Introduction—The research work for a novel dual-stator composite-rotor synchronous machine (DSCRSM) will be introduced. Compared with the conventional permanent magnet-assisted synchronous reluctance machine (PMASynRM), the proposed DSCRSM is capable to provide a higher output torque when the same amount of ferrite magnets consumed. The electromagnetic torque of the DSCRSM is consisted of two components, namely, magnetic and reluctance torques, while the superiority of the DSCRSM is obtained by the utilization of a composite rotor that is capable of full use of the torque components. To evaluate the contribution, Finite element method (FEM) is utilized to investigate the torque performances for both PMASynRM and DSCRSM with the same amount of ferrite magnets.

Modeling of DSCRSM

A conventional PMASynRM with U shape flux barriers is designed as the referenced model shown in Fig.1 (a). The electromagnetic torque of PMASynRM consists of two components, namely, PM torque and reluctance torque. Based on machine operation principles, torque characteristics of a conventional PMASynRM is as presented in Fig. 1 (b).

The proposed DSCRSM is shown in Fig. 2 (a). Dual-stator structure is used for the machine, while the three phase winding of outer stator are in series connection with the corresponding phase winding of inner stator.

Composite rotor (Fig.2 (b)) is formed by the outer rotor component with flux barriers and the inner rotor component with ferrite magnets mounted. Magnetic isolation is placed between the two rotor components.

Torque Characteristics by FEM

The torque characteristics of both the referenced PMASynRM and the proposed DSCRSM are investigated by Finite element method (FEM), while the results are given in Fig. 3. It is worth noticing that the same amount of ferrite magnet is consumed by the two machines in this study. The windings of both machines are powered by the same rated sinusoidal current (phase current amplitude: 22 A) and operating at rated speed (1500 rpm). It is found that PM and reluctance torque components of the DSCRSM reach their peak values near the same current phase angle. Compared to the referenced PMASynRM, the maximum output torque of the DSCRSM is increased by 19.6% when consuming the same amount of ferrite magnets.

Torque performance comparison

Fig.4 shows the torque waveforms for the two machines. The torque ripple factor for PMASynRM is 38.2%, while it is reduced to 22.7% for the DSCRSM. Figure 5 further presents the back EMF waveforms for the two machines.

Conclusions

Compared with the PMASynRM consuming the same amount of ferrite magnets, the maximum output torque of the proposed DSCRSM is increased 19.6% by full utilization of the machine torque components. Moreover, torque ripple of the developed DSCRSM is also obviously reduced. Therefore, the proposed DSCRSM exhibits higher average torque output capability with lower torque ripple.