

CAT 1: Electrical machine design

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April 20, 2025

Electrical Engineering Questions

1. Enumerate four desirable characteristics of a conducting material that can be used in electrical machine design. (4 marks)

- **High Electrical Conductivity:** This minimizes resistive losses and improves efficiency by allowing current to flow with minimal resistance.
- **High Thermal Conductivity:** This helps in dissipating heat generated during operation, preventing overheating and enhancing the longevity of the machine.
- **Mechanical Strength and Durability:** The material should be strong enough to withstand mechanical stresses and vibrations during operation without degrading.
- **Corrosion Resistance:** The material should resist oxidation and other forms of corrosion to maintain conductivity and structural integrity over time.
- **Low Cost and Availability:** The material should be affordable and readily available to ensure cost-effective manufacturing.
- **Lightweight:** A lower density material reduces the overall weight of the machine, which is essential for applications like electric vehicles and aerospace systems.
- **Flexibility and Malleability:** This allows easy shaping and winding, especially in the case of wire conductors.

2. What are the advantages and disadvantages of large air gap length in induction motor? (2 marks)
3. Using neat diagrams, differentiate between Oil natural-air forced (ONAF) and Oil forced-air natural (OFAN) methods of transformer cooling. (4 marks)
4. The ratio of flux to full load mmf in a 400kVA, 50Hz, single phase core type transformer is 2.4×10^{-6} . Calculate the net iron area and the window area of the transformer if the maximum flux density in the core is 1.3 Wb/m^2 , current density 2.7 A/mm^2 and window space factor is 0.26. Also, calculate the full load mmf. (7 marks)
5. Find the main dimensions of a 2500kVA, 187.5 rpm, 50Hz, 3-phase, 3kV, salient pole synchronous generator. The generator is to be vertical, water wheel type. The specific magnetic loading is 0.6 Wb/m^2 and the specific loading is 34000 A/m. Use circular poles with a ratio of core length to pole pitch = 0.65. Assume a winding factor of 0.955. (7 marks)
6. What is window space factor K_w as used in electrical machine design? (2 marks)
7. Design a DC shunt generator rated at 100kW, 220V, 4-pole, operating at 1500 rpm with a square pole face. Given: Specific magnetic loading, $B_{av} = 0.40 \text{ Wb/m}^2$, Specific electric loading, $q = 14000 \text{ A/m}$, Pole arc to pole pitch ratio, = 0.65, Full-load efficiency, $\eta = 0.90$. Determine the main dimensions (armature diameter D and effective core length). (6 marks)