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Wed-Mo-Po.05-01: Winding Configuration of REBCO Fully Superconducting Linear Synchronous Motor for Launch System for eVTOL

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Electric Vertical Takeoff and Landing (eVTOL) aircraft is attracted as a new means of transportation. The vertical takeoff consumes much amount of energy, leading the limitation of range and payload. To address this problem, we proposed a new method of takeoff by using a launch system for eVTOL with fixed wings. The eVTOL is accelerated by a linear motor mounted on the system. When the eVTOL reaches takeoff speed, the fixed wings generate lift force to take off. Since the system is assumed as installed at narrow space such as rooftop of the building at downtown, it should be designed as small size and lightweight. Thus, we propose applying the fully superconducting linear synchronous motor for the system. Both the stator and mover windings consist of REBa₂Cu₃O_y (REBCO) wires.
The REBCO windings can generate high magnetic field without iron cores owing to its high critical current property, realizing lightweight design of machines. The distribution of the magnetic field generated by the air-cored windings strongly depends on the winding configuration, thus the optimization of the winding configuration is the key of designing the motor. Without the optimization, the field contains spatial harmonics and this causes some problems as follows. One of those is the thrust ripple that can lead velocity fluctuation, vibration, and noise pollution. Furthermore, the harmonics causes increasing of the AC loss is generated. To prevent these problems, we design the winding configuration for both the stator and mover windings.
The REBCO wire is tape-shaped, and its critical current deteriorates if it is curved in the edgewise direction or twisted. Thus, the REBCO windings in the motor are composed of racetrack coils to avoid deterioration of the critical current. The stator windings are used as the armature windings generating a moving magnetic field by energizing by three phase AC power supply. The mover windings are used as the field windings generating a constant magnetic field. To generate an ideal field distribution without harmonics, the currents of each winding should be distributed as an ideal sinusoidal waveform spatially. However, the spatial distribution of the current is discrete corresponding to the positions of the wires composing the racetrack coils. Hence, based on the pulse width modulation technique, we set the positions of the REBCO wires so that it imitates sinusoidal distribution. We applied this configuration both for armature and field windings. In this study, the effectiveness of such configuration for the motor properties is investigated from the viewpoint of the reduction of thrust ripple and AC loss. The motor properties are calculated by electromagnetic analysis based on finite element method.

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