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Design and Analysis of a Novel Large Mover Slot Opening Flux-Reversal Linear Permanent Magnet Machine with HTS Bulks

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The flux-reversal linear permanent magnet machines (FRLPMs) have the features of high thrust density, high efficiency and robust stator structure, which make it a suitable solution for linear traction motors, wave energy generators and linear servo motors. But the FRLPMs suffer from the doubly-salient structure and thus it is hard to further improve the flux-linkage and the thrust density of the machine. In this paper, in order to improve the thrust density of the machine, a novel flux-reversal linear permanent magnet machine with consequent-pole permanent magnets and high-temperature superconducting (HTS) bulks is proposed. The permanent magnets (PMs) are mounted on the teeth top of the mover and the HTS bulks are mounted on the stator slot, between every two adjacent stator teeth. Only half of the teeth top of the mover is inset by the PM and all the PMs have the same polarity, which is so-called consequent-pole PMs. The HTS bulks can shield the flux leakage and strengthen the modulation effect of the stator teeth. Moreover, the consequent-pole structure can reduce the usage of PMs and further improve the flux-linkage of the armature windings. In other words, the flux density of the machine can be improved with the combination of consequent-pole PMs and HTS bulks, which results in the improvement of the thrust density. The analytical expressions of magnetic motive force (MMF) excited by the PMs, the air-gap flux distribution and the back electric motive force (back-EMF) will by derived in the paper. Finite element method (FEM) will be employed to verify the superiority of the proposed machine. It can be seen from the FEM results that the thrust density of the proposed FRLPM can be improved by 31% compared to the regular FRLPM.

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