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# Wed-Mo-Po3.12-10 [105]: Design and Analysis of a Magnetless Linear Variable Reluctance Motor with Modular Mover Units for Electric Propulsion

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Due to its stator robustness and the substitution of permanent magnets by DC field windings, the magnetless linear variable reluctance motor (MLVRM) possesses several advantages: high reliability, low cost and flexible flux regulation capability, which is a good candidate for rail transit applications. However, the MLVRM is essentially a doubly-salient machine, so there exists a drawback of large force ripples.

In this paper, a MLVRM with $n$-module mover units is proposed to suppress the force ripples. The proposed motor consists of a stator and a mover with $n$-module mover units. The stator is constructed with laminated iron core only, while each modular mover unit consists of armature windings, DC field windings and laminated iron core.

In order to suppress the force ripples and attain the highest back electromotive (EMF), two design conditions must be followed:

$d = (k + \frac{1}{n})\tau_s$, $k \geq 0$ and $n \geq 2$. Where $d$ represents the distance between two adjacent mover units; $\tau_s$ denotes the stator pole-pitch; $n$ indicates the number of the mover unit; $k$ is an integer.

$\alpha_1^i = \frac{i-1}{n}360°$, $i = 2, 3...n$. Wherein, $\alpha_1^i$ represents the position between the $i$th mover unit with the first one, which is expressed in electrical angle. When $0° \leq \alpha_1^i \leq 90°$ or $270° < \alpha_1^i \leq 360°$ , the connection of the armature windings in the $i$th mover unit is the same as that in the first one. When $90° < \alpha_1^i \leq 270°$ , the connection of the armature windings in the $i$th mover unit is the opposite to that in the first one.

In this paper, the utilization rate (UR) of the $n$-module mover units will be defined to measure the level at which the motor attains the highest back EMF. MLVRMs with $n$-module mover units ($n \geq 2$) are quantitatively evaluated by the finite element method. The anticipated results of the proposed MLVRM will possess a remarkable effect in reduced force ripples. In addition, the paper describes the process to optimize the number of modular mover units ($n$) for the proposed MLVRM capable in both suppressing force ripples and achieving a higher UR.

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