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Development of an iron powder metallurgy soft magnetic composite core switched reluctance motor

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ABSTRACT - Soft magnetic composite (SMC) material and SMC electromagnetic devices have undergone a significant development in the past decade. Much effort has been carried out on designing and prototyping different types of electrical machine. The basis for soft magnetic composites is bonded iron powder and the powder is coated, pressed into a solid material using a die. However, it has the drawback that the properties will in most cases be different from those obtained from compaction and machining process. To investigate "pre-fabricated SMC blank" products, this paper presents the design and analysis of a switched reluctance (SR) motor with a pre-fabricated SMC blanks of low mass density to replace the existing induction motor in a dishwasher pump. This can be fast and low cost approach is to machine the component from a preform blank. Finite element analysis (FEA) study has been conducted to accurately determine key motor parameters, and performance predictions are validated by the experimental results on the prototype model.

Keywords: prototyping material; Somaloy; Soft Magnetic Composite (SMC); Switched Reluctance Motor (SRM)

Pre-fabricated SMC core and prototype motor

Three pieces of pre-fabricated SMC blanks (Somaloy1000 3P) each for stator and rotor are considered and to fabricate stator and rotor these three pieces have to be bonded together using epoxy glue. The bonded stator and rotor blank has been subjected to precession machining to yield the stator and rotor of design dimensions.

Conclusion and discussion

The following inferences are observed from the measured dynamic characteristics of SMC prototype machine: The prototype provides a stable output on a full operating range, even though the problems of large magnetizing current and inferior magnetizing curve with lower μr-max values of 850. The dynamic performances are fully dependent on the nature of the stator core and losses of the machine. It is also revealed that during the dynamic operating condition, the initial current drawn by the SMC machine is higher due to the requirement of higher level of magnetization energy in bulk material than in laminates for a cycle of the source frequency. The comparative analysis of measured temperature rise values of the SMC prototype machine and simulation results shows: the SMC machine temperature rise is lesser than conventional machine. This is due to the SMC stator core is a smooth surface that allows a good thermal contact between the winding and the core assembly. Moreover this lead to more efficient electromagnetic coupling as well as more efficient heat transfers ability and cooling capability. This enhances the thermal limit of the SMC prototype motor. The comparative analysis of measured vibration frequencies of the SMC prototype machine and FEA results of natural mode shape frequencies of stator and rotor shows: the marked reduction in the natural frequencies of the stator and rotor assembly of SMC machine due to the cushioning nature of the insulation binder which has a very good viscous-elasticity property and iron powder cores would present a higher damping factor in the radial and circumferential directions compared to a similar laminated structure. As observed from the measured vibration spectrum, only two mode frequencies (mode 2 and mode 4) are dominant in the spectrum and other mode frequencies are suppressed since the acceleration particles in the SMC stator structure are evenly distributed due to the distributed insulation around the iron particles.