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Design method of an ultra-high speed PM Motor/Generator for Electric-Turbo Compounding System

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In various industries, ultra-high speed motor is actively studied and developed for diverse industrial applications like generators/starters for micro gas turbines, turbo-compressor, vacuum pump and turbine generator. Electric Turbo Compounding System (E-TCS), which operates with motor/generator unit at a very-high speed, is the most realistic alternative technology that can respond to fuel efficiency regulation by applying an electrical system to the existing turbocharger. In the low-speed region where the exhaust gas energy in the turbocharger is insufficient, the motor assists the compressor to improve the dynamic characteristics and output of engine, whereas in the high-speed region where the energy of the exhaust gas remains, it operates as a generator and produces electrical energy with excess exhaust gas energy and improves system energy efficiency. This paper presents the design of an ultra-high speed PM motor driven by 10kW at the rated speed 70,000 rpm and the maximum speed 100,000 rpm for applying E-TCS. In this paper, Response Surface Method (RSM) and Finite Element Method (FEM) are used to perform the optimal design of PM motor. For operating at the ultra-high speed, the design of PM motor should be considered the mechanical and structural safety of rotor and losses for the high efficiency. Therefore, the objective function of RSM are the secureness of mechanical and structural safety of rotor and the minimum of losses, occur at the rotor and sleeve. Furthermore, this paper presents the design of the sleeve according to the materials. As the results, the optimal design method of PM motor, using carbon fiber is proposed to not only reduce the eddy-current loss, prominently occur at very-high speed, but also ensure the structural safety. Finally, experiment is performed to verify the validity of the proposed design method and effectiveness of the PM motor, fabricated as a prototype.

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