Motor-CAD: Latest features in v13

February 2020
• The market leading tool dedicated to the design and analysis of electric motors.

• Enables rapid and accurate electromagnetic, thermal and mechanical analysis of an electric machine across the full operating envelope.

• Designed and developed in close collaboration with expert electric machine designers.

• Embedded engineering expertise.

• Great customer support and response to user feedback – **we are continually developing and enhancing the software to meet user needs.**
New Features in Motor-CAD v13

• Motor-CAD software is under continuous development, with the last major software release in February 2019.

• Changes in Motor-CAD v13 include:
  • Significant calculation speed increases
  • New features
  • New templates
  • New calculation methods
  • Improved integration with ANSYS tools.

• This presentation details the latest features and improvements.
New Features in Motor-CAD v13

**GENERAL FEATURE**
- Up to 150% faster calculations
- Multi-physics system level simulation
- New licencing options
- Export animations to GIF files
- Default settings
- File history

**ELECTROMAGNETIC**
- Force analysis
- Improved force calculations
- ANSYS Maxwell 2D template links
- ANSYS Maxwell 3D export
- New hairpin winding templates
- IM machine saturation model
- Improved magnet definition
- Sinusoidal Halbach array improvements
- Added airgap flux density plots
- Magnetic solution with non-symmetrical ducts
- Housing included in EMag calculations
- SYNC skew modelling capability

**THERMAL**
- Close-coupled transient solution
- Spray cooling of hairpin windings
- Added endspace area multiplier control
- Improved bearing interface gap definition

**MECHANICAL**
- Rounding of corners in magnet geometries
- Improved mesh control

**LAB**
- Improved graphing interface for Lab module
- Close-coupled transient solution
- New Lab BPM machine control strategies
Motor-CAD v13 now has twice the amount of memory, which results in a calculation speed improvement of up to 150% (depending on calculation type)

- The latest version of Motor-CAD is now 64 bit, previously was 32 bit.
- This means calculation speeds can be significantly faster in this new release.

Example: Open Template | e8 e-Mobility IPM
### Up to 150% faster calculations

<table>
<thead>
<tr>
<th>Calculation Type</th>
<th>Time 32 Bits (sec)</th>
<th>Time 64 Bits (sec)</th>
<th>Speed Up Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque (30 steps/cycle)</td>
<td>23</td>
<td>9</td>
<td>2.6x</td>
</tr>
<tr>
<td>Torque – 5 skewed rotor slices (30 steps/cycle)</td>
<td>124</td>
<td>50</td>
<td>2.5x</td>
</tr>
<tr>
<td>LAB Build Model (Saturation + Losses)</td>
<td>569</td>
<td>477</td>
<td>1.2x</td>
</tr>
</tbody>
</table>

1 – System: Intel Core i7, CPU 1.8GHz, 8 Cores, 16GB RAM  
2 – Multi-thread enabled (7 cores)
Multi-physics system level simulation

Users can now integrate advanced multi-physics motor models into system level simulations, which have high accuracy and fast solution times.

Users can now carry out system level co-simulation of Motor-CAD models:

- **Electromagnetic only model** (torque / speed, Max current, DC bus voltage)
- **Thermal only model** (Losses, coolant flow rates, speed)
- **Combined Electromagnetic and Thermal model**:
  - **Inputs** - Torque / speed, Max current, DC bus voltage, coolant flow rates and temperature.
  - **Outputs** - Current, phase advance, Torque, machine temperatures, coolant outlet temperature.
New licencing options bring Motor-CAD v13 installation process in line with other ANSYS tools, so users can get started as quickly as possible.

- Licenses for Motor-CAD v13 will now be available on the ANSYS license server and the FlexLM licence server using motordes daemon.
Users can now export 3D geometry and FEA results as animated gifs to enhance presentations of results.
Improved feature in Motor-CAD v13 means a significant speed-up of force analysis and powerful visualisation of the electromagnetic forces and modal shape.

- Enhancement of existing feature that enables users to calculate forces.
- Now users can display modal animation of forces.
Improved force calculations

Significant increase in calculation speed for forces and improved analysis in Motor-CAD

- Symmetry now used in force calculations
- Harmonic analysis of radial and tangential forces
New feature makes it quick to export fully parameterised models from Motor-CAD to Maxwell 2D.

- New feature to export to ANSYS Maxwell machine geometries defined using primitives.
- Provides greater flexibility with exported model.
- Quicker setup of ANSYS Maxwell models.
Motor designers can now export models from Motor-CAD to ANSYS Maxwell 3D in seconds

- Motor-CAD v13 has a new, automated 3D export option which means users can quickly set up and define a model in ANSYS Maxwell
- Parameterised stator and winding exported using UDP
- Symmetry, boundary conditions and excitations are automatically set-up

Valuable tool for investigation of:
- End leakage
- Endwinding inductances
- Different magnet, rotor, stator axial lengths
ANSYS Maxwell 3D export

- Automatic export for rotor skewing which will automatically export the number of slices and the skew angle.

3D export – BPM Rotor Skewing:
ANSYS Maxwell 3D export

- 3D export for IM
- Uses the UDP, so all the elements are parameterised (stator, rotor, bars and end ring).
- Bars and end ring parameterised with squirrel cage UDP.
- Rotor and stator skew automatically applied.
Users can now carry out multiphysics drive cycle analysis with coupled electromagnetic, thermal and control models—enabling improved accuracy for drive cycle analysis.

- Motor-CAD now allows **close coupling** of electromagnetic and thermal models during a complex drive cycle, to better account for changes in winding and magnet temperatures.

**At each time step:**
- Losses calculated using current machine temperatures
- Temperatures calculated from current machine losses
- Applicable to BPM, BPMOR and SYNCREL machine types.
- User specified machine drive cycle.
New hairpin winding templates

Motor-CAD v13 has specific templates for hairpin windings—allowing for faster model set-up and the ability to easily experiment with different hairpin winding configurations.

• Comprehensive information about the actual winding and conductor layout is captured in the model.
• New feature enables:
  • Better visualisation of hairpin windings
  • Improved winding definition with full winding paths
  • Improved calculation of endwinding lengths
  • Thermal model of end-winding accounts for spaces between conductors
• Added in-built expertise on hairpin windings.
New spray cooling options in Motor-CAD v13 allow users to specify cooling of all surfaces of hairpin endwindings, giving more flexibility in the spray cooling model.

- Spray cooling is an important method of cooling of hairpin windings.
- Motor-CAD now has new spray cooling options to specify cooling of all surfaces of hairpin endwindings.
Enhancement of an existing feature that automates and speeds up calculation of different operating points encountered in the analytic performance tests—saving time.

- Users can now create lookup tables for:
  - saturation factor
  - magnetizing reactance
  - core loss resistance
  - iron losses
- Lookup table can be created using either Analytical or FEA solver.
- Tables need to be recreated if change machine geometry, winding or drive definition.
Significantly improved templates for IPM geometries allow more realistic rotor design and improved accuracy in the stress calculation.

- More template flexibility with new option for U-shape and V-shape magnet geometries
- Allows users to more accurately calculate stresses with an option to round edges.
Improved mesh control

Improved accuracy and speed of mechanical analysis.

- Detailed mesh required around cut edges for accurate stress calculation.
- Do not require a detailed mesh on whole rotor lamination.
Default settings

Help ensure backward compatibility for consistent results across versions while giving users options to utilise the latest, most accurate models.

- Simplify the user interface, allow to view and reset old settings
- Compatibility – should always use default except to reproduce results from previous Motor-CAD versions
- Recommended – calculation options, shows best method. Also shown in main Settings page
- Useful for ensuring that model uses best available methods or checking results between versions
File history

Helps users keep track of file changes, modifications and contributors, for improved traceability and reduced risk of unintentional modifications.

- Shows when file is saved by different user or using different version of Motor-CAD.
Improved magnet definition

More comprehensive magnet material data now captured in Motor-CAD.

- Option to input non-linear demagnetisation curves
- Curves at different magnet temperatures
Sinusoidal Halbach array improvements

Improved flexibility for precise sinusoidal magnetisation definition.

- Continuous variation of magnetisation directions using neutral polar axis as reference.
Added airgap flux density plots

Enables designers to optimise airgap harmonics with ease.

- Radial and tangential airgap flux densities
- Harmonic analysis of radial component
Magnetic solution with non-symmetrical ducts

Increased flexibility in templates and dxf imports

- Motor-CAD EMag FEA model normally generated from single slot and pole to ensure uniform mesh.
- Problem: If slots or poles not uniform due to ducts then was not possible to model.
- New option to generate full model when slots or poles are non uniform.

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New Lab BPM machine control strategies

Increased scope for different types of control

- Ability to set fixed phase advance or custom phase advance defined by speed
Housing included in EMag calculations

More accurate electromagnetic results for PMDC machines.

• Housing automatically included for PMDC if no stator back iron thickness.
• Housing can be included for all machines.
• Overhang factor:
  • User specified value
  • Multiplies the housing BH curve to take account of overhang.
SYNC skew modelling capability

With Motor-CAD v13 it is now possible for users to model continuous stator / rotor skew for Synchronous Wound Field machines.

- Enhanced design and parameterisation options for Synchronous machines
Added endspace area multiplier control

Increased flexibility for precise calibration of cooling off end windings

• Useful to be able to adjust endwinding surface areas when modelling hairpin windings.
Interface gap material selection

Physical interfaces can be more accurately described.

- Previously always air.
- Can now specify the interface material.
- For example glue between magnets and rotor lamination.
Improved bearing interface gap definition

Motor-CAD v13 now enables users to check their machine model adheres to DIN732 and DIN ISO 15312 standards for more accurate results.

• With Motor-CAD v13, users now have more options when thermally modelling bearings, with DIN732 and DIN ISO 15312 bearing interface standards now added.

• Thermal conductance calculated based on bearing area.
Improved graphing interface for Lab module

More powerful visualisation of machine performance across the torque / speed range.

- The graphing interface has been improved based on user requests.
- Now users can view multiple parameters on the same plot, generate 3D surface plots, save and load plot settings.
- Users also have more control over plot options.