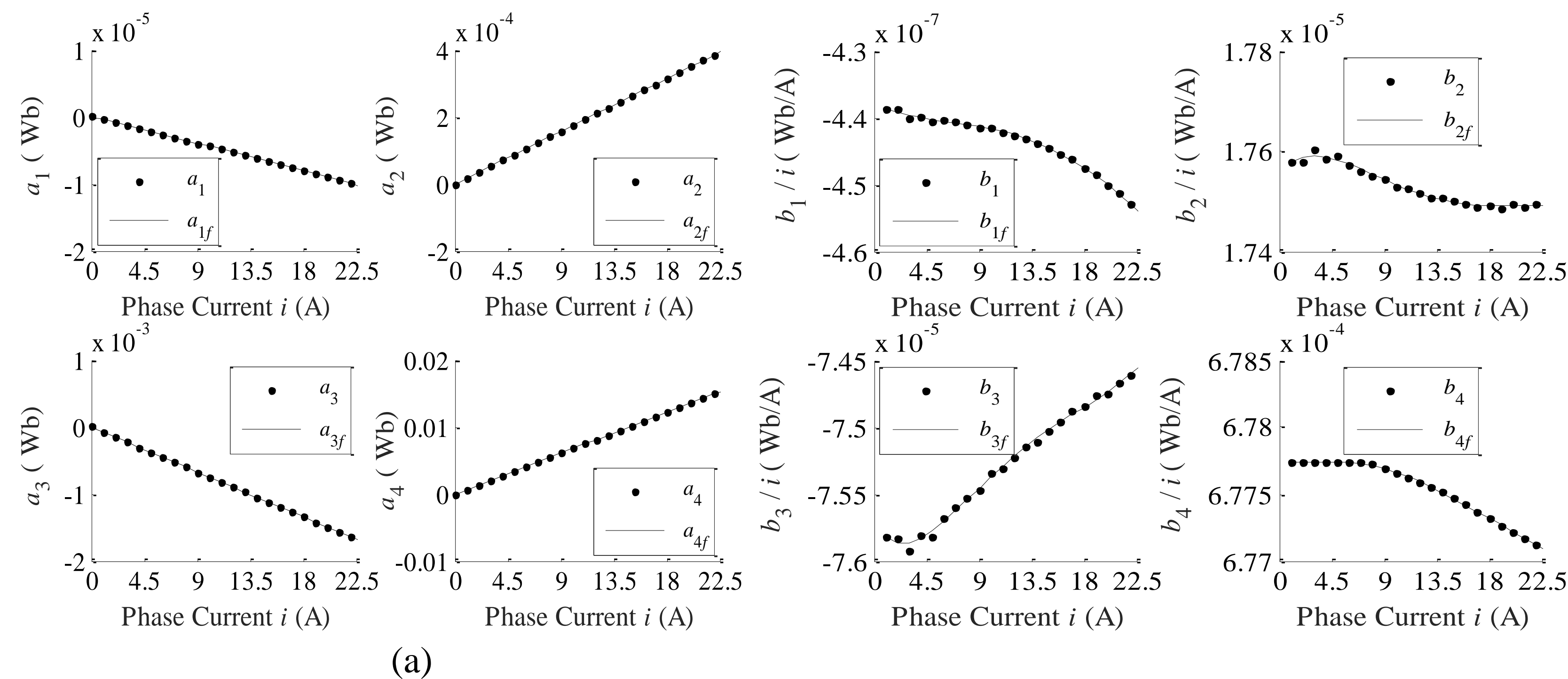


Fig. 2. The coefficient to fitting. (a) The relationship between the ψ and i . (b) the relationship between b_m and i_n .

Modeling Based on the Analytical Polynomial (2)

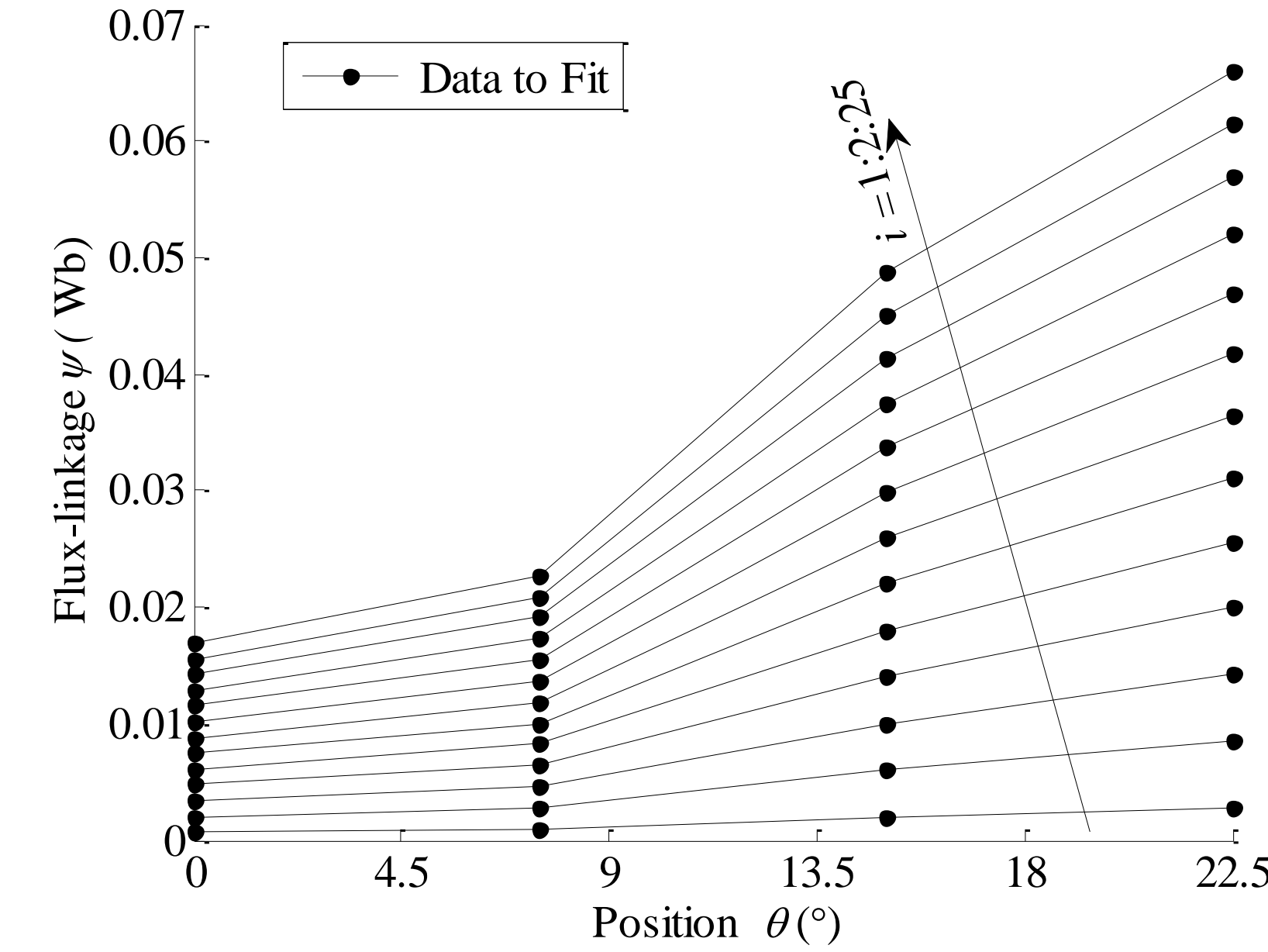


Fig. 3. The flux linkage data to fit.

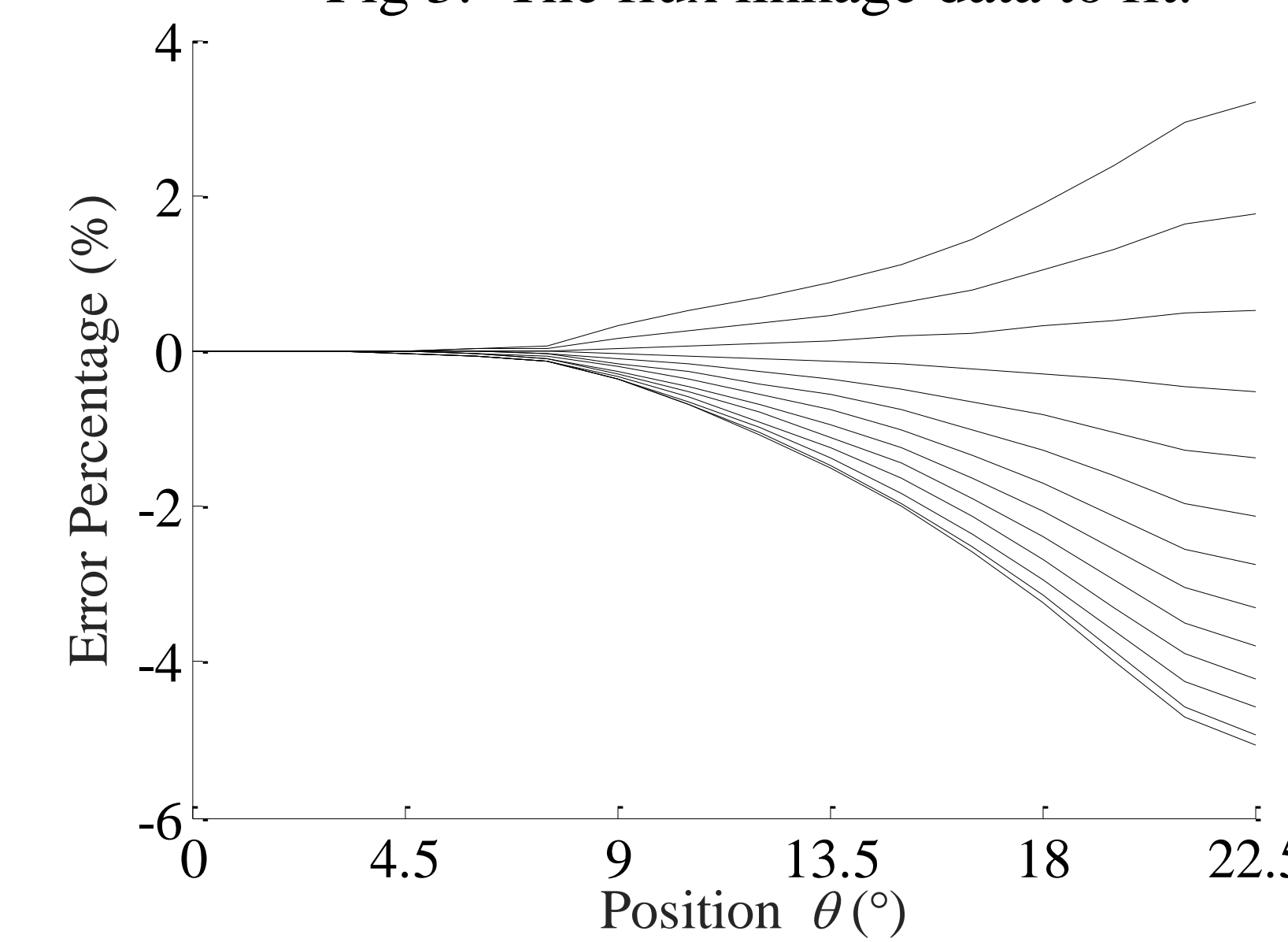


Fig. 7. Error percentage of fast model.

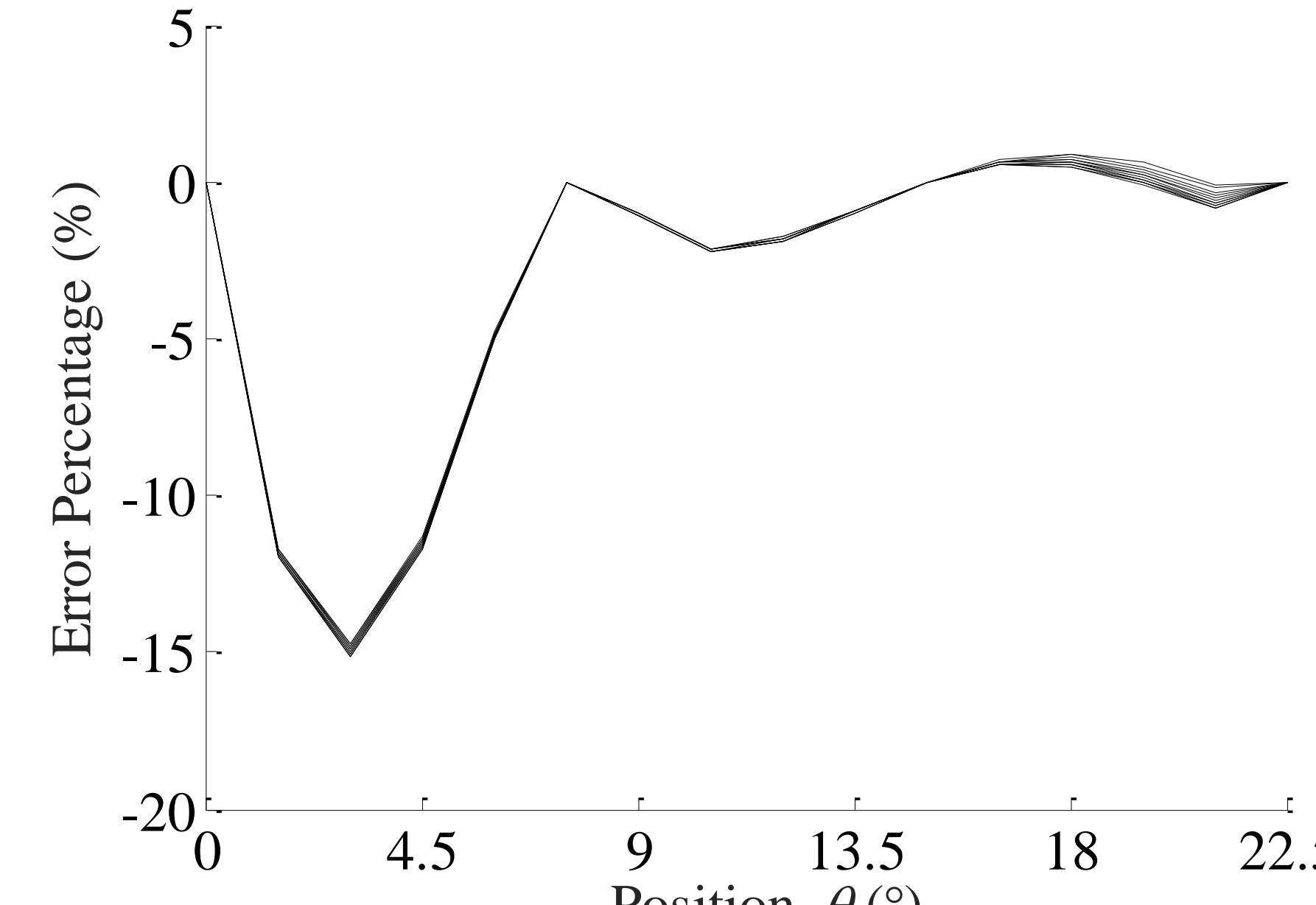


Fig. 4. Error percentage of original model.

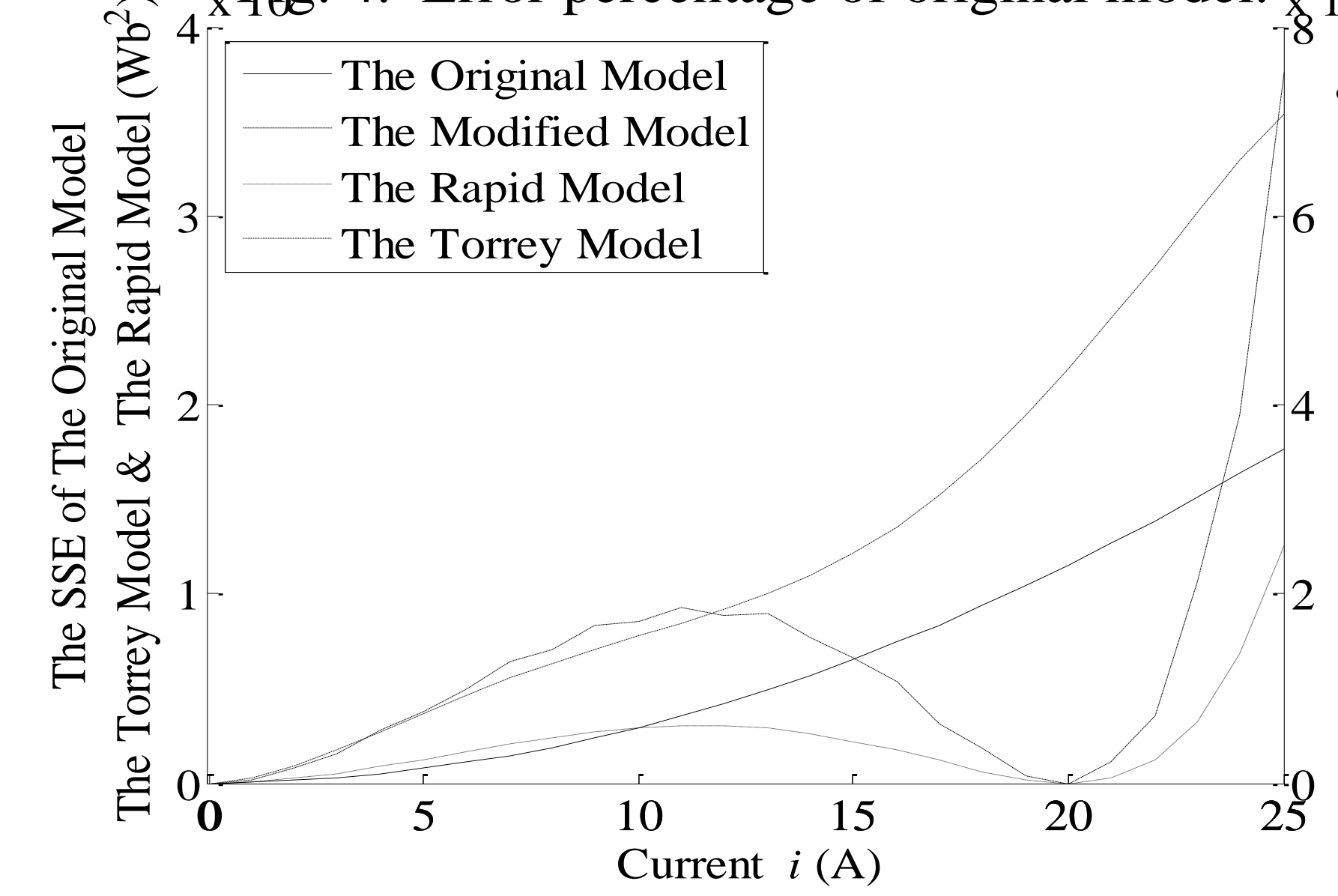


Fig. 8. SSE of different models.

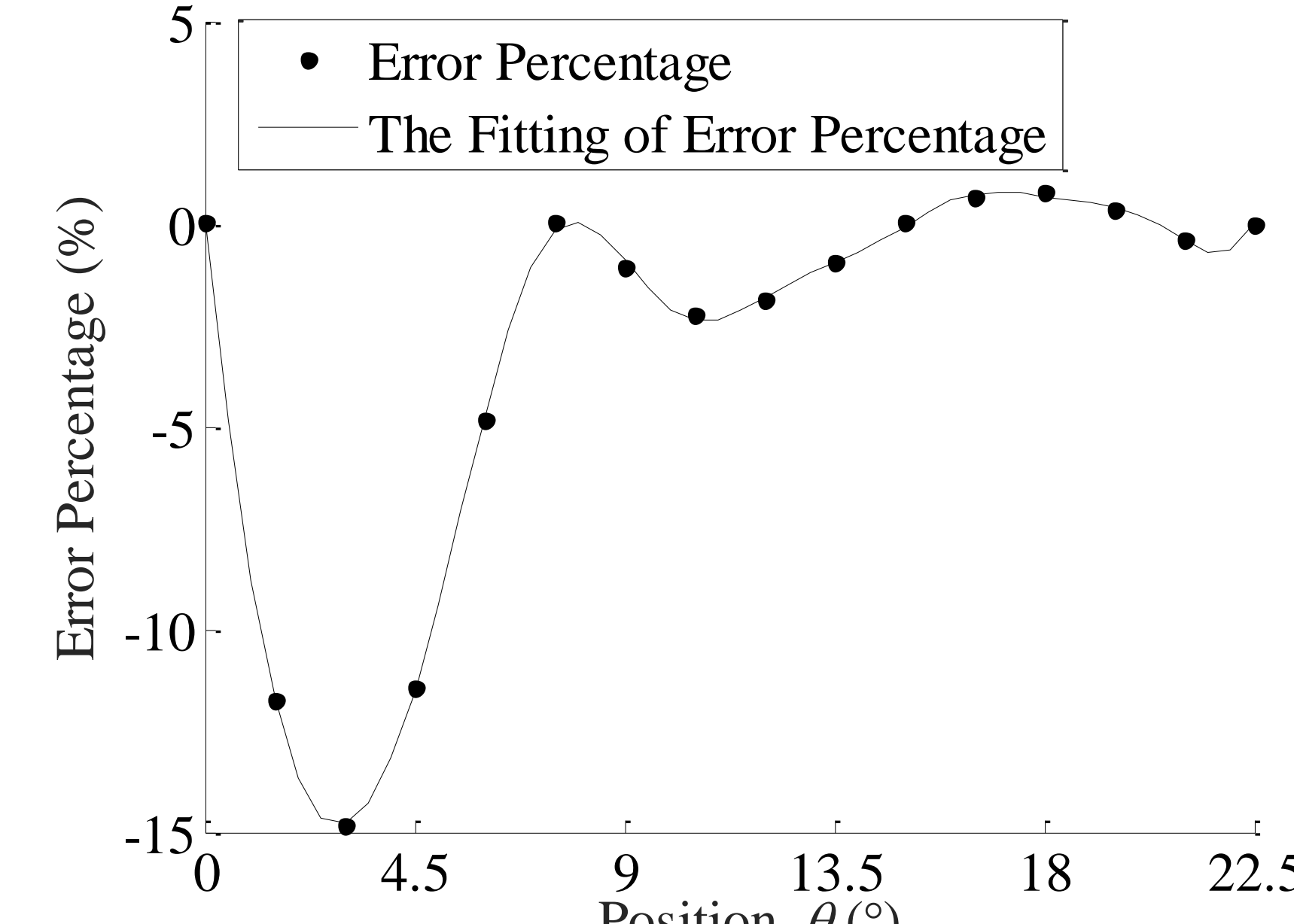


Fig. 5. Error percentage curve at current 20A.

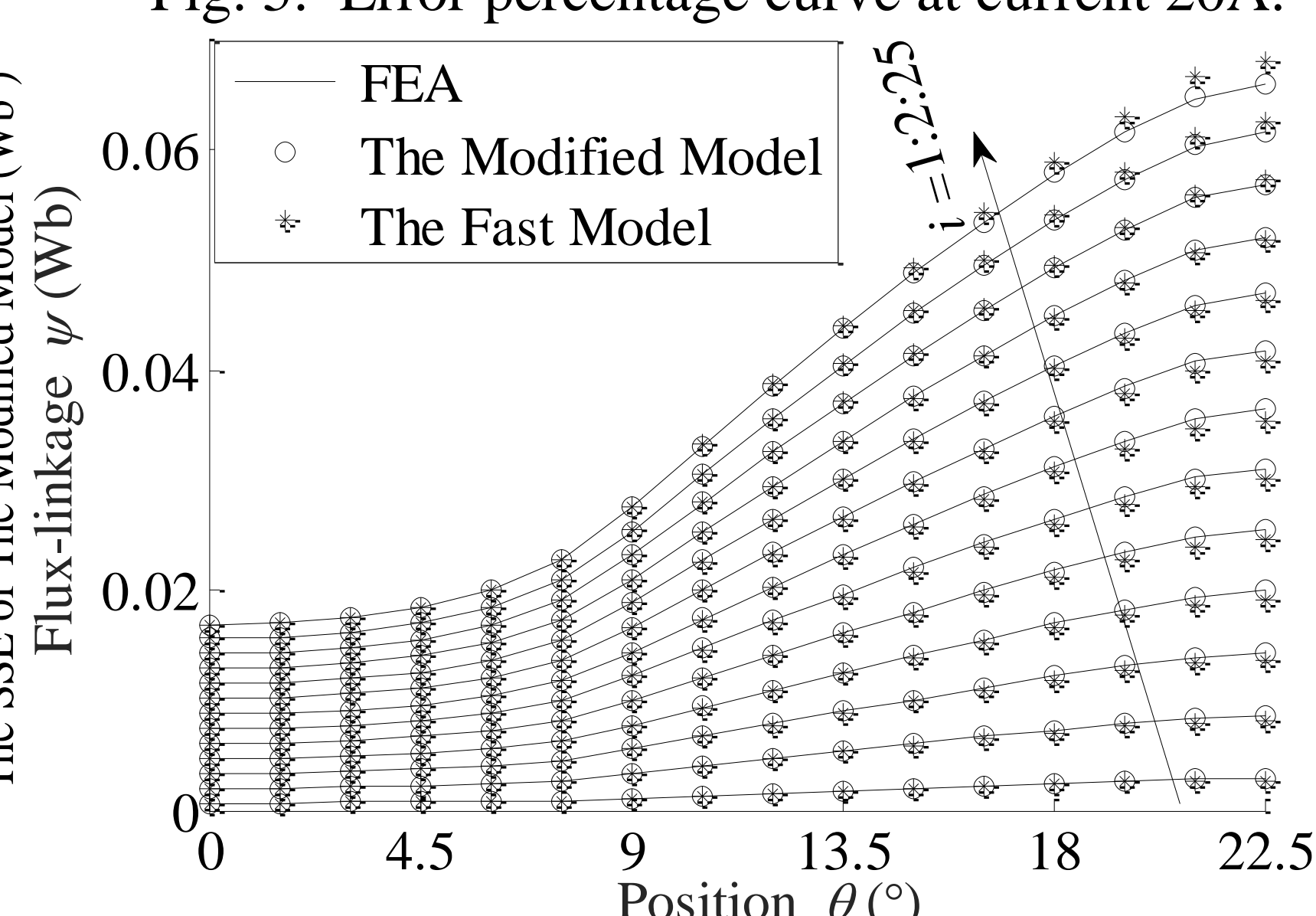


Fig. 9. The ψ of modified and fast model.

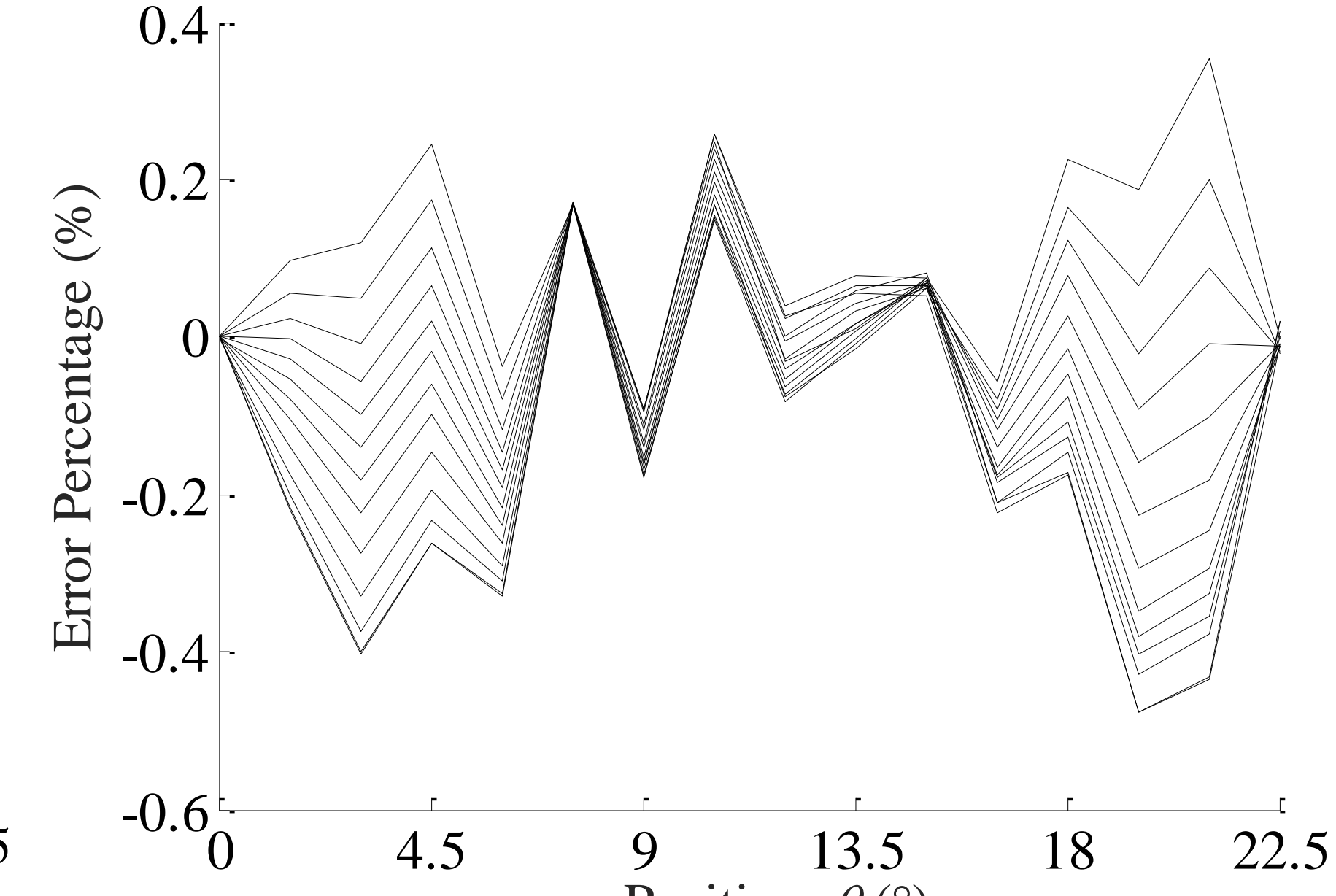


Fig. 6. Error percentage of modified model.

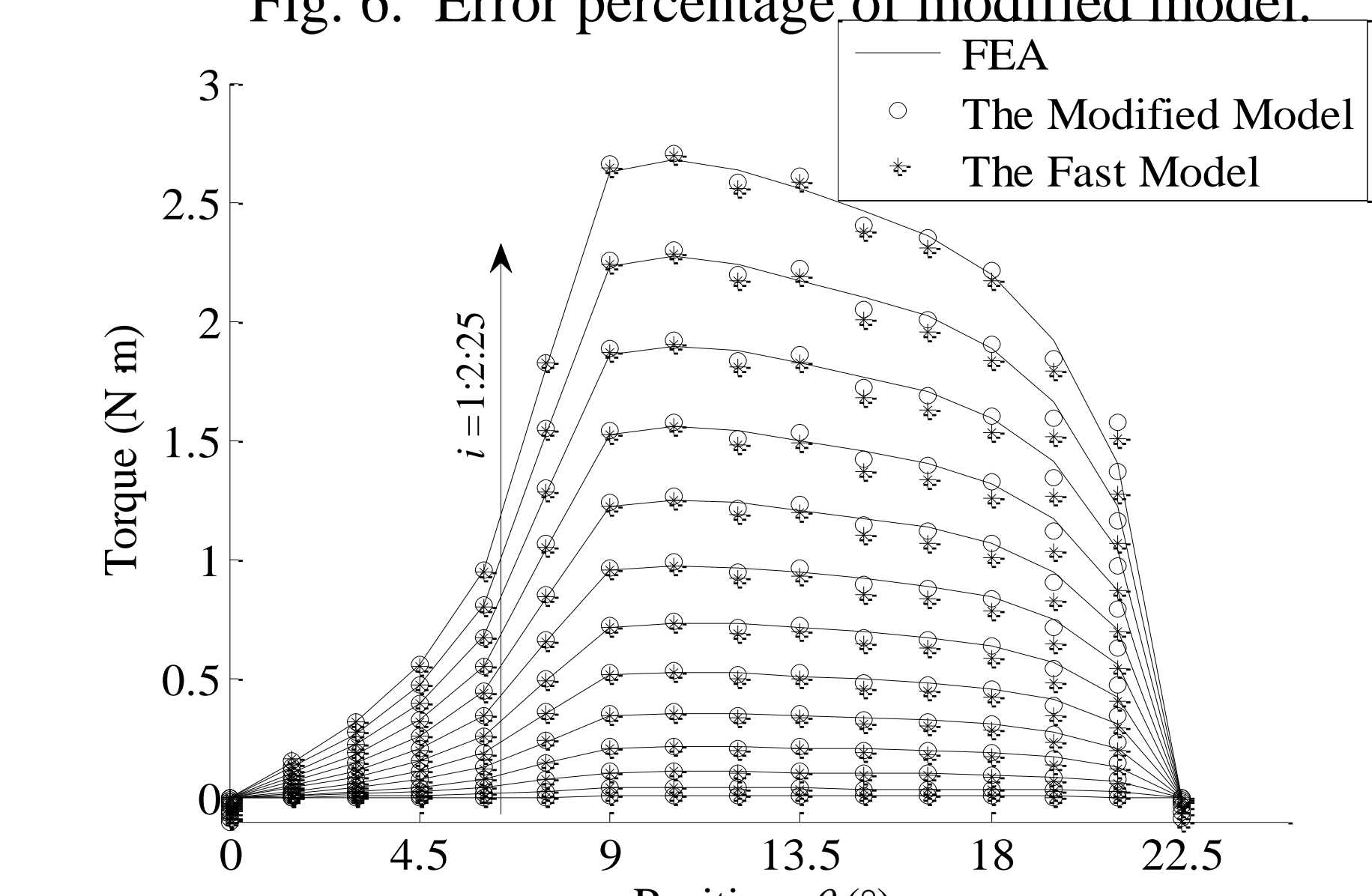


Fig. 10. Torque of modified and fast model.

Experimental Verification

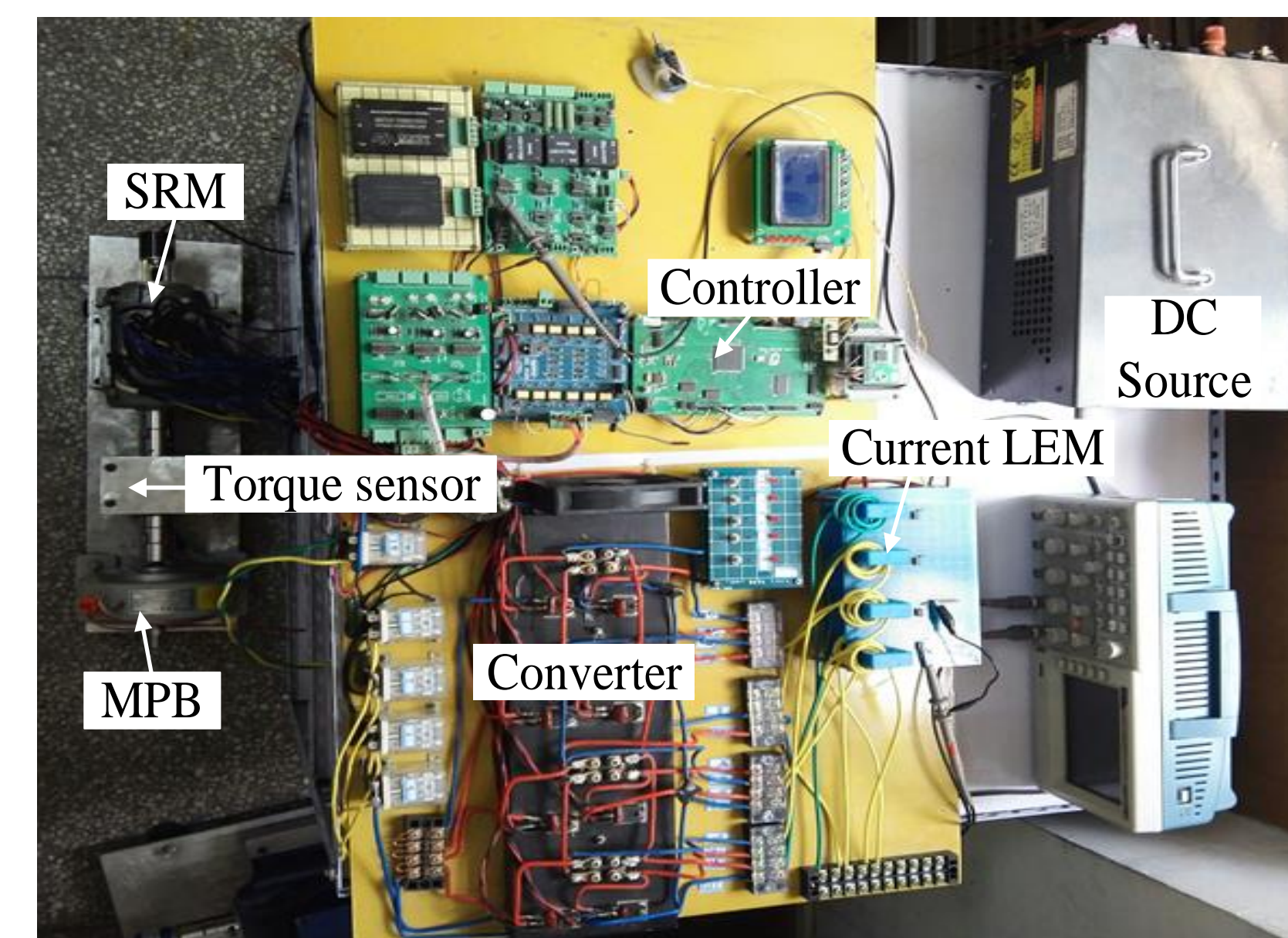


Fig. 11. The experimental platform

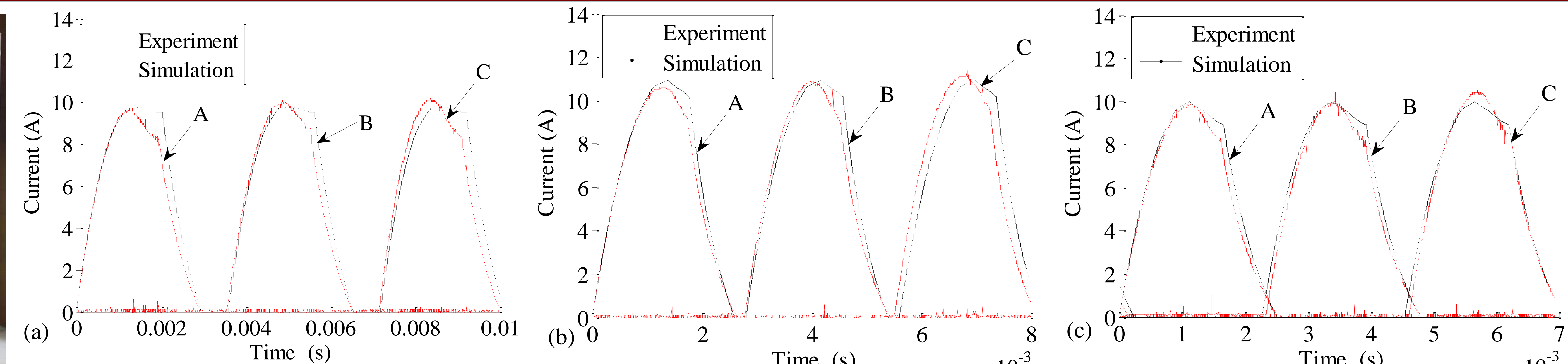


Fig. 12. Simulation and measured waveforms under APC (a) $n=700$ r/min, (b) 900 r/min, (c) 1100 r/min.

Conclusions

The SSE of the three models is compared with the Torrey model. It is shown that the fitting effect of the three models is better than the Torrey model and the modified model is the best one. The electromagnetic torques of the SRM is also calculated by the modified model and the fast model, which are matched well with the torque calculated by FEA method. The dynamic simulation model is built based on the modified model. Finally, an experimental platform is established to validate the proposed models. Compared the current waveform of the experiment and the simulation operated at different rotation rates, the results verifies that the nonlinear model of flux linkage is creditable. Because the modelling is very fast which is can be applied in the multi-objective optimization of the SRM, it is can saving lots of the time required in the process of optimization.