A transverse flux single-phase tubular switched reluctance linear motor

(Mon-Af-Po1.04)

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Introduction

Tubular switched reluctance linear motor (TSRLM) with novel structure has attracted scholars' increasing interest for its lower loss and force density ratio than common types switched reluctance motor (SRM). TSRLM with four stator poles in the cross section is proposed in this paper. The structure of the TSRLM is illustrated thoroughly. In order to seek the proper parameters of the TSRLM with largest electromagnetic thrust, the sensitivity analyses of the TSRLM on different stator yoke thickness, mover cylinder's thickness, stator pole width and stator ferromagnetic ring width are carried out via 3D finite element method, of which the results are also analyzed. A new winding mode is proposed, and the performance of the TSRLM with the new winding mode is compared with the traditional winding mode which is proved to be better.

Structure of Proposed TSRLM

To some extent, the structure of the proposed TSRLM is similar to that of the rotary switched reluctance machine (RSRM). In the both types of the switched reluctance machines, the stator slots and the stator poles are on an identical plane. Since the space of winding coils in the stator slots and the length of the magnetic flux paths are determined by the varied stator poles, the selection of different models of the TSRLM is necessary. Concerned about the decisive influence of the basic structure of the TSRLM, it should be carried out before the optimizations of the structure parameters. The structure of the TSRLM proposed in this paper is shown in Fig. 1.

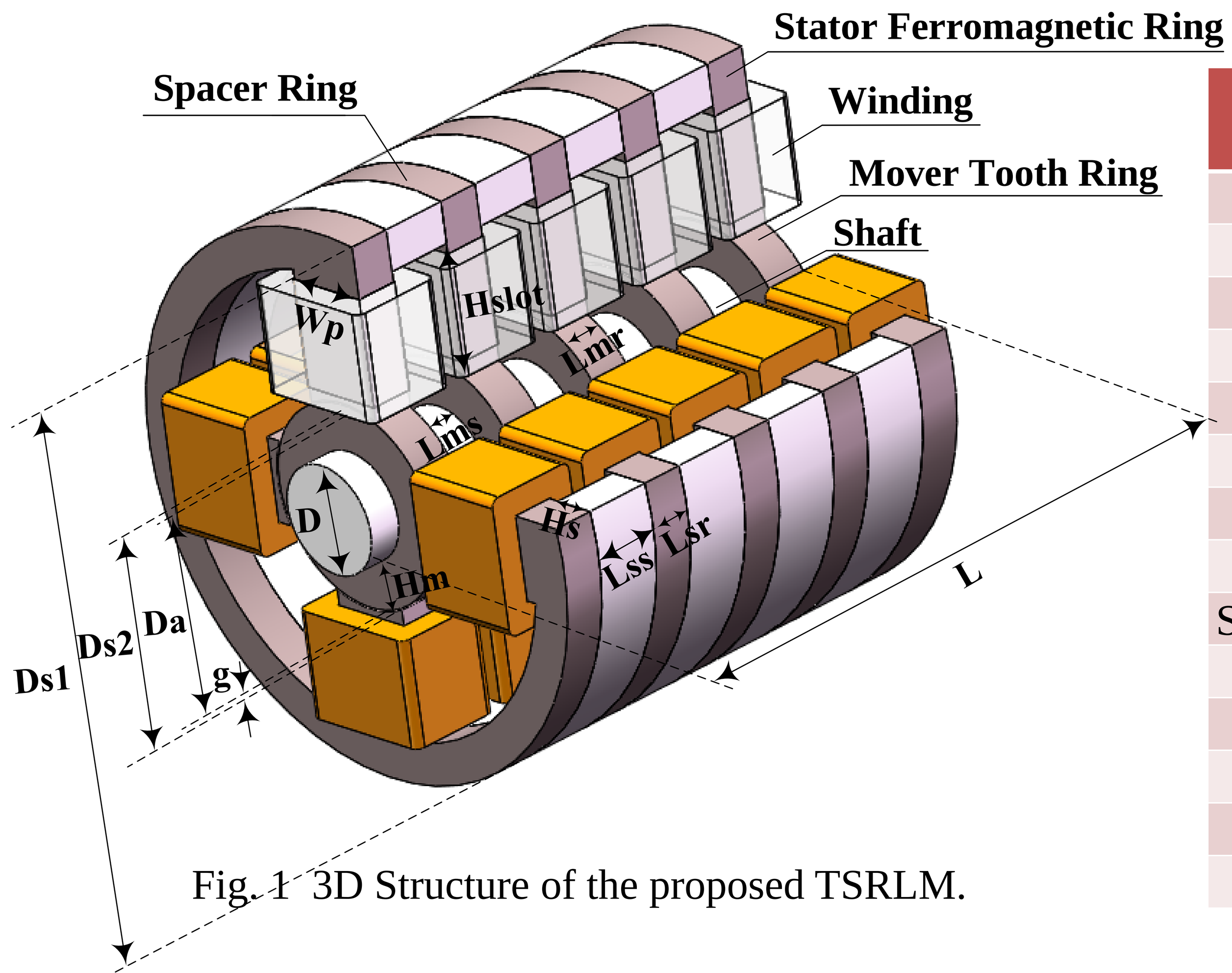

Fig. 1 3D Structure of the proposed TSRLM.

Table I Final geometry dimensions of DR-SRM

Name	Parameters	Initial Dimensions	Final Dimensions
Stator outer diameter	Ds1	63.0	63.0
Stator inner diameter	Ds2	25.6	23.8
Mover outer diameter	Da	25.2	23.4
Shaft diameter	D	12.6	12.6
Stator yoke thickness	Hs	6.3	4.8
Mover cylinder's thickness	Hm	6.3	5.4
Stator slot depth	Hslot	12.4	15
Stator pole width	Wp	9.0	9.8
Stator ferromagnetic ring thickness	Lsr	5.0	5.0
Stator spacer ring thickness	Lss	8.0	8
Mover tooth ring thickness	Lmr	5.0	5.0
Mover spacer ring thickness	Lms	8.0	8.0
Air gap thickness	g	0.2	0.2
Mover laminated thickness	L	65.0	65

The stator poles are set on the plane where the magnetic flux paths surround, so the amount of stator poles has a great influence on the value of flux linkage and the formation of flux path, thus affecting the performance of the TSRLM. In the meanwhile, shorter magnetic flux path has smaller reluctance, which increases the thrust-to-volume ratio. That is to say, the machine with more poles may have better performance for its shorter flux path and smaller reluctance. But actually, the numbers of the stator poles also decides the size of the area of stator slot, thus affecting the turns of coils which has great influence on the performance of the motor. The machine with fewer poles will reserve more space for the stator slot, which means there can be more turns of coils. Taking into account many of these factors, the TF-TSRLM with 4 poles is proposed in this paper. The initial dimensions of the TSRLM are presented in Table I.

Sensitivity Analyses

The initial geometric dimensions proposed in the former part are not accurate enough. Further optimization should be conducted to obtain the most appropriate structure with the ideal performance. As a result, sensitivity analyses on different stator yoke thickness, mover cylinder's thickness, stator pole width and stator ferromagnetic ring width are carried out in this section to obtain the optimal parameters which contribute to the largest electromagnetic thrust.

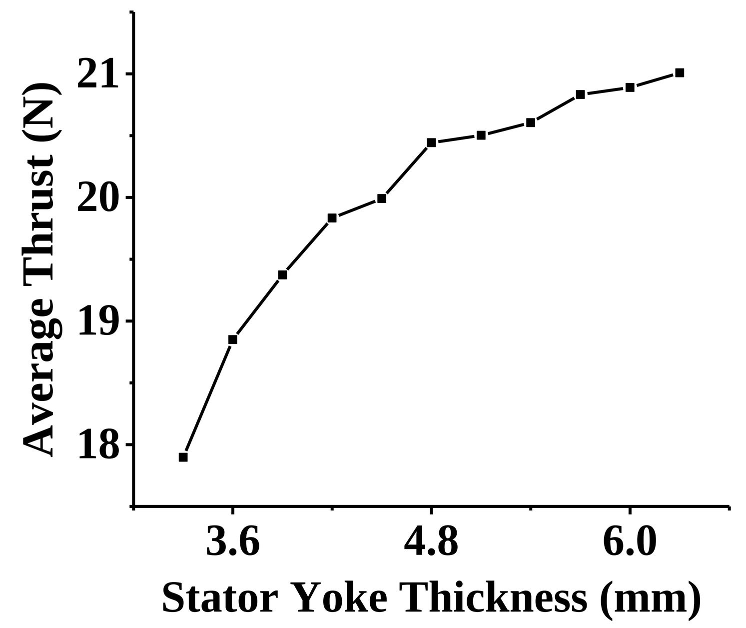

Fig.2.Different stator yoke thickness.

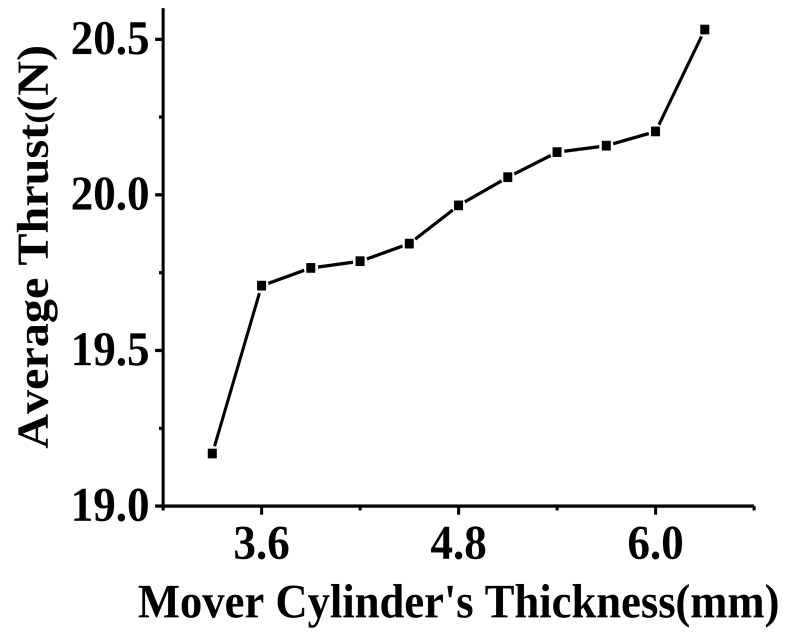

Fig.3.Different mover cylinder's thickness.

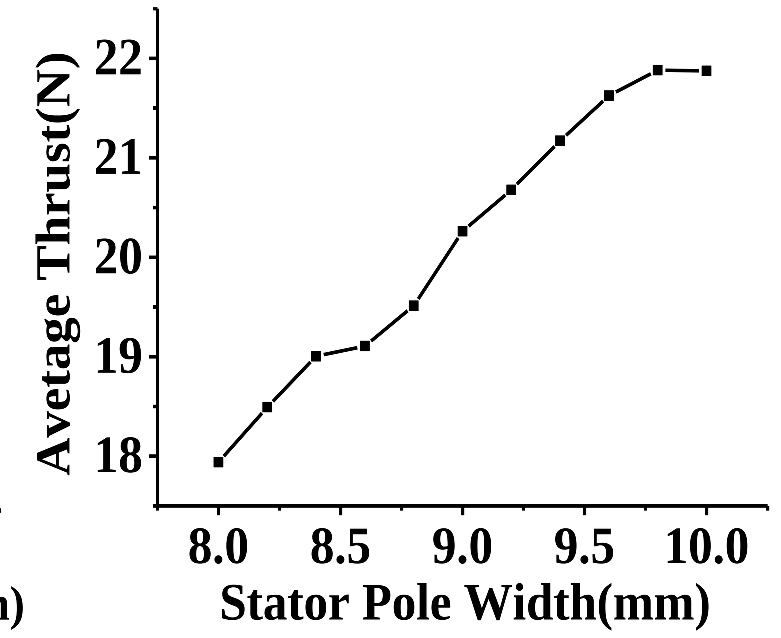

Fig. 4. Different stator pole width.

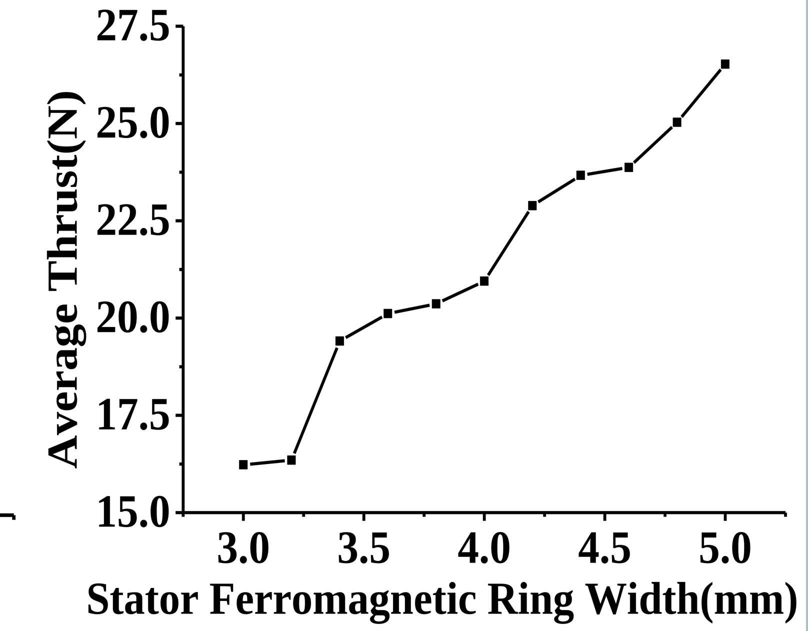

Fig.5.Different stator ferromagnetic ring width

TSRLM with New Winding Mode

In the analysis process, we found that the space for placing windings is limited by two slots. One slot is between two stator poles which is on the cross section. The other slot is between two stator ferromagnetic rings which is on the longitudinal section. Owing to the limitation of processing technology, the slot filling rate of motor with small volume usually can not exceed 0.7. Enhancing the space utilization rate of the machine is a good way to improve the performance of machines. In this section, a new windings mode is proposed which is shown in Fig. 6.

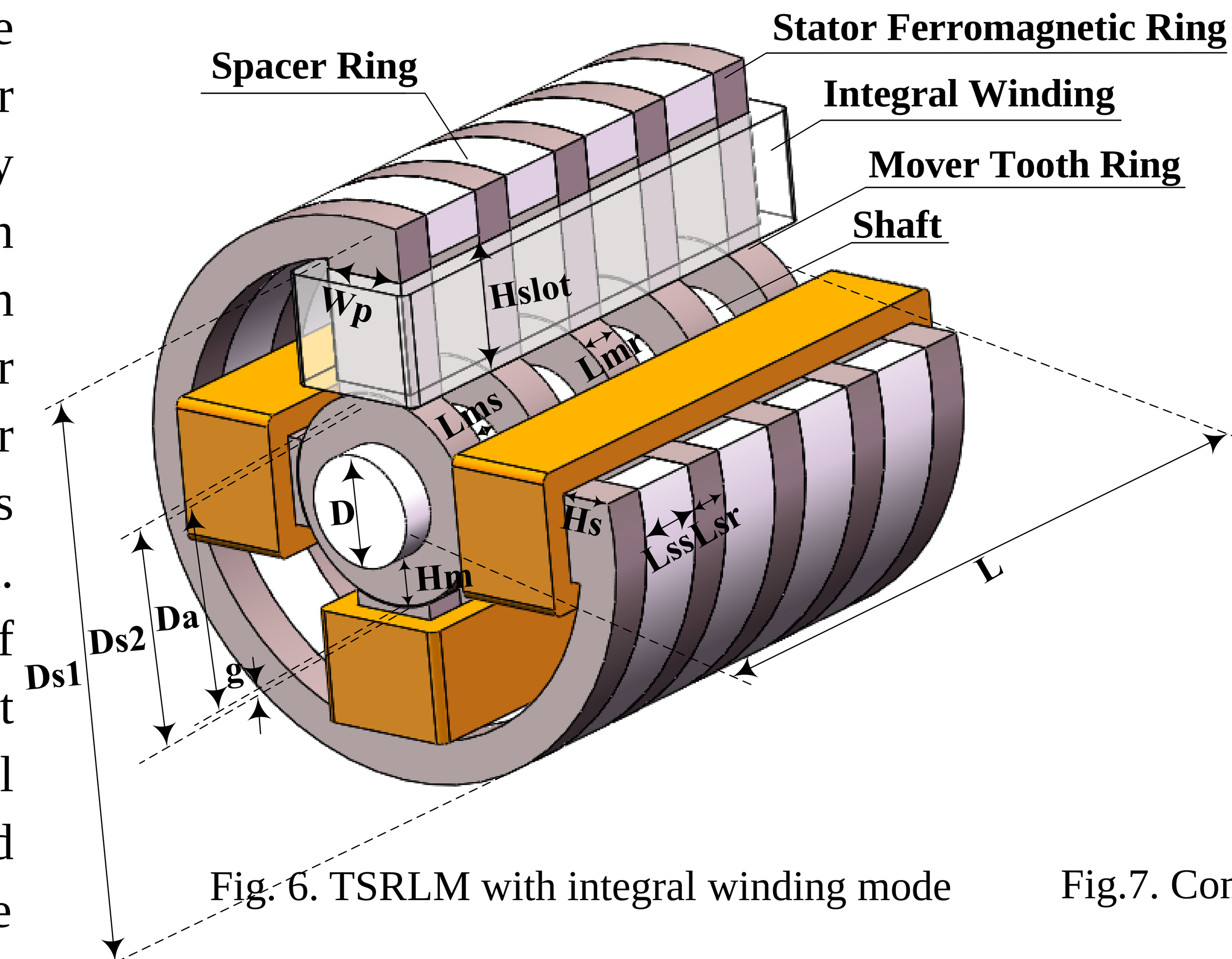

Fig. 6. TSRLM with integral winding mode

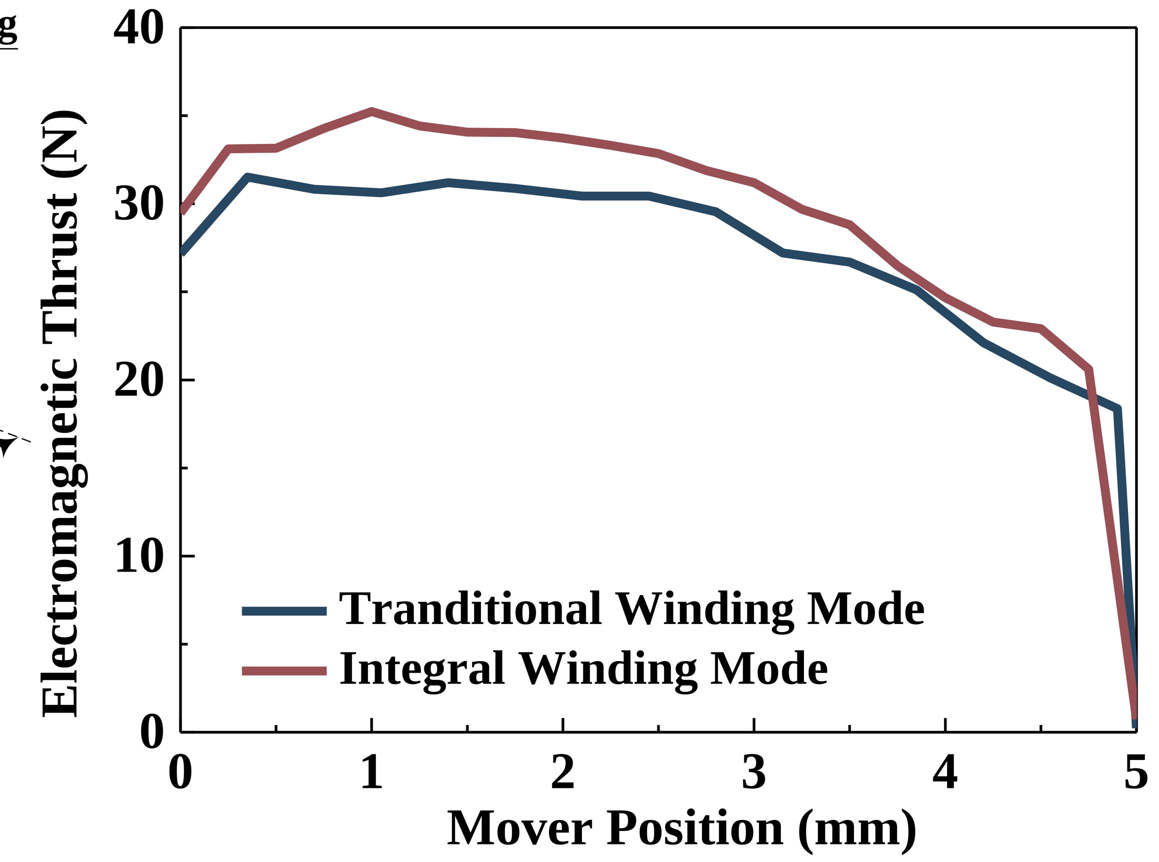

Fig.7. Comparison on electromagnetic thrust with different winding modes

Conclusions

This paper introduces a TSRLM with four stator poles. In order to enhance the electromagnetic thrust of this machine, the sensitivity analyses on different stator yoke thickness, mover cylinder's thickness, stator pole width and stator ferromagnetic ring width of TSRLM via 3D FEM are conducted. The structures and final geometric dimensions of TSRLM are presented. A new winding mode is proposed and it is compared with the classical TSRLM in performance. The average thrust of the TSRLM with integral winding mode is 28.948N, which is larger than that of the classical one with 26.03N. Thus, the integral winding mode is selected. It is considered as a promising structure that can be researched further in future studies.