EFFECT OF MOTOR DESIGN PARAMETERS ON COGGING TORQUE– PART 1

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

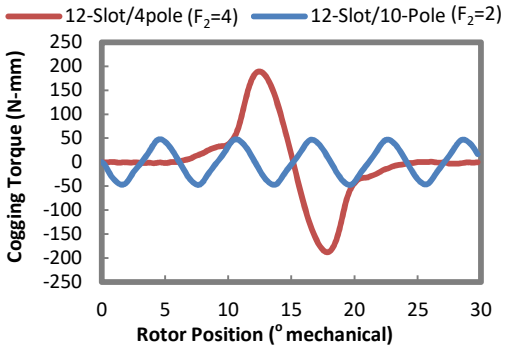
Causes for electromagnetic phenomeon:
- Cogging torque
- Unbalance magnetic pull
- Reluctance torque
- Commutation torque ripple
- Phase unbalance
- Input current distortion
- Magnetic saturation
- Magnetostriction

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:

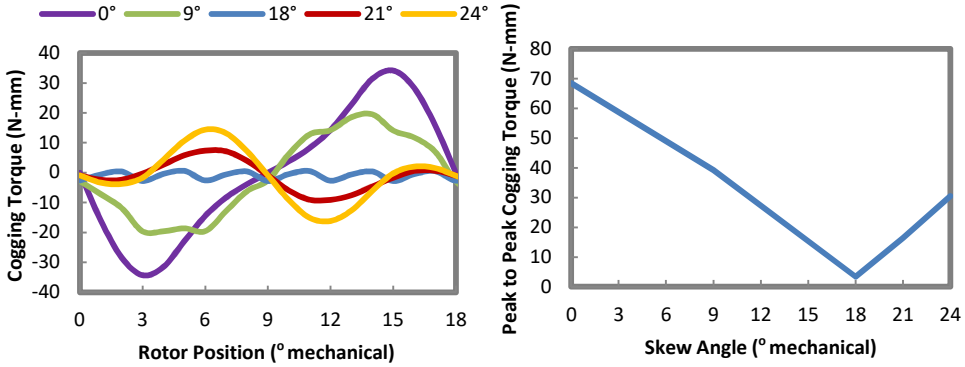
- Fractional slot per pole
- Function 1 (F_1) : Highest [Least Common Multiple (Slots, Poles)]
- Function 2 (F_2): Smaller $(\frac{\text{Poles} \times \text{Slots}}{F_1})$



Effect of slot/pole on motor cogging torque

Skewed Magnet / Magnetization

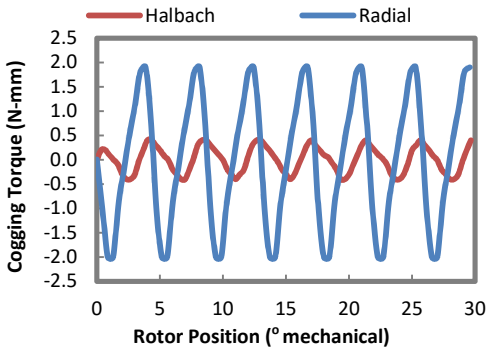
- Skewing reduces the rate of change of reluctance seen by magnet flux
- The optimum skew angle for minimum cogging torque is Function 3 (F_3): $(\frac{360}{F_1})$
- The optimum skew angle for 10-Slot/4-pole motor is F_1 =20, F_3= 18° mechanical



Effect of skew angle on 10-Slot / 4-Pole motor cogging torque

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



Effect of magnetization profile on 12-Slot / 14-Pole motor cogging torque

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