Principles and Components of Power Electrical Engineering

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This part consists of 2 pages

Short questions

1. A transformer designed to have its primary connected to a 110V power supply is connected to a 220V supply. Assuming no permanent damage occurs, describe any consequences this might have on the transformer operation.

2. When designing electrical devices such as transformers, electrical machines, or electrical energy transport systems, manufacturers often impose a maximum current density. What (non-electrical) phenomenon is meant to be limited by this practice? On a more practical level, what physical parameter is determined?

3. A single-phase transformer operating at an apparent power of 10kVA supplies a motor and a radiator. The motor consumed 5kW of active power and 5kVAR of reactive power. How much power does the radiator consume? Show your reasoning/work.

4. A direct-current motor is supplied at 100V and 10A. The motor turns a mechanical load at a speed of 90 rad/s with a torque of 10Nm. The motor's rotor winding has a resistance of 0.9ohm. What can you say about the power balance of the system? Where is the missing power being dissipated?

5. Describe three advantages that a three-phase electrical system has over a single phase system.

Problem n°1

A DC machine with a rotor winding resistance R_a = 0.6 ohm and a field winding resistance R_{fw} = 0.4 ohm is to be used as a motor to power a fan. When the motor is powering the fan and is supplied by a DC source at 220V, it draws 33,3 A and turns at a speed of 700 rpm. The magnetic circuit can be considered to behave linearly and the mechanical and magnetic losses may be neglected.

1. Calculate the counter-emf E and the voltage constant $k\Phi$.

2. Calculate the power and torque delivered to the fan, and the efficiency of the motor neglecting any losses in the field windings.

3. Knowing that the field windings are supplied at a voltage of 13.3V, calculate the value of the constant K (where $k\Phi = KI_{fw}$), then calculate the overall efficiency of the motor.

4. The fan turns at 700 rpm when the torque calculated in part (2) is applied. The fan requires 7 N·m at startup and its torque is proportional to the square of its speed plus this constant value. We now want the fan to run at 500 rpm. Calculate the voltage needed to be applied to the rotor windings to maintain this speed.