EFFECT OF MOTOR DESIGN PARAMETERS ON COGGING TORQUE—PART 1

Major causes of noise in a motor are
- Electromagnetic phenomenon
- Mechanical structure
- Aerodynamic behavior

Causes for electromagnetic phenomenon:
- Cogging torque
- Unbalance magnetic pull
- Reluctance torque
- Commutation torque ripple
- Phase unbalance
- Input current distortion
- Magnetic saturation
- Magnetostriction

Cogging torque is one of the major electromagnetic sources for motor noise. Reducing cogging torque results in a quieter motor.

**Slot Per Pole Combination**

Optimal combination of slot per pole is one with:
- Fractional slot per pole
- Function 1 ($F_1$): Highest [Least Common Multiple (Slots, Poles)]
- Function 2 ($F_2$): Smaller \(\frac{\text{Poles} \times \text{Slots}}{F_1}\)

**Skewed Magnet / Magnetization**

- Skewing reduces the rate of change of reluctance seen by magnet flux
- The optimum skew angle for minimum cogging torque is Function 3 ($F_3$): \(\frac{360}{F_1}\)
- The optimum skew angle for 10-Slot/4-pole motor is $F_1=20$, $F_3=18^\circ$ mechanical

**Magnetization Profile**

- Preferred magnetization profile depends on selection of number of poles as well as magnet thickness
- Halbach magnetization is preferred in a motor with higher pole number and thicker magnet
- For magnet with fewer poles, radial magnetization with/without skew is preferred