Motor Development For Electric Drive Systems

Tutorial 7

Induction motor, fed by a voltage source inverter

For an electric vehicle application, an induction motor with a voltage source inverter has to be designed. The battery delivers 120 V and 200 A. The motor is connected to a single-stage gear box and shall provide 14 kW rated power at 1600 min^{-1}. Temporary (2 min.) 20 kW output power is requested. The motor shall operate in constant power mode between 1600 min^{-1} and 5500 min^{-1}.

The following motor with water jacket cooling has been chosen:
Stator outer/inner diameter: 180/114.5 mm, length of stator iron core: 165 mm, number of poles: 4, single layer winding, number of stator/rotor slots 36/28, aluminium diecast cage, stator slot fill factor: 42%, stator slot cross section: 80 mm^2, air gap 0.5 mm, *Blondel* leakage coefficient $\sigma = 0.1$.

1) At its voltage limit, the inverter operates with block shape voltages to provide a maximum possible fundamental harmonic. What is the number of turns per phase if the air gap flux density (fundamental wave) is aspired to be 0.9 T at rated speed?

2) Determine the rated and maximum torque at rated speed. What is the apparent inverter output power? (Estimate reasonable values for both efficiency and fundamental harmonic power factor) Is the maximum battery current sufficient for maximum torque at rated speed?

3) Calculate the *ESSON* coefficient of this motor. What are the values of current layer and current density for this motor? Are these values permitted for water jacket cooled motors?

4) Determine the magnetizing inductance L_h, the leakage inductance L_σ and the breakdown torque M_b at rated speed. (Assume that the total magnetization is 1.5 times that of the air gap magnetization!)

5) What is the maximum speed for constant power operation with 20 kW and 14 kW? Draw the $P(n)$-diagram for rated power within a speed range of 0..5500 min^{-1}.

6) Estimate the harmonic currents up to the 13^{th} harmonic. Neglect the influence of ohmic resistance, take only inductances into consideration. What are the additional ohmic losses in the stator compared to the ohmic losses of the fundamental current?