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A Novel Tubular Permanent Magnet Linear Generator (Wed-Mo-Po3.05-10 [36])

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Abstract----A novel single phase tubular permanent magnet linear generator (TPMLG) for Stirling engines is proposed in this paper. It has a bread type winding, which has no cutting. The structure and operation of the generator are illustrated in detail One of the structural advantages of this generator is that it is easy to control. The three-dimensional finite element (FE) model of proposed TPMLG is established. The model and its boundary conditions are presented. Through the FE model, its electromagnetics analysis is carried out. The performance of this generator under reciprocating frequency 75Hz is investigated and analyzed. The advantages of the generator that it has high-power density are shown out with simulation results.

Structure

The TPMLG comprises an outer-stator, an inner-stator and a mover, and they are mounted in a cylinder. The winding coils are wound in a ring shape and placed in the slot of the outer-stator.

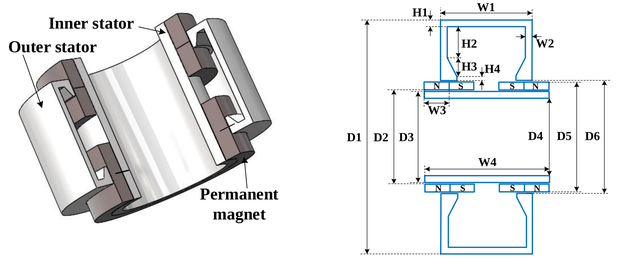
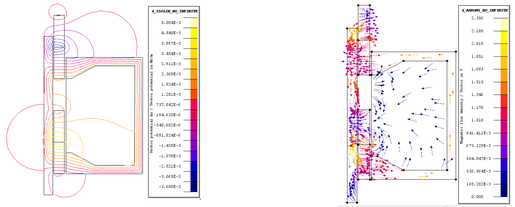


Fig. 1. Structure of the proposed TPMLM

Table I Dimensions of Proposed TSRLM

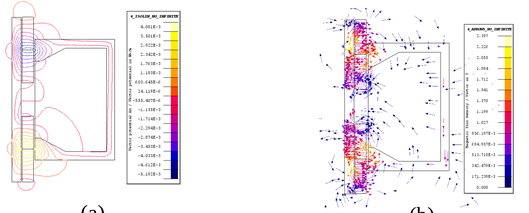
Parameters	Dimensions	Parameters	Dimensions	Parameters	Dimensions
D1	80.0mm	D6	51.0mm	W1	22.0mm
D2	46.4mm	H1	1.5mm	W2	1.6mm
D3	46.0mm	H2	7.5mm	W3	6.0mm
D4	42.6mm	H3	4.5mm	W4	30.0mm
D5	50.4mm	H4	1.0mm		

Electromagnetic Field Computation



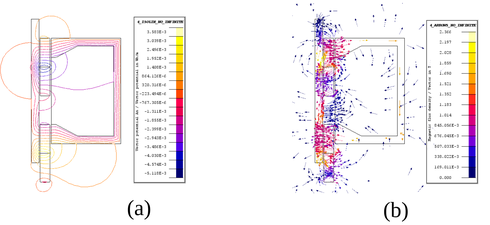
(a) (b)

Fig. 2. Isolines of magnetic vector potential and distribution of flux linkage when mover is located at -4mm. (a) Isolines of magnetic vector potential (b) Distribution of flux linkage



(a) (b)

Fig. 3 Isolines of magnetic vector potential and distribution of flux linkage when mover is located at 0mm. (a) Isolines of magnetic vector potential (b) Distribution of flux linkage



(a) (b)

Fig. 4 Isolines of magnetic vector potential and distribution of flux linkage when mover is located at 4mm. (a) Isolines of magnetic vector potential (b) Distribution of flux linkage

Performance Analysis

The static analyses, including the isolines of magnetic vector potential and the distribution of flux linkage, are conducted in the two-dimensional FE model in order to save electromagnetic field computation time. for achieving more accurate calculation results in dynamic performance, the1/4 three-dimensional FE model is also established.

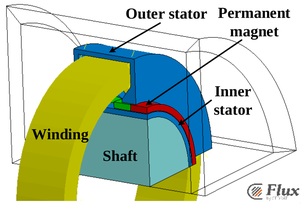


Fig. 5 Three-dimensional FE model

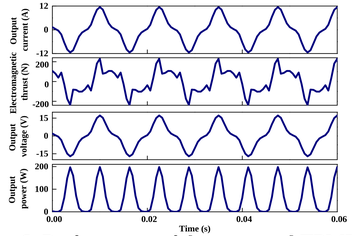


Fig. 6. Performance of the proposed TPMLG.

Table II Performance Summary

Performance	Values
Weight (g)	853.8
Mass of iron core (g)	401.0
Mass of Nd-Fe-B (g)	56.9
Mass of aluminum (g)	115.4
Mass of copper (g)	280.5
Voltage RMS (V)	12.2
Current RMS (A)	8.1
Average power(W)	98.9
Average power per unit mass (N/ kg)	115.8

With the FE model, the weight of the iron core of outer-stator, inner-stator, coils of copper, mover with four permanent magnets and the support shaft are calculated thoroughly. The total weight of this TPMLM is around 853.796 g. When the reciprocating frequency is set as 75Hz, the voltage virtual value is 12.181V, and the current virtual value is 8.12A. The average power is about 98.911W. The average power per unit mass of proposed TPMLG is around 115.848W/kg. With these simulation data of the TPMLG, it is shown that the generator can generate certain power with less weight and material. The proposed TPMLG can realize power generation with high-power density so that it can be used as the generator in the Stirling engine. Its performance at reciprocating frequency 75Hz.

Conclusion

A novel single phase tubular permanent magnet linear generator for Stirling engines is proposed in this paper. Its structure and dimensions are presented, and its operation principle is introduced and analyzed by two-dimensional FEM. The boundary conditions of the electromagnetic field computation is given briefly. Meanwhile, in order to accurately analyze the dynamic performance of the Proposed TPMLG, a three-dimensional FE model is established. The dynamic electromagnetic field computation results show that the proposed TPMLG can realize power generation with high-power density. Therefore, it can be used as the generator in the Stirling engine.