

A Novel Tubular Switched Reluctance Linear Machine Shielding from End Effect ([Tue-Af-Po2.20-08 [60])

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Abstract — Traditional linear machines are under great influence of end effect because of their finite stacking lengths in transverse and longitudinal directions. Transverse end effect will produce a lot of flux leakage enclosed with air. Longitudinal end effect will cause imbalance of phase performance so that linear machine's force fluctuation is aggravated. The negative impact of longitudinal end effect on a flat type switched reluctance linear machine (SRLM) is verified in this paper. In order to avoid this problem, a novel tubular switched reluctance linear machine (TSRLM) is proposed, which can shield from unexpected impact of end effect. In structure, there is no transverse cut in tubular linear machines, so tubular linear machines are not influenced by transverse end effect. The stator sleeve of proposed TSRLM includes six ferromagnetic rings and five spacer rings. The mover is composed of an aluminum tube and several fan-shaped poles. The adjacent fan-shaped poles are placed at 120 degree intervals. Its equivalent magnetic flux path is analyzed, which proves that the TSRLM is not influenced by longitudinal end effect. A prototype is manufactured, and its corresponding hardware platform is established. A series of simulations and experiments verify that there is no deviation performance among phases. Traditional longitudinal end effect in linear machines caused by longitudinal cuts can be thoroughly evaded.

Structure of proposed TSRLM

The stator sleeve of proposed TSRLM includes six ferromagnetic rings and five spacer rings. There are twelve salient poles on every stator ferromagnetic ring. The winding coils are all through windings. The mover is composed of an aluminum tube and several fan-shaped poles. The adjacent fan-shaped poles are placed at 120 degree intervals. The stator poles of energized phase only drag the mover ferromagnetic rings with the same-direction fan-shaped poles.

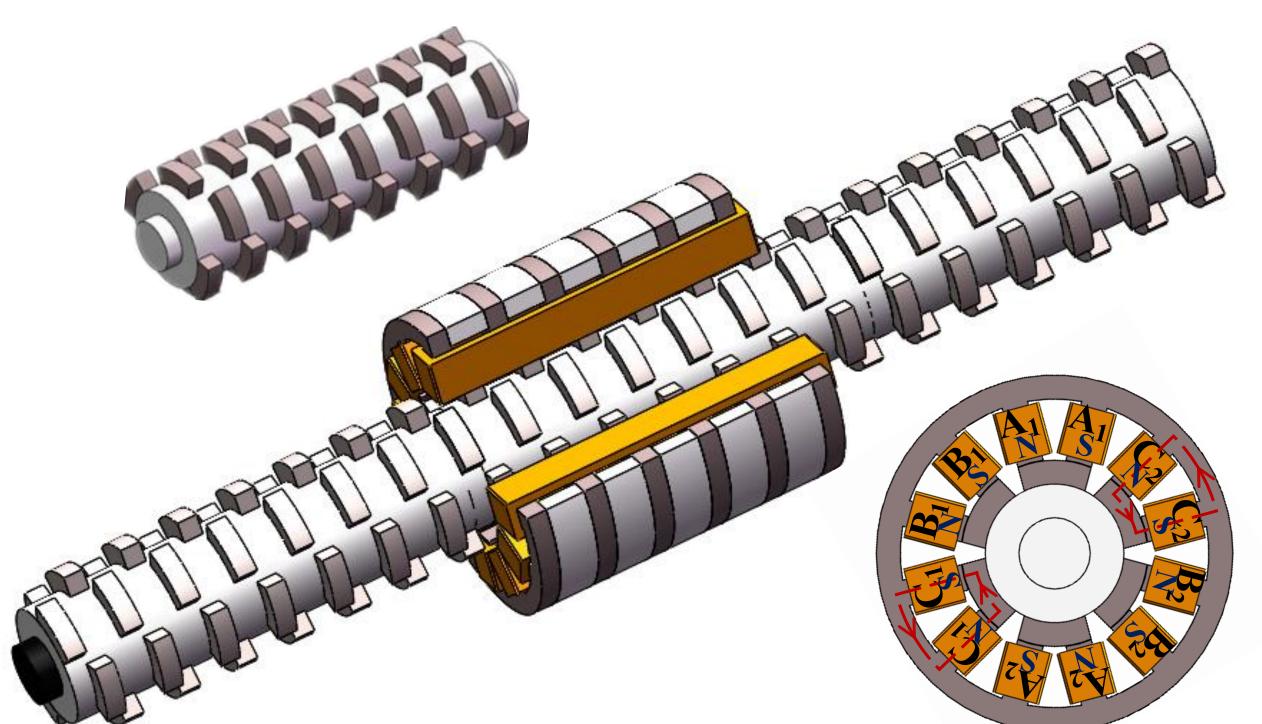


Fig. 1. Structure of the proposed TSRLM

The traditional flat type SRLM used in this paper for comparison is a three phase 6/4 double-sided SRLM. Its mover is yokeless.

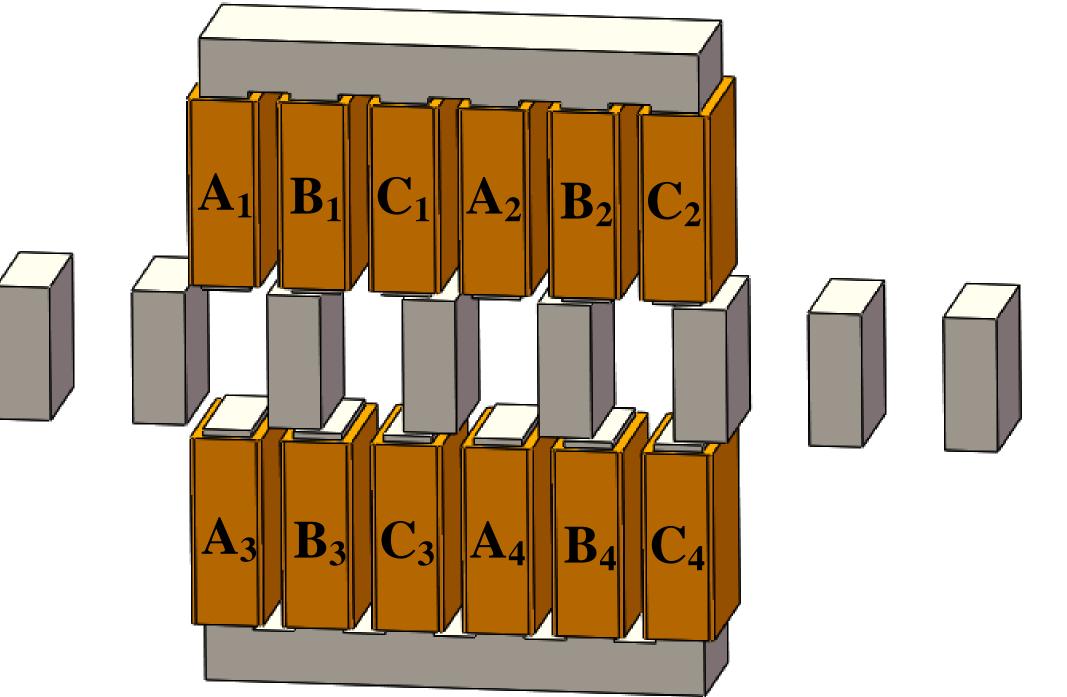


Fig. 2. Traditional flat type SRLM

Equivalent magnetic circuit

In the traditional flat-type SRLM, the equivalent magnetic circuit of phase in the middle differs from that of phase at the end, which can cause the unbalance of electromagnetic characteristics in different phases and aggravate the force ripple of this machine.

The proposed TSRLM can avoid this proplem.

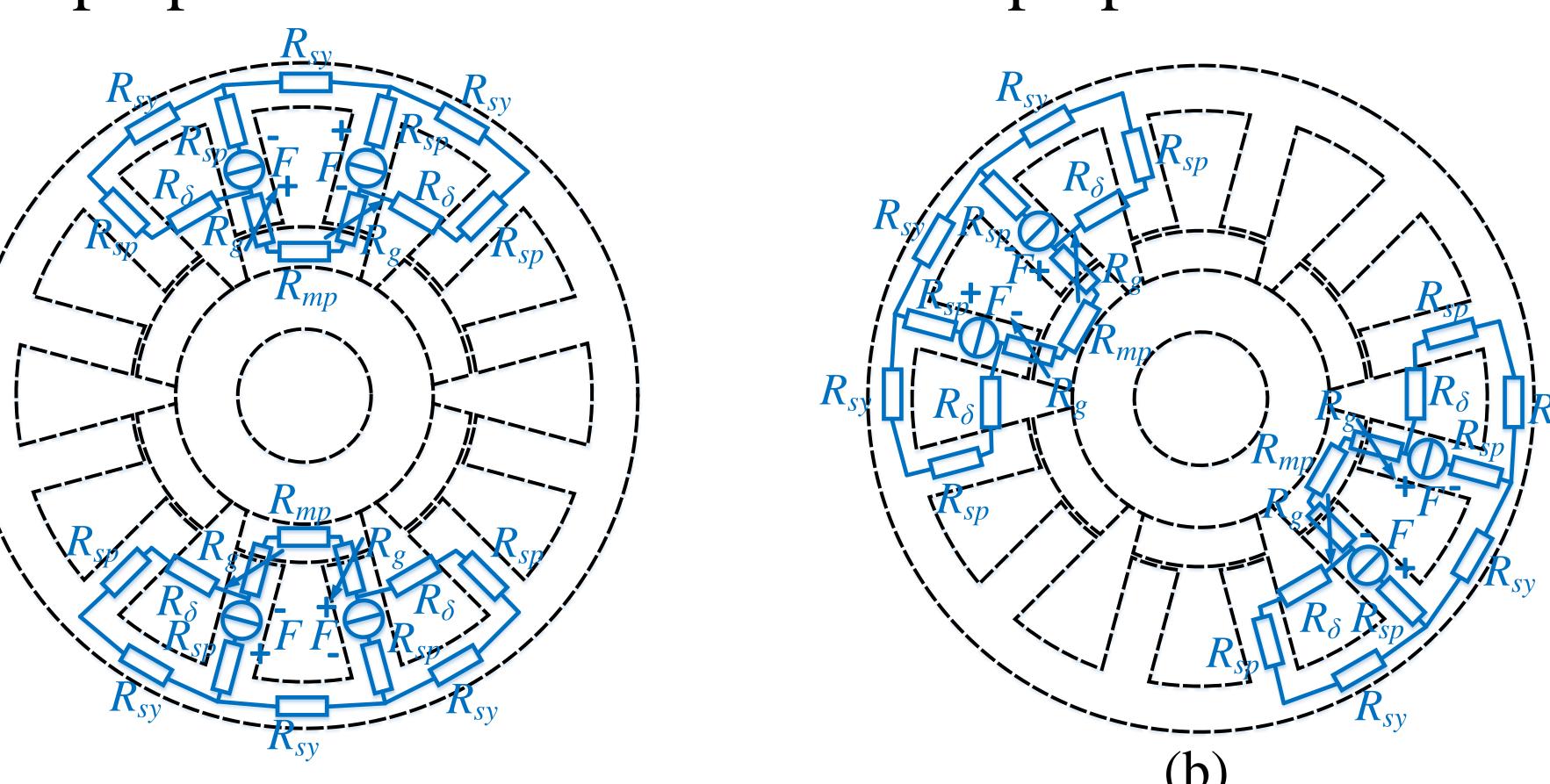
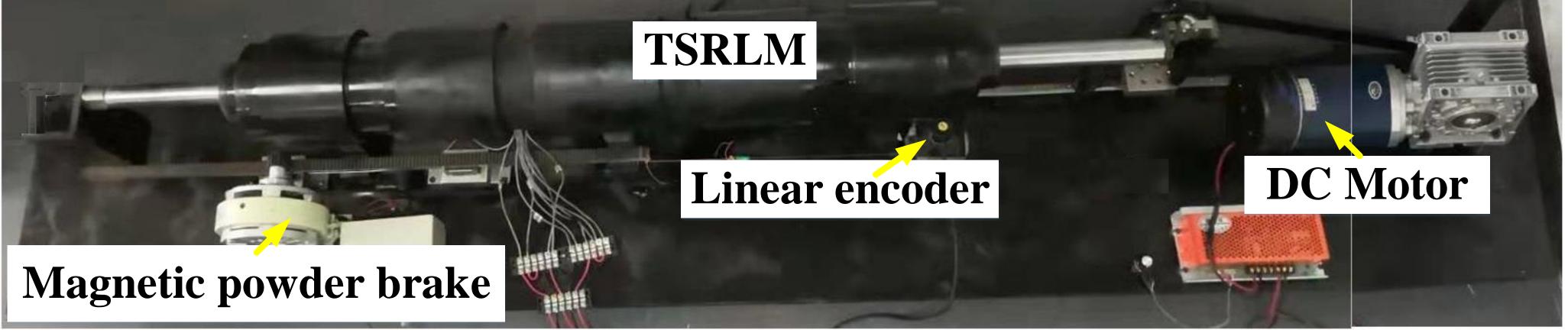


Fig. 3. Equivalent magnetic circuit of the TSRLM (a) phase A (b) phase B Fig. 4. Equivalent magnetic circuit of traditional flat type SRLM (a) phase A (b) phase B



DC Motor SRLM **Connecting Rod**

Fig. 5. The prototype of the proposed TSRLM

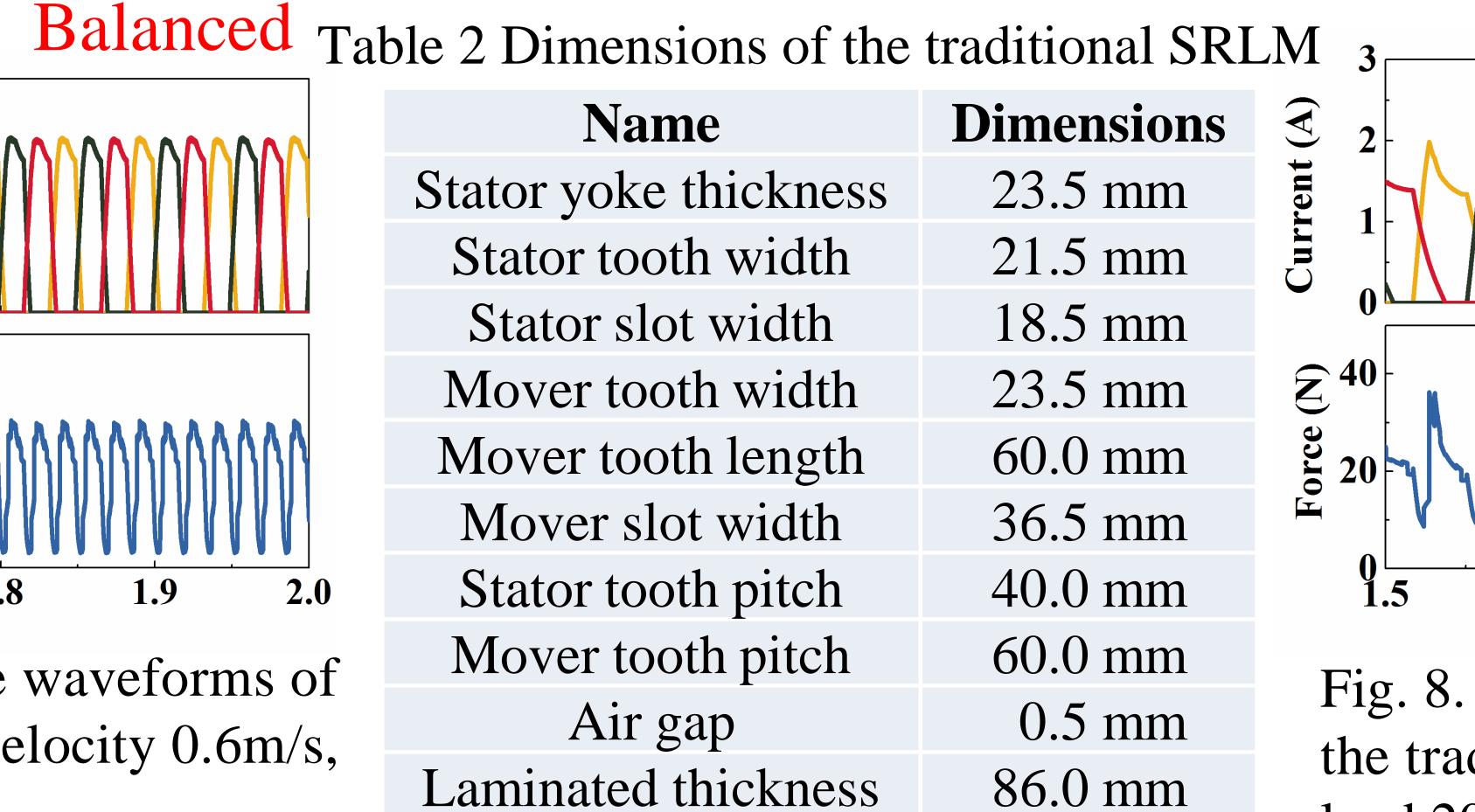
Table 1 Dimensions of the proposed TSRLM

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Name	Dimensions	•
Stator outer diameter	150.0 mm	
Stator inner diameter	79.0 mm	(
Mover outer diameter	78.6 mm	
Shaft diameter	30.0 mm	
Stator yoke height	10.0 mm	
Stator pole width	12.5 mm	
Stator ferromagnetic ring thickness	11.0 mm	
Stator spacer ring thickness	19.0 mm	
Mover ferromagnetic ring thickness	10.0 mm	_
Mover pole height	14.0 mm	-
Air gap thickness	0.2 mm	4
Laminated thickness	600.0 mm	-

Fig. 7. Current and force waveforms of the proposed TSRLM (velocity 0.6m/s, load 20N)

Fig. 6. The prototype of the traditional flat type TSRLM

Controller of DC Motor



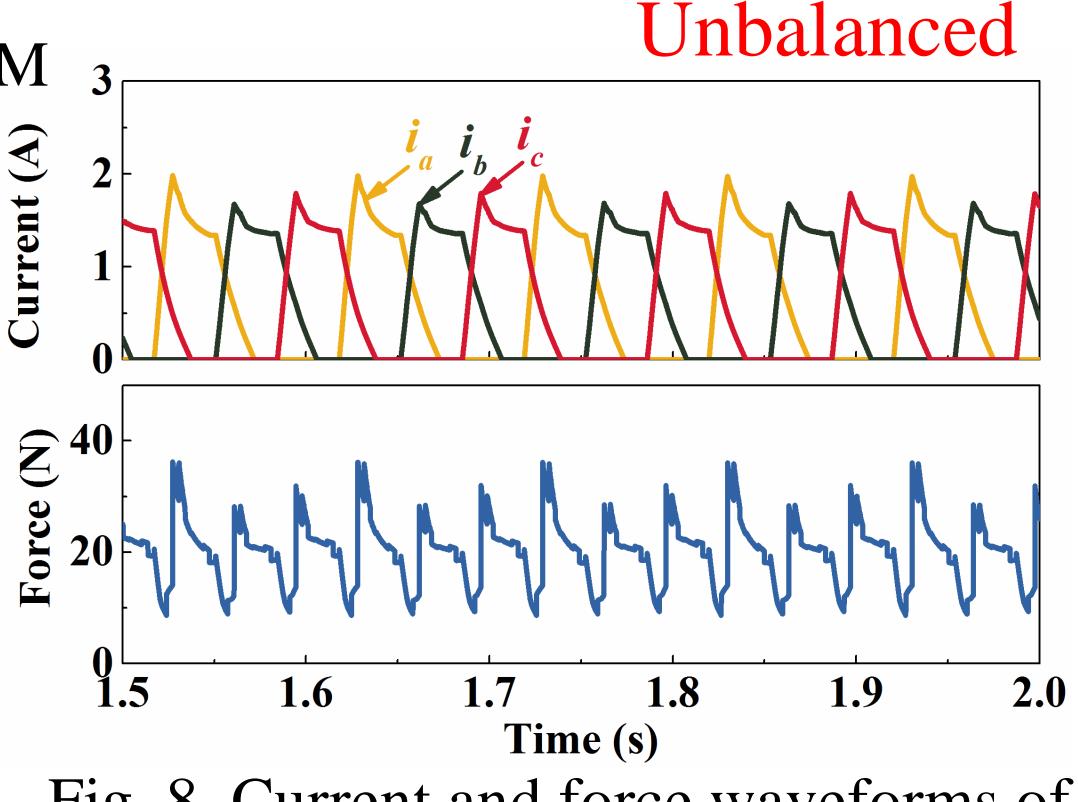


Fig. 8. Current and force waveforms of the traditional SRLM (velocity 0.6m/s, load 20N)