



Rotor Segmentation For Spoke Type Interior Permanent Magnet Servomotors

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Outline

1. PM SERVOMOTORS

2. PM SERVOMOTORS DESIGN PROCESS

3. SPOKE TYPE PM SERVOMOTOR STRUCTURE

4. FEA ANALYSIS

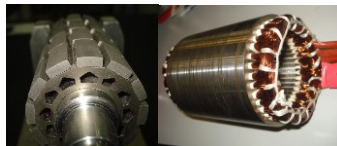
5. CONCLUSION



1. PM SERVOMOTORS

PM Servomotors Used in many applications such as :

- Home appliances,
- Automotive,
- Robotics,
- Defense industry,
- Position control applications,
- ...



PM servomotor rotor and stator

PM Servomotors Advantages:

- High torque density,
- High efficiency,
- Large torque to weight ratio,
- Low noise and vibration,
- ...

PM Servomotors Disadvantages:

- High cost,
- Complicated control,
- Complicated design process,
- ...



1. PM SERVOMOTORS



Lynx SEMA axial flux motor tested in University of Tennessee's future truck (Source: University of Tennessee)



Home appliances (Washing machine)



Robotics



Q™ axial flux PM motor used in American Solar Challenge by the North Dakota State University (Source: Bodine Electric Company)

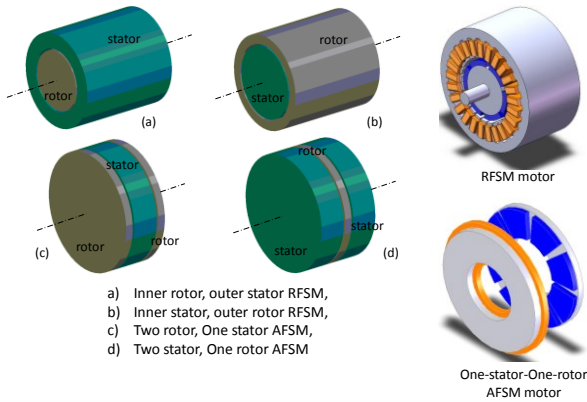


Defense Industry

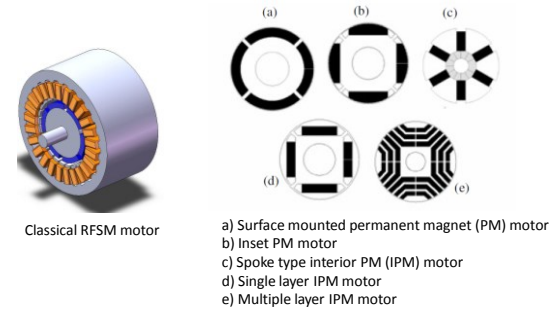
Electric bicycle for military applications



1. PM SERVOMOTORS



1. PM SERVOMOTORS

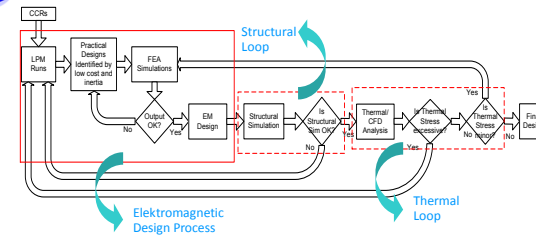


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2. PM SERVOMOTORS DESIGN PROCESS



Design Process

- After the design pass the electromagnetic design process, structural process begins.
- If the design passes the structural analysis, thermal analysis starts. But if the design have a structural problem, design process returns to the electromagnetic design process.
- When all of the design loops are completed, final design is obtained.

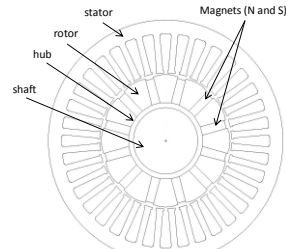


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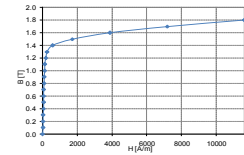


3. SPOKE TYPE PM SERVOMOTOR STRUCTURE

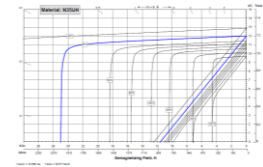


Cross section of 12 Poles 36 Slots Spoke Type Motor Structure

- Higher torque density,
- High distortion of airgap flux density,



Magnetic steel material (M270-35a)



Magnet material (N35UH)

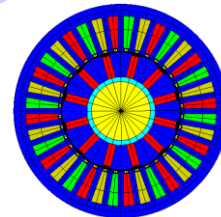


Outline

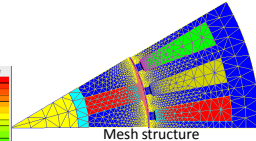
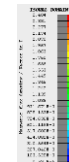
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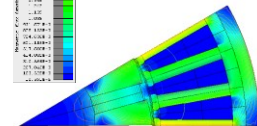
4. FEA ANALYSIS



Spoke Type Motor 2D FEA Model (with Flux by CEDRAT)



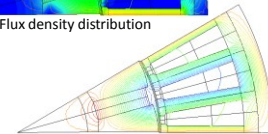
Mesh structure



Flux density distribution



Definition of airgap



Flux lines



4. FEA ANALYSIS

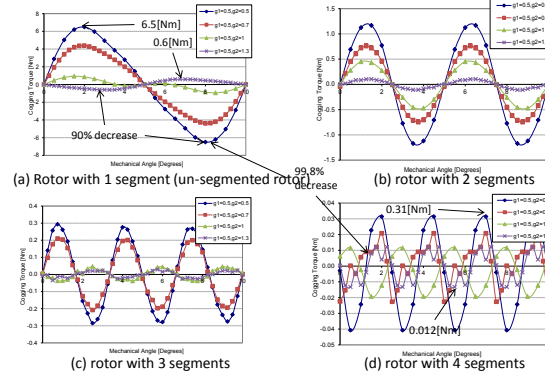
Video

Creation informations :
 Project : sp_0p5_bemf.FLU
 Scenario : BACK_EMF
 Pilot : ANGPOS_ROTATING_ROTOR
 Pilot values : 0.5 - 60.0
 Images count : 120
 Displayed entities :
 Isolines : 1_ISOLIN_DOMAIN
 Date : 2011-09-16 09h38m08



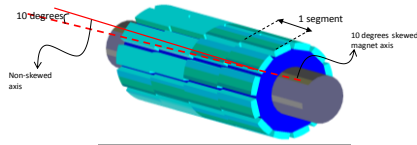
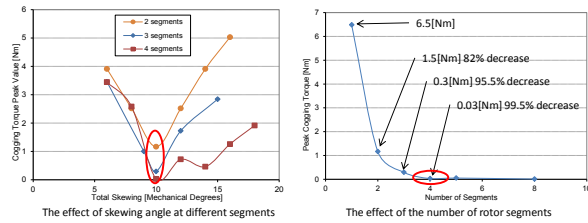
4. FEA ANALYSIS

Cogging Torque : Caused because of the interaction between magnets and stator



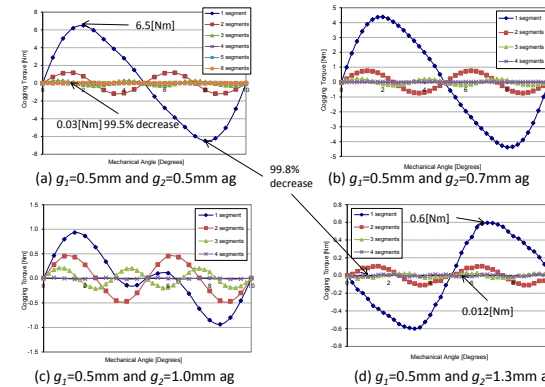
4. FEA ANALYSIS

Definition of Skewing Angle and Number of Segments



4. FEA ANALYSIS

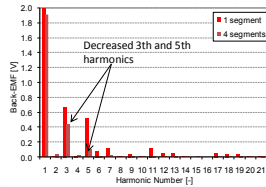
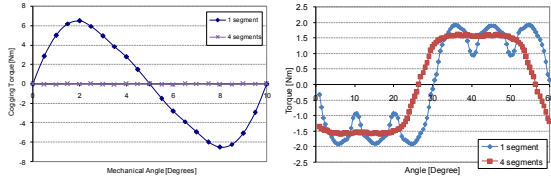
Cogging Torque





4. FEA ANALYSIS

For 500rpm, $g_1=0.5\text{mm}$ and $g_2=0.5\text{mm}$ ag, 1 segment and 4 segments,



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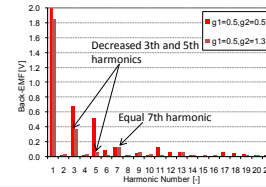
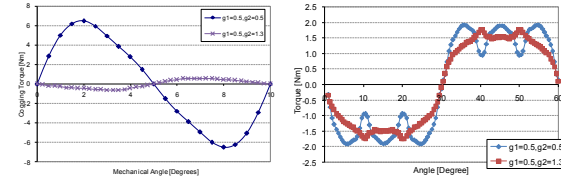
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4. FEA ANALYSIS

For 500rpm, $g_1=0.5\text{mm}$ and $g_2=1.3\text{mm}$ ag, 1 segment



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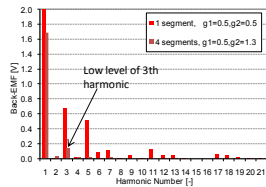
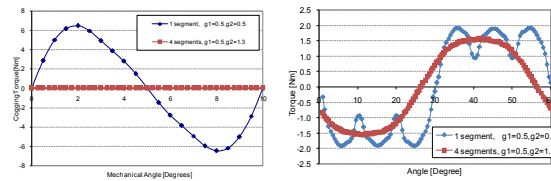
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4. FEA ANALYSIS

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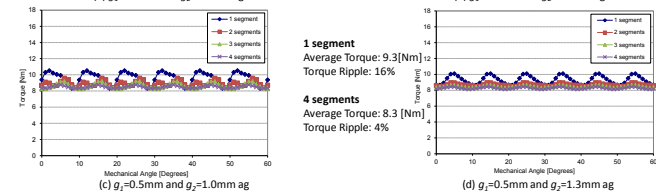
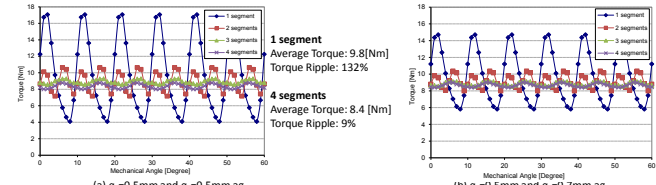
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4. FEA ANALYSIS

Torque Outputs



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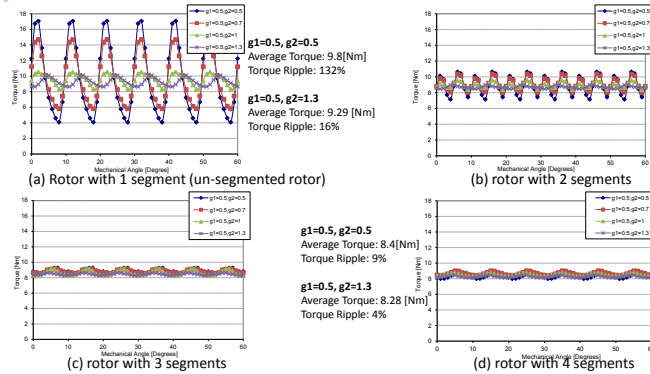
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4. FEA ANALYSIS

Torque Outputs



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5. CONCLUSION

- Some design issues for a spoke type interior permanent magnet servomotor have been investigated.
- A set of different design parameters have been investigated in detail to improve the motors torque quality including cogging torque and torque ripples components
- All of the analyses have been carried out using 2D Flux FEA Package
- Effect of skewing and segmented rotors have also been examined and it was found out that it is possible to use single un-segmented rotor without any skew for a 36 slot stator for industrial servo applications.
- However, if a low speed or precise position control is required, 4 segmented rotor will provide the best torque quality for such IPM motors.

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