Design of a 200 kW PM SynRel Motor without rare-earth PM for electric vehicle

P3W35

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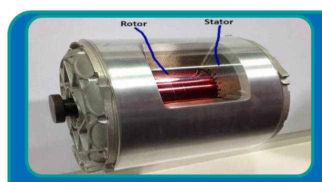
Context

- Electrical machines with rare-earth permanent magnets performances and their limits

Advantages	Disadvantages
Compactness	Supply chain uncertainty for rare-earth PMs
High efficiency	Volatile costs
A wide speed regulation region	High costs

So, less or no rare earth PMs can be considered to decrease the total cost of electrical machines

- Rare earth magnet alternatives and their limits


Induction machine :Tesla model 3
- Copper rotor losses


Wound rotor : Renault ZOE
- Copper rotor losses


SRM: Land Rover Defender
- Vibration acoustic noises


SynRels : not yet
- Low power factor

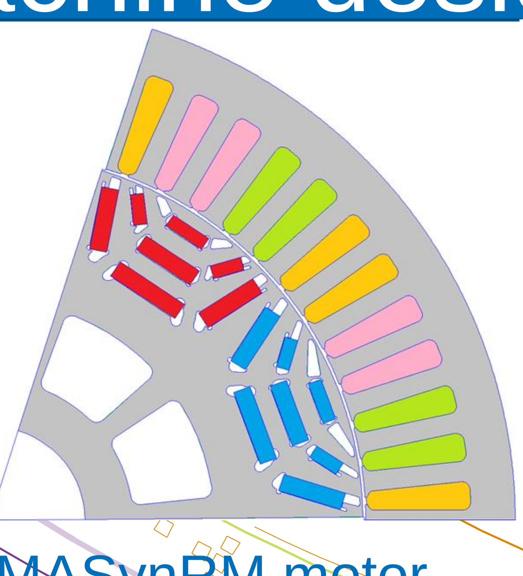

Reduced rare earth : BMW i3


Other magnets (Ferrite): Chevrolet volt

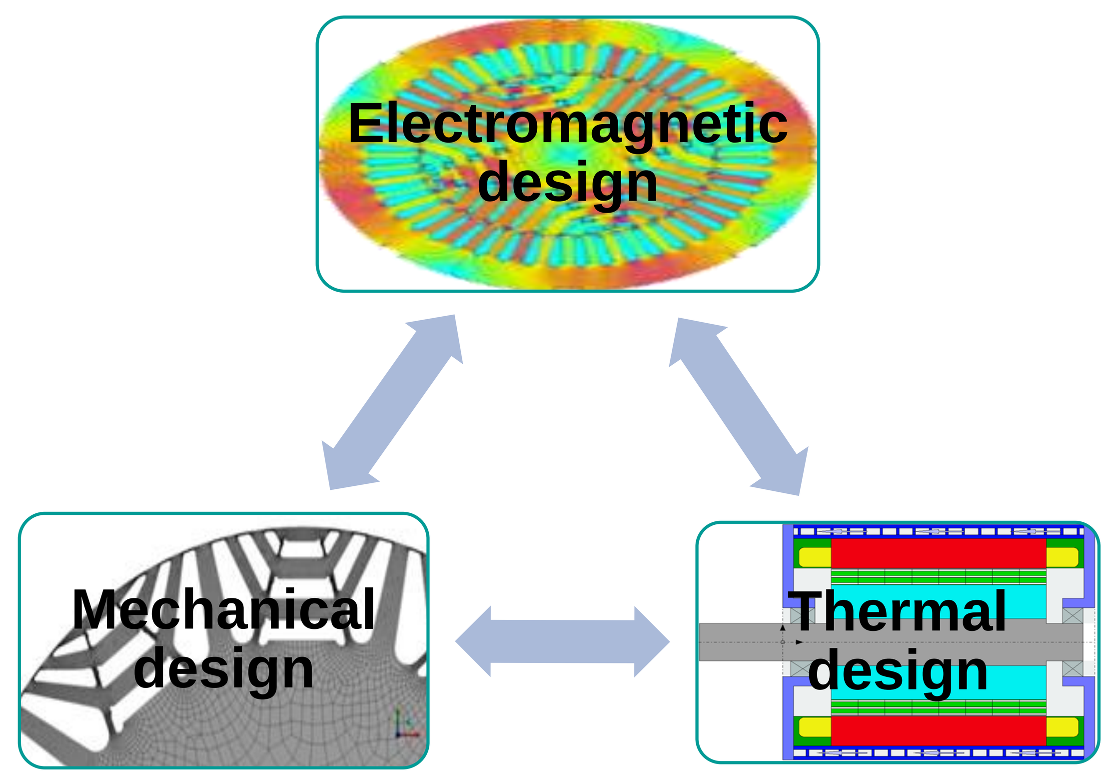
In this work in order to achieve high performance and reduce total cost of electrical machines, a novel permanent magnet-assisted synchronous reluctance machine (PMASynRM) with ferrite magnets is proposed.

Requirements and machine design

Performances	Reference
DC Voltage [V]	800
Base speed [RPM]	5000
Stator outer diameter [mm]	220
Stack length [mm]	200
Maximum torque [N.m] (30 s)	424
Maximum power [kW]	200
Maximum current [A]	590
Cooling	liquid

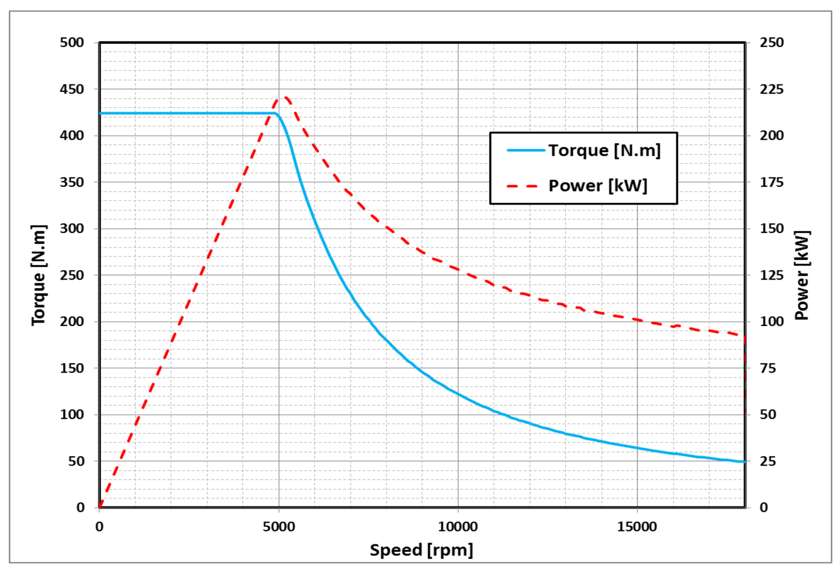

PMASynRM motor with an asymmetrical rotor

Design process

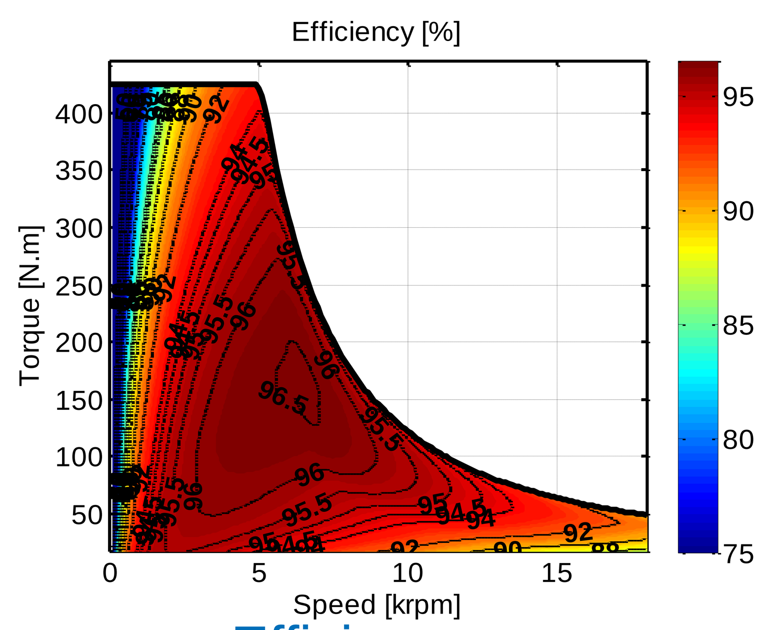


Results

- Electromagnetic performances :

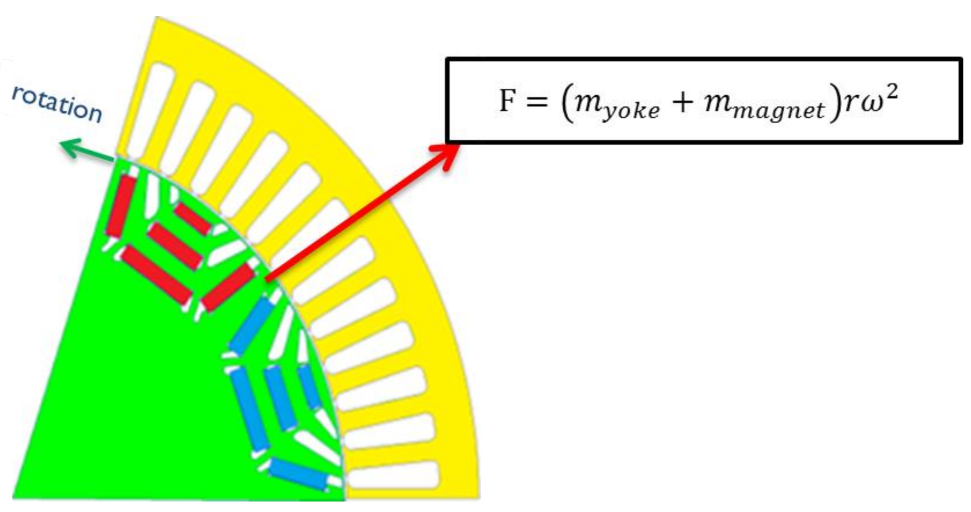


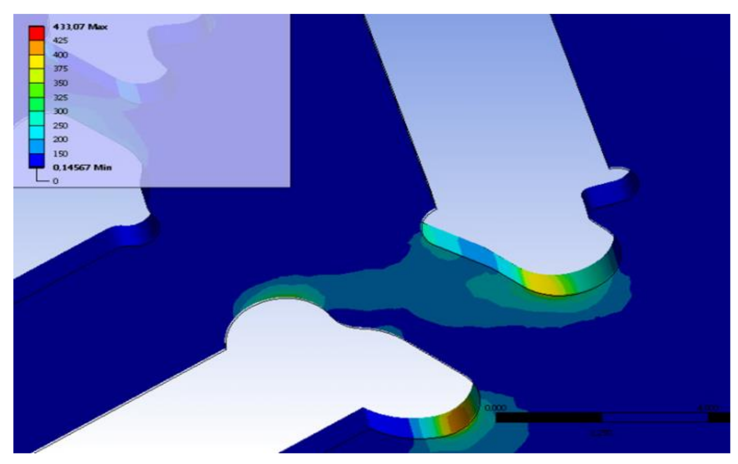
Torque and output power vs. speed



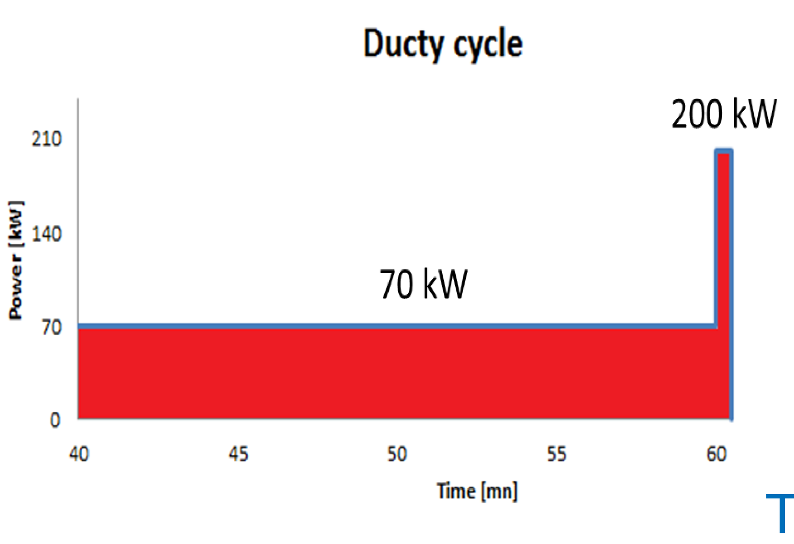
Efficiency map

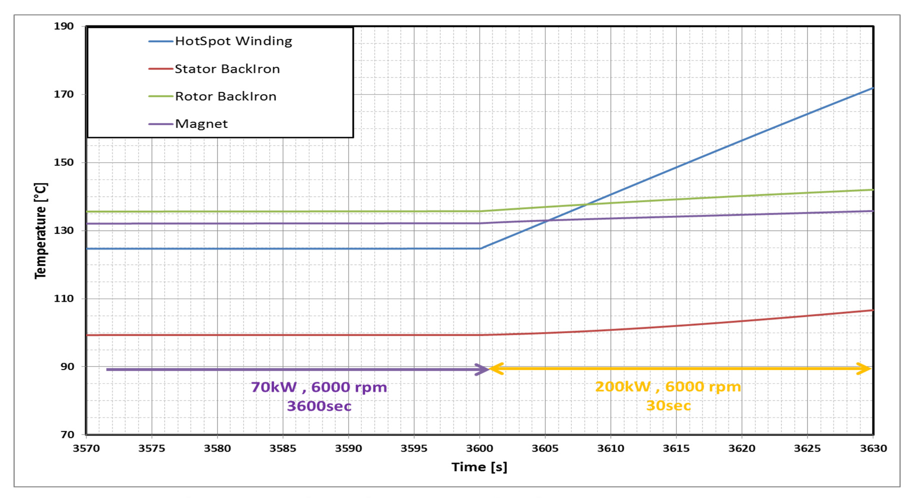
- Mechanical stress analysis : Centrifugal force




Von Mises stress at the maximum speed

- Thermal design validation





Temporal evolution of the temperature

Conclusion

In this work a design of a ferrite-PMASynRM with high power is proposed. Different phenomena's such as the demagnetization behaviour, mechanical strength, thermal stress and torque ripple are analysed. This study shows that a design of PMASynRM requiring high power and high torque could be achieved using ferrite magnets.

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