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Analytical Modeling and Experimental Verification for Electromagnetic Analysis of Permanent Magnet Linear Synchronous Machines with Horizontally Magnetized Permanent Magnets accounting for Flux-Passing Iron Pole

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Permanent magnet linear synchronous machines (PMLSMs) are able to provide thrust force directly to the load without mechanical gears and transmission; therefore, they have significant advantages over rotary machines, such as simplicity and high efficiency. Generally, PMLSM uses vertically magnetized permanent magnets (PMs). However, we proposed a PMLSM with horizontally magnetized PMs, which is very advantageous in terms of weight because there is no back core to make magnetic flux. As is well known that the detailed knowledge of the magnetic field distribution in air gap is vitally important for design and optimization of PMLSMs. Although numerical tools, such as finite element method (FEM), are able to offer precisely field prediction, they can provide neither closed-form solution nor physical insight. Analytical methods are useful for the first evaluation of machine performances and for design optimization since continuous derivatives, which are issued from the analytical solutions, are required during most optimization methods. However, it is difficult to gain insight into the influence of the design parameters on the machine performance of PMLSM with horizontally magnetized PMs through analytical solutions due to magnetically complex PM mover structures. In this study, an exact analytical solution based on a Fourier analysis is proposed to compute the electromagnetic performance in PMLSMs with horizontally magnetized permanent magnets. By using the separation-of-variables technique, we obtain the analytical solutions to Poisson's equations in the PM and slot subdomains (magnetization or current density regions) and Laplace's equation in the air-gap and end subdomains. From these solutions, the electromagnetic performance is also determined. The validity of the analytical method presented in this paper is verified by comparing it with the results of FEM and experiment. The analytical modeling, analysis results, and measurements will be presented in more detail in the full paper.

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