Nowadays, linear induction motor (LIM) has been widely used in rail transit, but the efficiency and power factor of the LIM are rather low; linear permanent magnet synchronous motor has the advantages of high efficiency, high power density, small volume, good performance and so on, but the armature windings and PMs of traditional linear permanent magnet synchronous motor respectively arranged in different sides, which one of sides must be along with the track. Therefore, manufacturing and maintenance costs are high, and the applications in long distance rail traffic are limited.

Objectives

- Structure requirement: Both the permanent magnet and the windings are in the primary side.
- Performance requirement: Good no-load characteristics will be obtained.

The primary (Short side) consist of a primary core made of silicon steel sheets, three-phase armature windings and PMs. The pole number of the armature winding is 2p, the pole number of the permanent magnet is 2p, and the two magnetic fields are matched by different poles. In order to facilitate windings, the primary iron core is designed with a half closed slot, and the permanent magnet is attached to the surface of the primary tooth.

The secondary are composed of magnetic layers and magnetic obstacle layers. This kind of secondary structure can cause flux to flow along paths conducive to electromechanical energy conversion. The polar arc factor is defined as length lambda 1 divided by length lambda 2, and the electromechanical coupling ability of the motor can be adjusted by changing the polar arc coefficient.

The air-gap permeance can be approximately represented as:

$$\lambda_1 (x,t) = \lambda_1 + \lambda_2 \cos[N \frac{2 \pi x}{L_p} - \frac{\pi}{2} (x - a_1 - a_2)]$$  \hspace{1cm} (1)

In the formula(1), \( \lambda_1 \) is the mean value of air gap permeance, \( \lambda_2 \) is order harmonic amplitude, \( N \) is the number of secondary convex pole, \( L_p \) is primary length, and \( \lambda_0 \) is initial position and \( V_t \) is the motor speed.

The magnetomotive force generated by the permanent magnet can be approximately represented as:

$$F_{PM}(x,t) = \frac{4 B_0 R_{PM} L_p}{\mu_0} \cos[p \pi x/L_p]$$  \hspace{1cm} (2)

Where \( B_0 \) is the residual magnetism of permanent magnet, \( h_0 \) is the thickness of permanent magnet, \( R_{PM} \) is the number of permanent magnet pole-pairs and \( \mu_0 \) is vacuum permeability.

Thus, the air gap flux density can be expressed as:

$$B_{g}(x,t) = F_{PM}(x,t) - \lambda_1 (x,t)$$

The third term in the formula(3) is chosen as the effective harmonic component of the LPPMSM.

$$B_{g}(x,t) = F_{PM}(x,t) - \lambda_1 (x,t)$$

The pole-pairs of the armature winding is

$$q = \left| P_{PM} - N \right|$$

Study on Design of a Novel Magnetic Field Modulation Linear Primary Permanent Magnet Synchronous Motor

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Background

- A novel magnetic field modulation linear primary permanent magnet synchronous motor (LPPMSM) has been proposed.
- In order to improve further capability of magnetic field modulation, the hybrid secondary structure has been used.
- The linear primary permanent magnet synchronous motor is carried out by 2D FEM, and the electro-magnetic characteristics of LPPMSM at no-load condition are obtained by 2D FEM.

Conclusion

- The air-gap permeance can be approximately represented as:

$$\lambda_1 (x,t) = \lambda_1 + \lambda_2 \cos[N \frac{2 \pi x}{L_p} - \frac{\pi}{2} (x - a_1 - a_2)]$$  \hspace{1cm} (1)

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Results

- The polar arc factor is defined as length lambda 1 divided by length lambda 2, and the electromechanical coupling ability of the motor can be adjusted by changing the polar arc coefficient.

- The air-gap permeance can be approximately represented as:

$$\lambda_1 (x,t) = \lambda_1 + \lambda_2 \cos[N \frac{2 \pi x}{L_p} - \frac{\pi}{2} (x - a_1 - a_2)]$$  \hspace{1cm} (1)

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