

Three-dimensional Magnetic Equivalent Circuit Research of Double-sided Switched Reluctance Linear Machine (Tue-Af-Po2.21-04 [68])

Hao Chen, Senior Member, IEEE, and Xuekun Liu, Wenju Yan School of Electrical and Power Engineering, China University of Mining & Technology, Xuzhou, Jiangsu, China

Abstract

This paper proposed a 3D MEC method to analyze the flux linkage characteristics of DSRLM. The magnetic resistance of each part was obtained by the magnetic flux tube method. According to the established 3D MEC model, the Gauss-Seidel iteration method is used in MATLAB to solve the flux linkage-current magnetization curves at two representative positions. Utilize the magnetization curves obtained by MEC to solve the electromagnetic force-mover position curves at different currents. And compare the curves obtained by MEC with the curves obtained by software FLUX and experiment. By comparison, it can be found that the error is within an acceptable range, indicating that the scheme is more feasible.

Structure

DSRLM consists of a mover with non-magnetic yoke and two symmetrical stators. There are 8 tooth on the mover, and there are 6 windings on each stator. 3D sketch diagram of DSRLM is shown in Fig.1. And the Structural parameter is shown in Table I

Table I Structural parameter size of DSRLM

18.5

23.5

60.0

86.0

90.0

1.5

Structural parameter

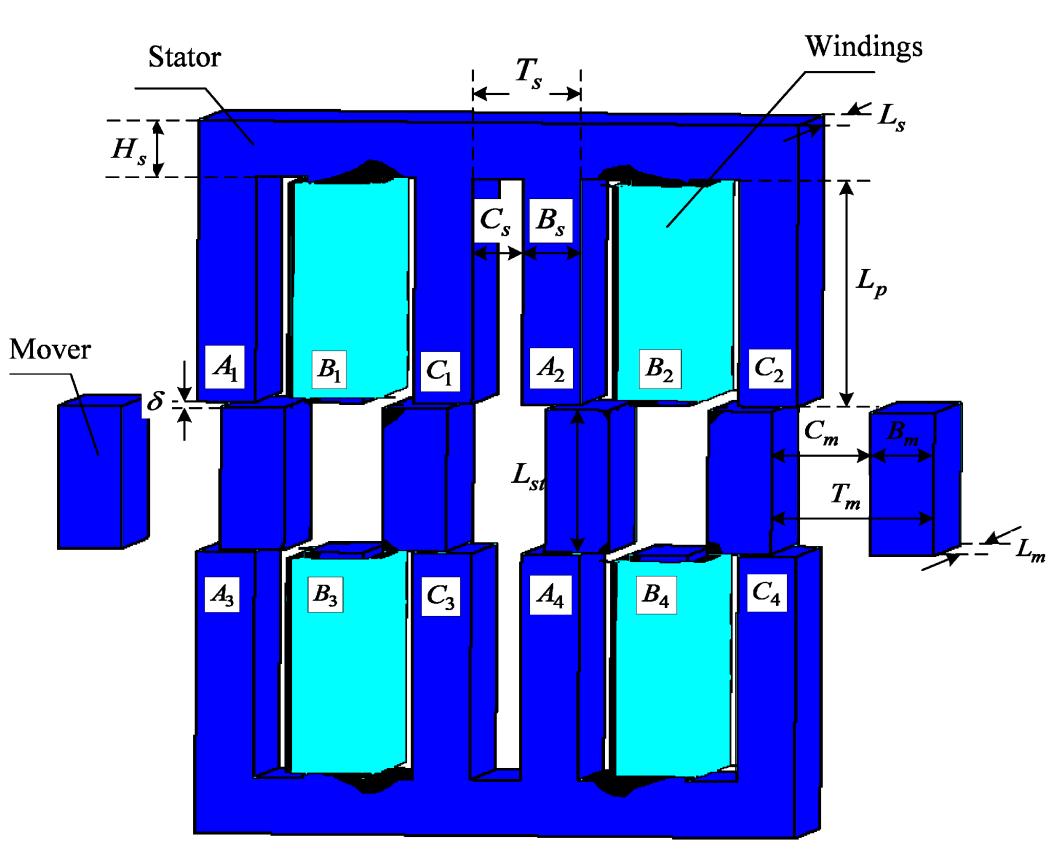
Mover pole pitch T_m

Stator tooth width B_s

Mover tooth width B_m

Stator slot width C

Air gap δ



Mover slot width C_n Stator thickness H. Mover thickness H_m Stator slot depth L_p Mover slot depth L_{st} Stator thickness L Mover thickness L

Fig. 1 3D sketch diagram of DSRLM

Establishment of 3D MEC model

Through the 3D FEM model established, it is found that the magnetic field lines of DSRLM pass successively through the stator tooth, stator yoke, stator tooth, air gap, mover tooth, air gap, stator tooth, stator tooth, stator yoke, stator tooth, air gap, mover tooth and air gap to form a closed loop. Because DSRLM is symmetric both left-and-right and up-and-down in unaligned and aligned positions, it only needs to establish a 3D MEC for 1/4 of it.

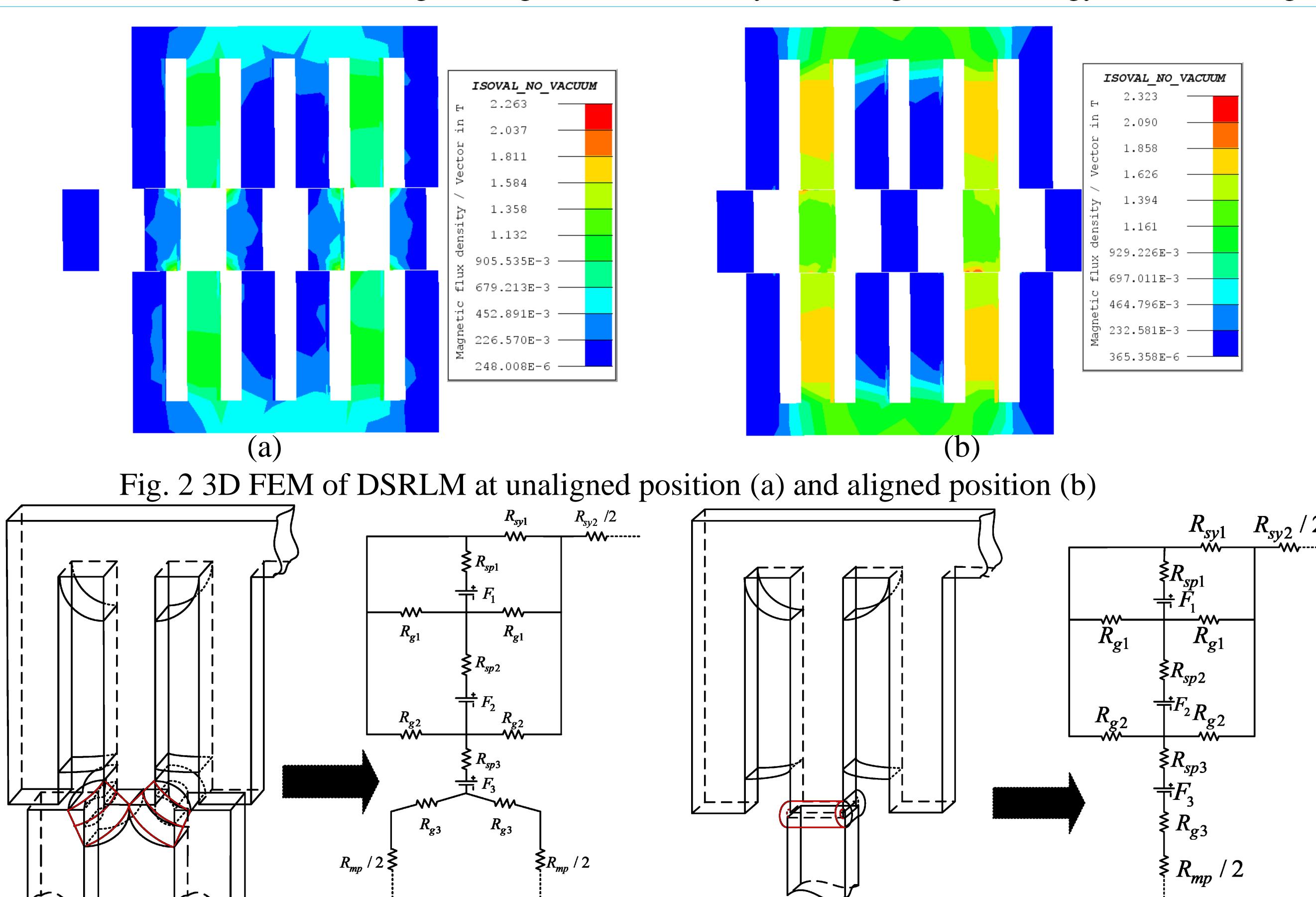


Fig.3 1/4 MEC diagram of DSRLM and 3D amplification of the end part at unaligned position (a) and aligned position (b)

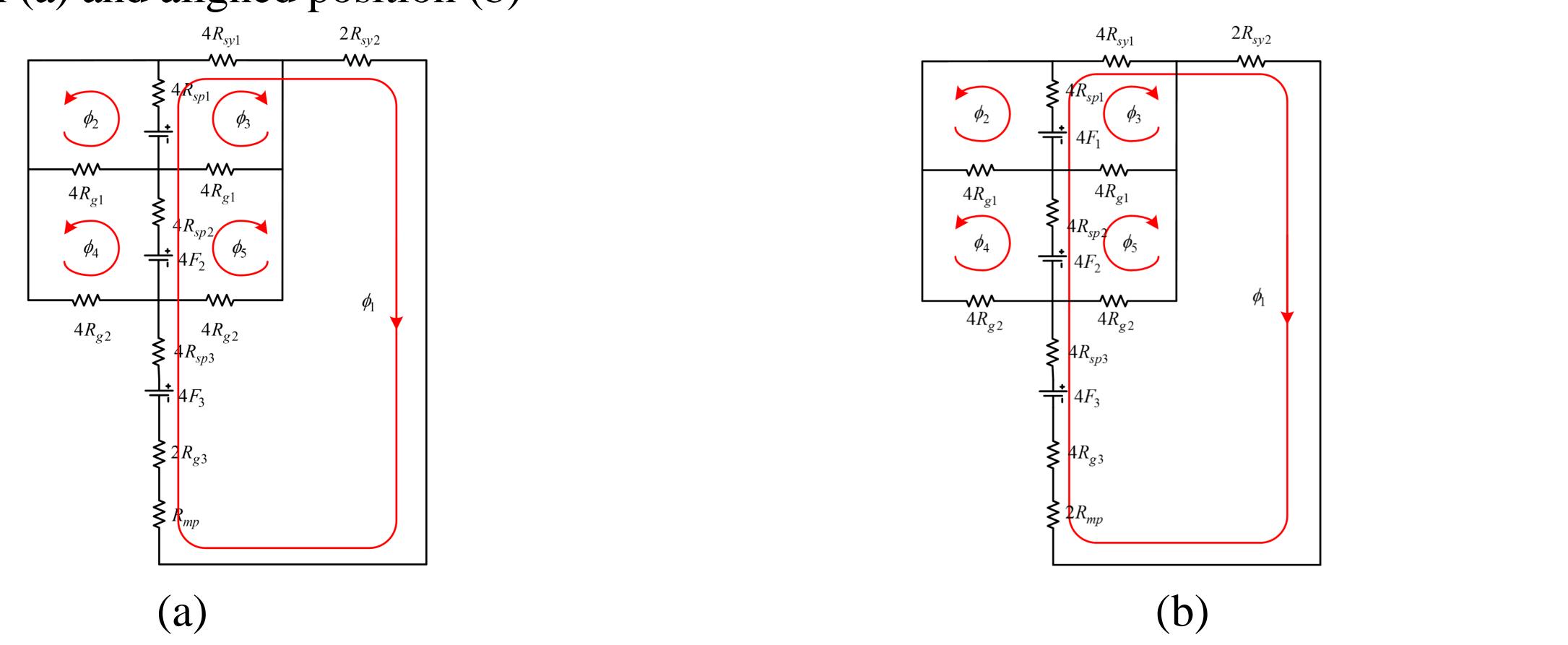


Fig.4 The whole MEC of DSRLM after simplification at unaligned position (a) and aligned position (b)

Simulation and experiment

The magnetization curves obtained by the MEC model, FEM and the experiment at the aligned position and the unaligned position are shown in the Fig.5.

The electromagnetic force obtained by the MEC model, FEM and the experiment are shown in the Fig.6. As can be seen from the Fig.5 and Fig.6, the error is within an acceptable range.

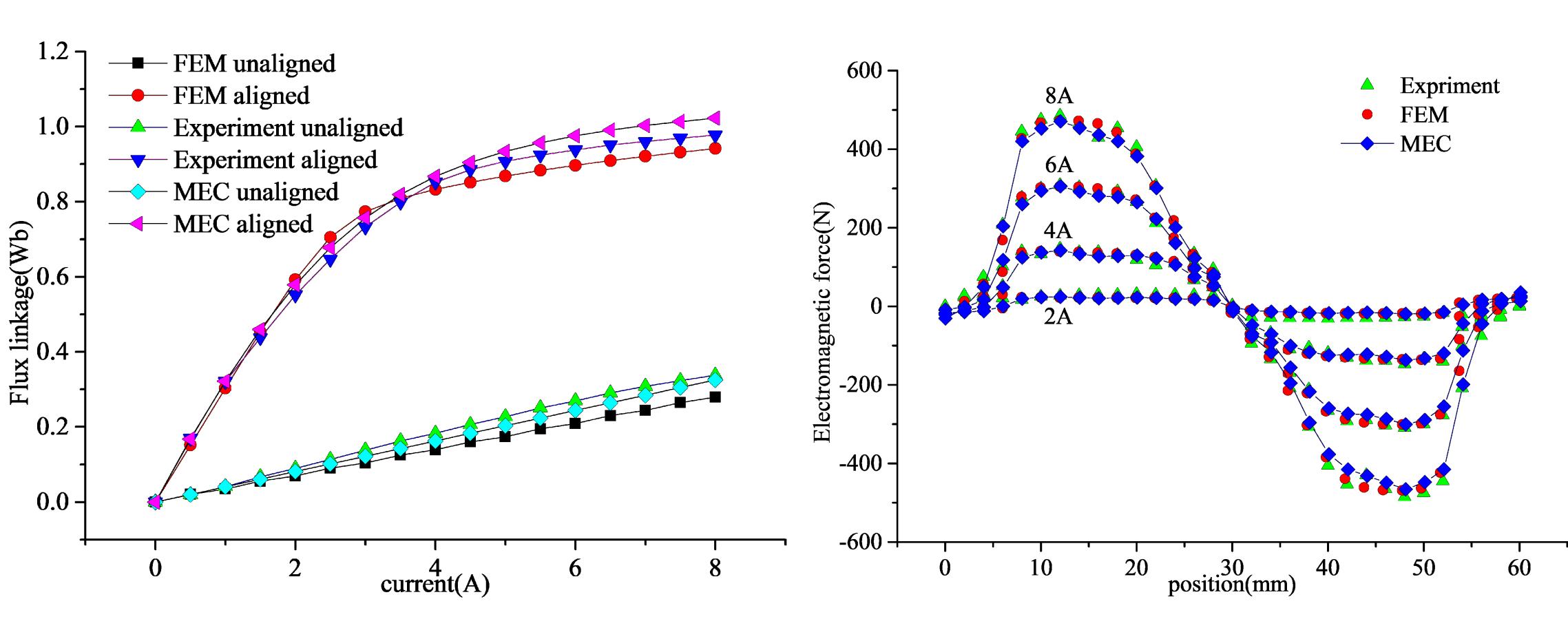


Fig.5 Comparison of magnetization curves by FEM and MEC in unaligned and aligned position.

Fig.6 Comparison of electromagnetic force by FEM, MEC and experiment

Conclusion

This paper proposed a 3D MEC method to analyze the flux linkage characteristics of DSRLM. The magnetic resistance of each part was obtained by the magnetic flux tube method. According to the established 3D MEC model, the Gauss–Seidel iteration method is used in MATLAB to solve the flux linkagecurrent magnetization curves at two representative positions. Utilize the magnetization curves obtained by MEC to solve the electromagnetic force-mover position curves at different currents. And compare the curves obtained by MEC with the curves obtained by software FLUX and experiment. By comparison, it can be found that the error is within an ac-ceptable range, indicating that the scheme is more feasible.