Motor Development For Electric Drive Systems

Tutorial 5

Switched Reluctance Machines

A four-pole, three phase switched reluctance motor with 7.5 kW rated output power at 1500 rpm (3000 rpm maximum speed) has a rated current of 12 A (rms-value) per phase for temperature class B. The maximum inverter output current is 30 A, the supply voltage is 400 V at 50 Hz. The motor is fan-cooled with a ribbed housing like a standard inverter motor. The following main dimensions have been chosen:

Stator outer/inner diameter 209.5 mm/120.9 mm; stator core length 193 mm; air gap δ = 0.45 mm; number of stator/rotor teeth 12/8; stator/rotor tooth width 16.0/16.7 mm; stator/rotor tooth height 30.5/19 mm; number of turns per coil 61; series connection of all coils; round wire diameter 1.8 mm; coil width/height 9/22.5 mm.

1) Calculate the ratio of peak to r.m.s. current at 120° current flow duration and ideal block current shape.

2) Calculate the coil resistance at 20°C and at maximum temperature for temperature class B, according to VDE 0530/1. The end winding length is 43 mm.

3) Determine the direct- and quatrature-axis inductivity for the non-saturated machine using the *CARTER*-model.

4) Calculate the internal torque at low speed with 120° block current supply from the change of the magnetic coenergy, if the flux linkage of the *d*-axis of the saturated machine has the following charateristic: 5A/0.69Vs, 10A/1.1Vs, 15A/1.25Vs, 24A/1.38Vs, 30A/1.43Vs. Use the data for 15A/1.25Vs and 30A/1.43Vs to linearize the characteristic. In the highly saturated area *d*- and *q*-axis flux linkage shall be parallel to each other. Use this data to determine the internal torque at maximum inverter output current and at rated motor current.

5) Check the results from 4) for rated speed (1500 /min), if the measured total losses are 1220 W and if temperature class B is fully exploited. Calculate the electric loading ("current layer") *A*, the current density *J* and the product $A \cdot J$ and compare it with that of standard induction motors of similar size, temperature class and number of poles (electric loading ca. 300 A/cm, current density ca. 7.5 A/mm^2).

6) Estimate the current rise time and assess the maximum speed for pulse control operation. (guide value: current flow time > 10 times the current rise time)