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# INFLUENCE OF SLOT/POLE COMBINATIONS ON THE PERFORMANCE OF DUAL-ROTOR AXIAL-FLUX

*SURFACE-MOUNTED PERMANENT MAGNET ELECTRIC MOTOR FOR AUTOMOTIVE APPLICATIONS*

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## Abstract

A comparison between different slot/pole combinations of axial flux electric machines is presented in this poster.

The main objective is to classify these structures according to torque density and electromagnetic performance, based on the specifications of a medium-sized electric car.

The study is carried out using 3D-FEA calculations.

## Introduction

The environmental and societal constraints described above have led car manufacturers to invest heavily in research, development and innovation to improve the performance of the electric vehicle (EV) propulsion system, which offers an emission-free solution with high efficiency.

A review of the different electric motor topologies used in EV and hybrid EV powertrains shows that the radial flux permanent magnet synchronous motor is the most widely used, due to its characteristics.

Car manufacturers are increasingly interested in the axial flux machine. A large body of research has shown that this machine offers considerable advantages for traction applications in terms of high-power/torque density, high efficiency and compact-modular structure.

**Axial gap electric machine**

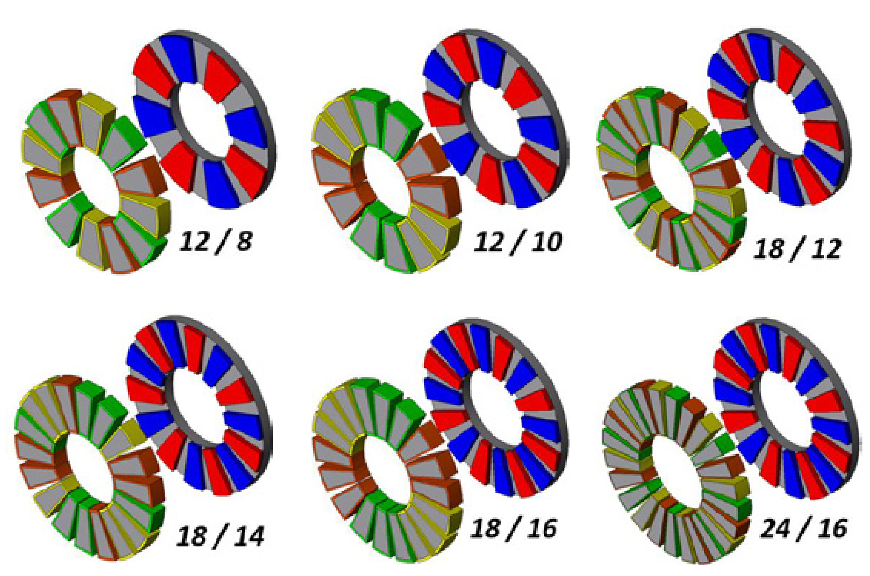
- **Rotor topologies**
  - Permanent magnet
  - Wound rotor
  - Induction (squirrel cage)
  - SRM
- **Strator topologies**
  - Concentrated winding
  - Distributed winding
- **Structure**
  - Dual rotor
  - Dual stator
- With stator / rotor yoke
- Yoke less (stator / rotor) Or core-less structures
- Airgap number (1, 2, 3, 4, 5...)

The comparison is carried out between six different axial flux machine configurations, at isogeometrical dimensions and at iso-electrical parameters for the sake of a fair comparison.

## Presentation of the structures & Performances

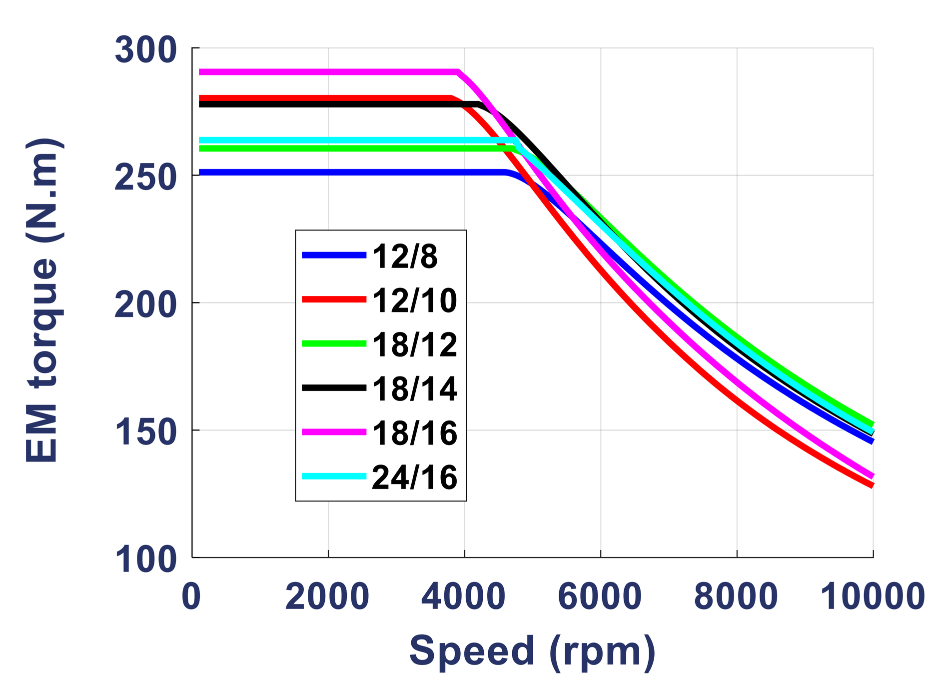
The choice of the slot / pole number is based on commonly used structures and other technical factors:

- structures with a low number of slots and a low number of magnetic poles could be the best from an industrialization point of view, thanks to the fewer parts that require handling.
- structures with a high winding factor offer the potential to develop a higher electromagnetic torque.
- structures with a high winding periodicity can generate less vibration; ensuring a more balanced magnetic attraction.
- combinations with a high LCM (Slots, Poles) can generate a low maximal value of cogging torque.

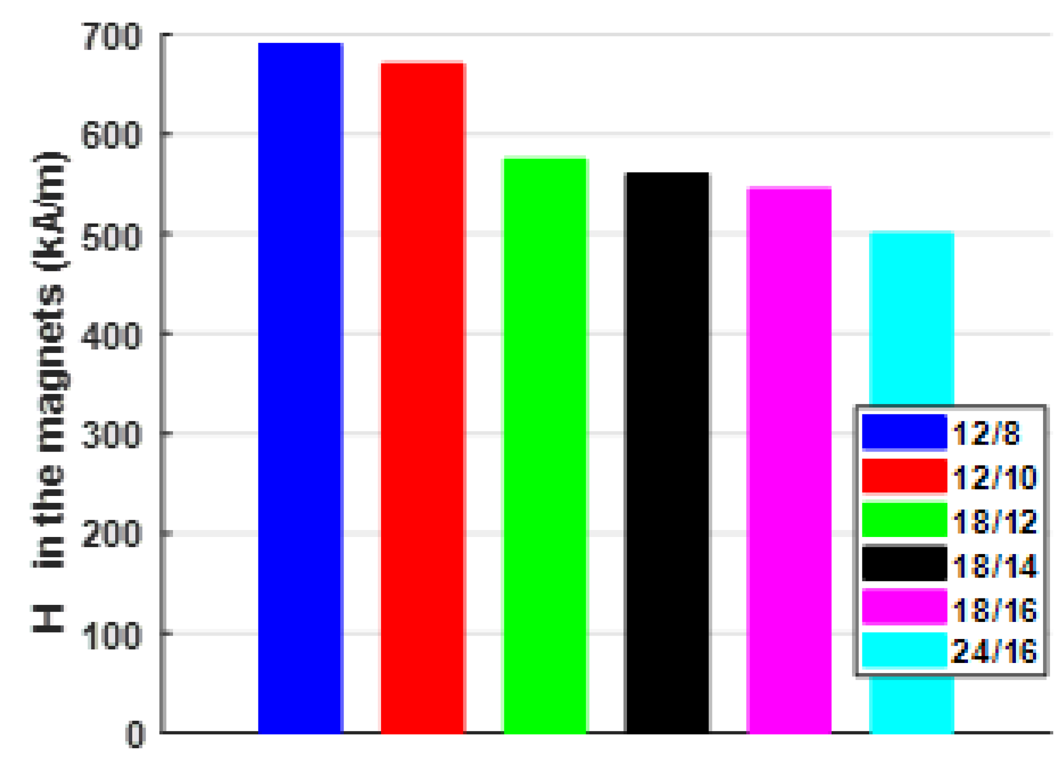



| | |
|---|---|
| Number of turns in series of the phase | 48 |
| Axial lenght | 78mm |
| Air gap | 2 X 1mm |
| Copper weight | 1.8kg |
| PM Thick / PM weight | 6mm / 1.5mm |
| Total weight | 13.6kg |

- the stator teeth: SMC (Höganäs Somaloy® 700HR-5P)
- the rotor discs: NOES (ArcelorMittal M230-35A)
- the permanent magnets: Br = 1.2T and Hc = 910 kA/m




Peak torque-speed curves for the studied structures (respecting the supply limits: $350V_{DC}$ and 400Arms)




PM-H values tolerating a demagnetization of 0.5% of the PM volume at 250 N.m

| Structure | 12/8 | 12/10 | 18/12 | 18/14 | 18/16 | 24/16 |
|---|---|---|---|---|---|---|
| Torque density | + | + + | + + | + + + | + + + | + + + |
| Power density | + | + | + + | + + | + + | + + + |
| Losses (@ low speed) | high | mid | high | mid | low | high |
| Losses (@ base speed) | low | mid | low | mid | high | mid |
| Losses (@ high speed) | low | mid | low | mid | high | mid |
| Demag Risk | high | high | mid | mid | mid | low |
| Torque ripples | high | low | high | low | low | high |
| Attraction forces | high | low | high | mid | low | high |

## Conclusion

- Structures with a high winding factor present the best performance in terms of high torque density, low DC joule losses in conductors and low magnetic attraction forces.
- For high-speed performance, structures with a low magnetic pole present low losses.
- Increasing the number of magnetic poles reduces the risk of PM demagnetization. In addition.
- For the presented medium-size vehicle specifications, the 18/12 and 18/16 structures have more advantages taking into account all magnetic performances.

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