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Development and Validation of Cylindrical Linear Oscillating Generator

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Abstract : This paper presents a linear oscillating generator of cylindrical type for hybrid electric vehicle application. The focus of the study is the suggestion of the optimal model and the design rule of the cylindrical linear oscillating generator with permanent magnet in the back-iron translator. The cylindrical topology is achieved using equivalent magnetic circuit considering leakage elements as initial modeling. This topology with permanent magnet in the back-iron translator is described by number of phases and displacement of stroke. For more accurate analysis of an oscillating machine, it will be compared by moving just one-pole pitch forward and backward the thrust of single-phase system and three-phase system. Through the analysis and comparison, a single-phase system of cylindrical topology as the optimal topology is selected. Finally, the detailed design of the optimal topology takes the magnetic saturation effects into account by finite element analysis. Besides, the losses are examined to obtain more accurate results; copper loss in the conductors of machine windings, eddy-current loss of permanent magnet, and iron-loss of specific material of electrical steel. The considerations of thermal performances and mechanical robustness are essential, because they have an effect on the entire efficiency and the insulations of the machine due to the losses of the high temperature generated in each region of the generator. Besides electric machine with linear oscillating movement requires a support system that can resist dynamic forces and mechanical masses. As a result, the fatigue analysis of shaft is achieved by the kinetic equations. Also, the thermal characteristics are analyzed by the operating frequency in each region. The results of this study will give a very important design rule in the design of linear oscillating machines. It enables us to more accurate machine design and more accurate prediction of machine performances.

Keywords : equivalent magnetic circuit, finite element analysis, hybrid electric vehicle, linear oscillating generator
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