Flux Motor and its Applications
Electric Vehicle(1)
Electric Vehicle(2): Hybrid Car
Motors for Electric Vehicles

- Three most popular Motors for Electric Vehicles
  1. DC motor: Short lifespan because of brush, brush noise
  2. BLDC (Brushless DC) motor: Expensive & Low output
  3. PMSM (3-phased AC motor): Cheap & Long lifespan

- Motor types of commercial electric(hybrid) cars

<table>
<thead>
<tr>
<th>Motor Type</th>
<th>Battery Type</th>
<th>Vehicle Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford Focus</td>
<td>107-kW PM electric motor</td>
<td>23-kWh battery</td>
</tr>
<tr>
<td>Tesla Model S</td>
<td>Kilowatts unknown 4-pole AC induction motor</td>
<td>40-, 60-, or 85- kWh lithium-ion</td>
</tr>
<tr>
<td>Toyota Prius</td>
<td>30-kW AC PM motor + 98 HP gas</td>
<td>27 kWh Ni-MH</td>
</tr>
<tr>
<td>Nissan</td>
<td>80-kW AC PM electric motor</td>
<td>24 kWh lithium-ion</td>
</tr>
<tr>
<td>Chevrolet</td>
<td>111-kW AC PM drive unit + 84 HP gas</td>
<td>16-kWh lithium-ion</td>
</tr>
</tbody>
</table>
PMSM (Permanent Magnet Synchronous Motor)
PMSM (Permanent Magnet Synchronous Motor)

- Faster
- More smooth
What is FluxMotor?
FluxMotor is a motor predesign tool.
A broad range of users

- Electric motor designer, Manufacturers, ... users of FEM software
- Integrators, OEM, ...
- Sales staff, suppliers, training staff
How does FluxMotor look?
Main Window (Supervisor) of FluxMotor
Motor Catalog: to select all motors for automotive applications and compare
Motor Catalog: to find the closest one to your topology and edit it
Motor Factory

FluxMotor

Motor Catalog
Automatic Sizing
Motor Factory

Part Library
Materials
Units

Resource
Preferences
Help
Motor Factory: to enter structural data of your motor

New synchronous machine - Permanent magnet - Inner rotor - 3-phase

RADIAL VIEW

STRUCTURAL DATA
Motor name: NewMotor1
Catalog: User:Synchronous

Dimension input mode

STATOR
Outer diameter (mm): 320.0
Inner diameter (mm): 180.0
Length (mm): 80.0
No. slots: 48

AIRGAP
Length (mm): 8.0 E-1

ROTOR
Outer diameter (mm): 178.4
Inner diameter (mm): 90.0
Length (mm): 80.0
No. poles: 8
Architecture & Functions

FluxMotor

Design the Difference with Digital twin

Flux
The Motor Factory to design & test
Designing electric motors

- A new machine project within minutes
- Build the machine step by step
- Never start from a blank page!
User-oriented winding tool

- 4 winding modes
  - Automatic, Easy, Advanced and Expert
  - Settings adapted to the task

- An automatic diagnostic is issued
  - With quality criteria of the winding
  - To adjust the winding parameters

- An **automatic winding report**
  - Main information to build the winding
Ref) Electric Motor’s Coil Windings
Part library: to select the part to edit/test
Part library: to create a new library
Materials: to create a new lamination and set general data
Building blocks available
A comprehensive and scalable material database

- A large selection of typical materials
- Users can manage their own materials
- Easy way to define B(H) curve or iron losses parameters
Effective machines parts management

• Libraries are provided with standard parts
• A large number of slots or magnets available
• All the topologies are parameterized
• Customization of parts is possible
# Units

## Angle Units

<table>
<thead>
<tr>
<th>Angle Unit</th>
<th>Current Unit</th>
<th>Unit</th>
<th>Symbol</th>
<th>Factor</th>
<th>Offset</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radian</td>
<td>rad</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0 rad + 1.0 rad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree</td>
<td>deg</td>
<td>1.745E-2</td>
<td>0.0</td>
<td>1.0 deg + 1.745E-2 rad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gradian</td>
<td>grad</td>
<td>1.571 E-2</td>
<td>0.0</td>
<td>1.0 grad = 1.571 E-2 rad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minute of arc</td>
<td>-</td>
<td>2.909 E-4</td>
<td>0.0</td>
<td>1.0' = 2.909 E-4 rad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second of arc</td>
<td>-</td>
<td>4.848 E-6</td>
<td>0.0</td>
<td>1.0&quot; = 4.848 E-6 rad</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Resource: to link “Altair Connect Website”
Preferences

Language: English
No. decimals after dot: 3
No. most recent used motors: 5
Result and Analysis
Testing and evaluating electric motors

• Predefined tests ready to be performed
• Relevant input parameters to control the test conditions
• Processes based on optimization technology
• Results are automatically illustrated
Process of computation – Back-emf - principle

- A few measurement points of the coupling flux are checked with FE
- The back-emf versus time is then deduced
Process of computation – dq-axis coupling flux - principle

- Combinations values of \(I_d\) and \(I_q\) are considered
- Characterisation of coupling flux – Maps \((I_d, I_q)\)
- Response surfaces are computed to prepare optimization

\[
T_e = m \times p \times (\Phi_d \times I_q - \Phi_q \times I_d)
\]
Solving technologies in FluxMotor

• Analytical computations are also used!
  • To get quick response when sufficient
  • To give input parameters to Flux

• “Flux” as Finite Element solver inside!
  • Topologies of machines are perfectly respected
  • Saturation of materials are taken into account

• Analytical + FE computations
  • Highest ratio between quick computations and accuracy of results
Complementarity with FE Flux

• Easy flux project export to Flux
  • To perform advanced studies like eccentricity, vibro-acoustic, thermal, drive and control,…

• At any time, the Flux model ready to be used
  • Full parameterized
  • All the physical properties embedded
  • Ready to be solved in Flux Environment
As a conclusion… Benefits

- High productivity
- A broad range of users
- Fulfill all the design tasks
- No compromise on accuracy
- Connection for advanced study
Thank you!