Analysis software

The addition of e-motor electromagnetic design and analysis tools meets the challenges posed by the increased integration of EV powertrain subsystems

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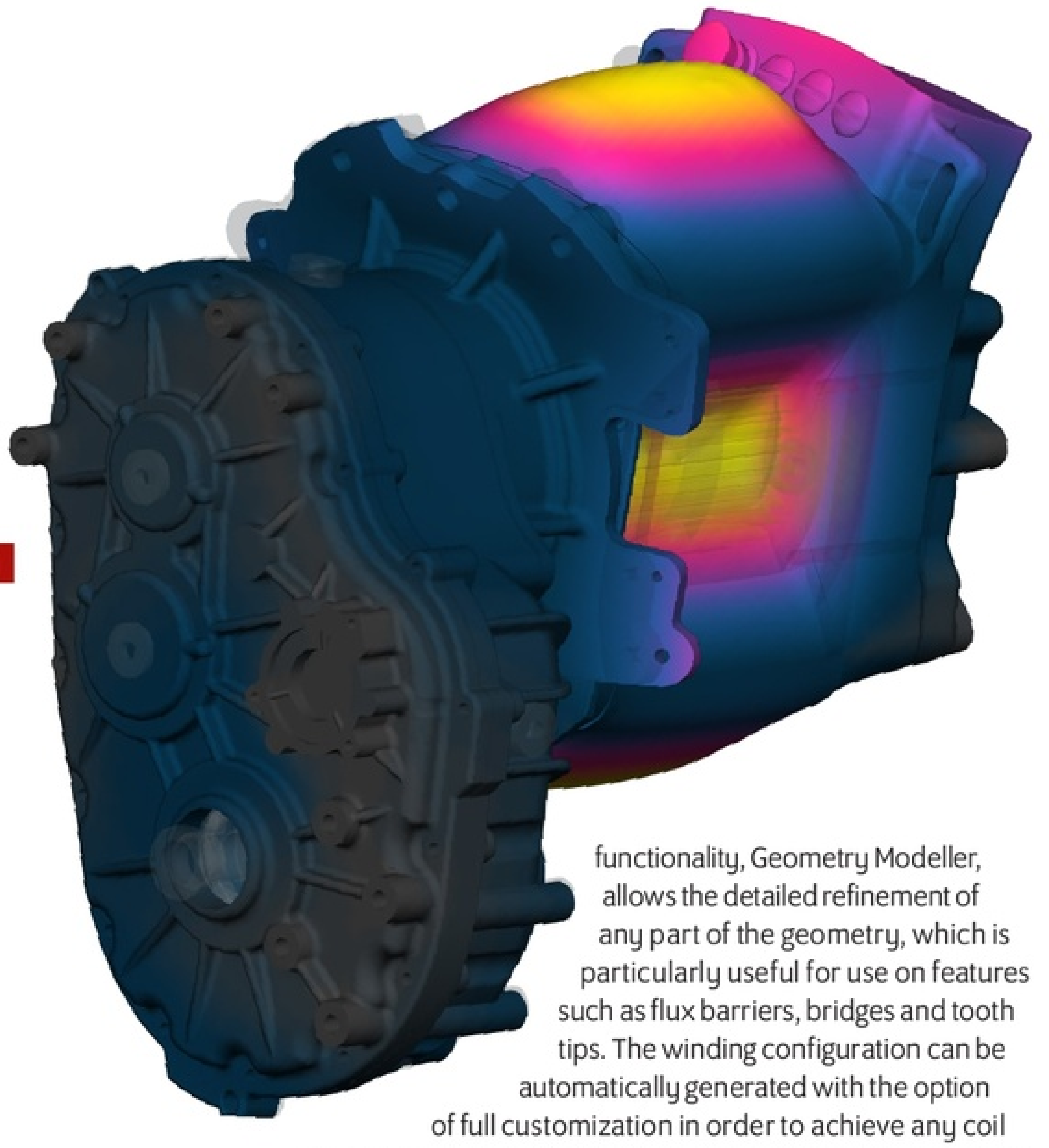

The trend toward increasingly integrated electric vehicle powertrains in the automotive sector is creating a greater need to understand the coupling effects between the three principal subsystems consisting of the transmission, electric machine and power electronics.

Key performance targets for electric vehicle powertrains include efficiency, durability, and noise and vibration levels. The performance of each individual subsystem regarding each criterion can be obtained easily by using appropriate software tools. However, when – for example – the electric machine is coupled to the transmission, each subsystem can influence the performance of the others in key areas. These effects need to be captured efficiently, effectively and as early in the design process as possible.

Typically, a multidomain approach requiring electromagnetic, mechanical and thermal analysis is needed to model the subsystems and their interactions to fully predict performance. Traditionally, this is accomplished by employing several separate software tools to model behavior in these domains. The process of predicting component interactions is undertaken by coupling these different tools by co-simulation, data transfer or a combination of both. However, this can be a slow and complicated process and can include the risk of potential data transfer errors.

TRUE INTEGRATION

MASTA has been a leader in the design and analysis of transmission systems for many years. The focus of MASTA 12 has been the development of truly integrated tools to improve the connectivity between different modeled subsystems and different analysis domains. A new feature that has made a considerable contribution to achieving this objective is the ability to perform electromagnetic analysis of electric machines within MASTA.

Machine geometry can be specified using templates based on common machine topologies. This enables users to begin the design process by exploring a large potential design space quickly and easily. Later in the design process, a link with MASTA's CAD functionality, Geometry Modeller, allows the detailed refinement of any part of the geometry, which is particularly useful for use on features such as flux barriers, bridges and tooth tips. The winding configuration can be automatically generated with the option of full customization in order to achieve any coil configuration. Materials for the rotor and stator core, magnets and electrical conductors can be selected from a database, and new materials can be added to the database. For core materials, B-H curves can be specified and power loss coefficients can be input directly or obtained from power loss curves entered by the user.

The analysis is based on a high-fidelity electromagnetic finite element model of the electric machine design. The user is given a high degree of flexibility to control analysis setup and mesh, should they need it, to allow coarser and finer meshes as the situation

1. Integrated drive systems require a joined-up approach to simulation

2. Dynamic forces in the electric machine can be calculated

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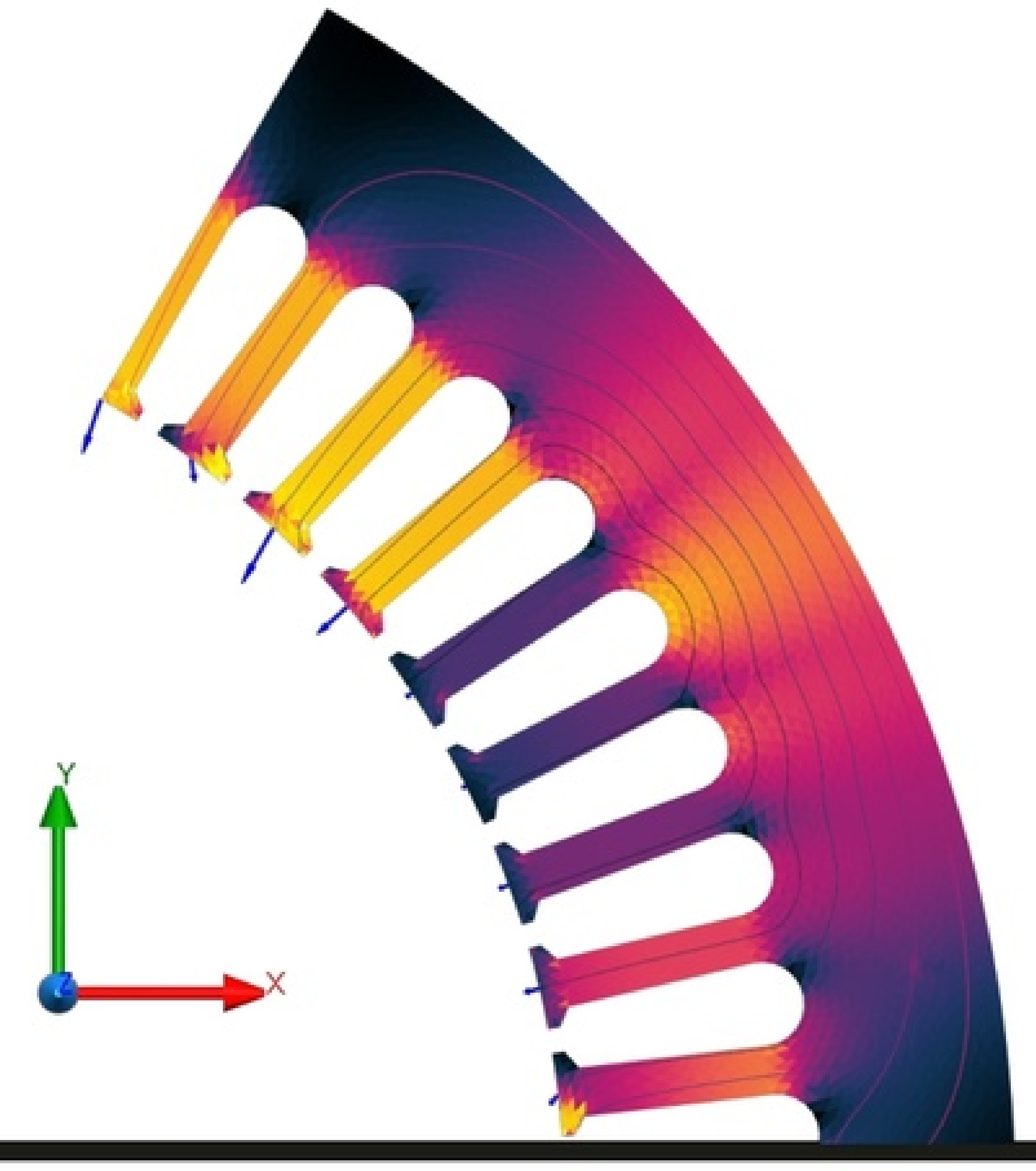

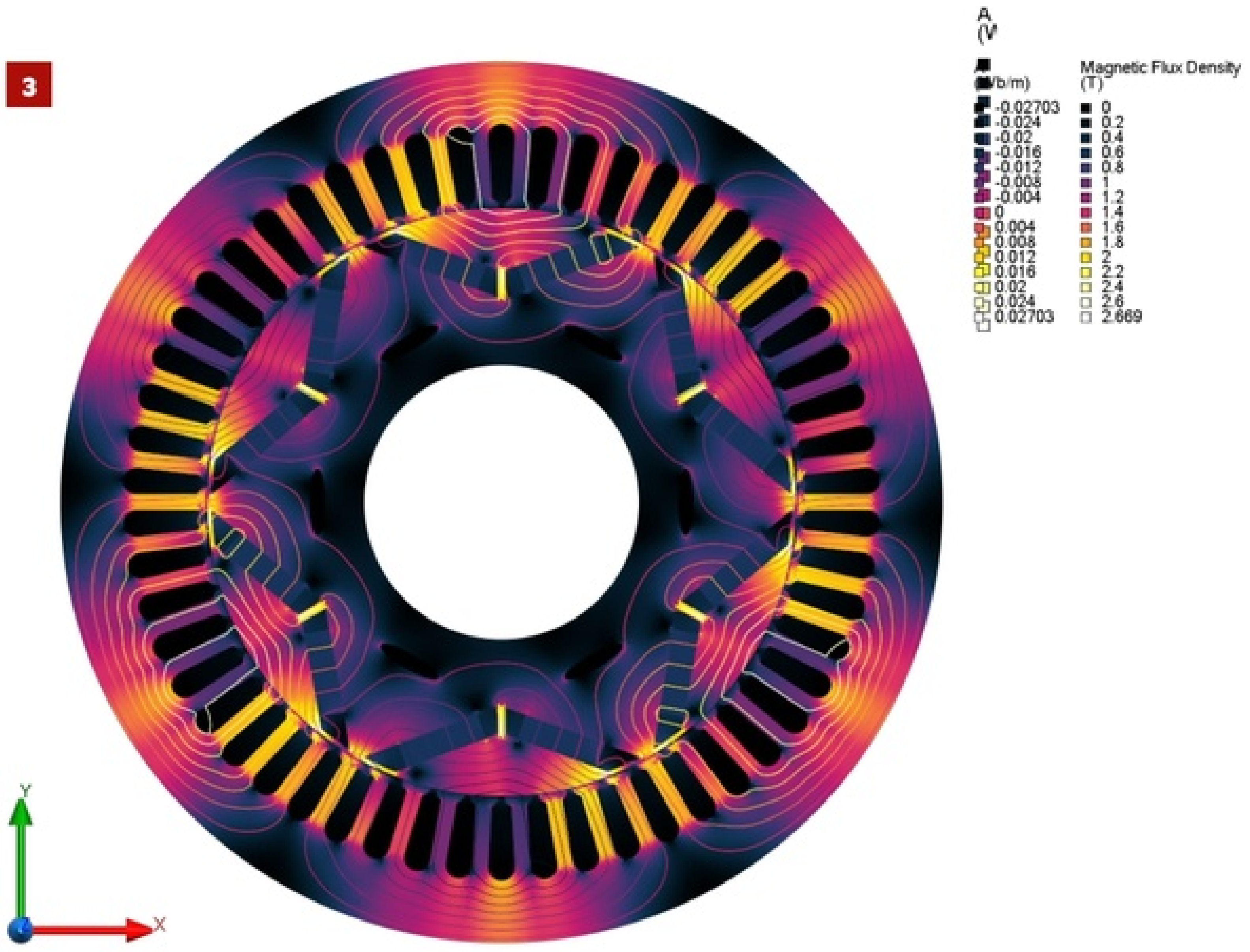

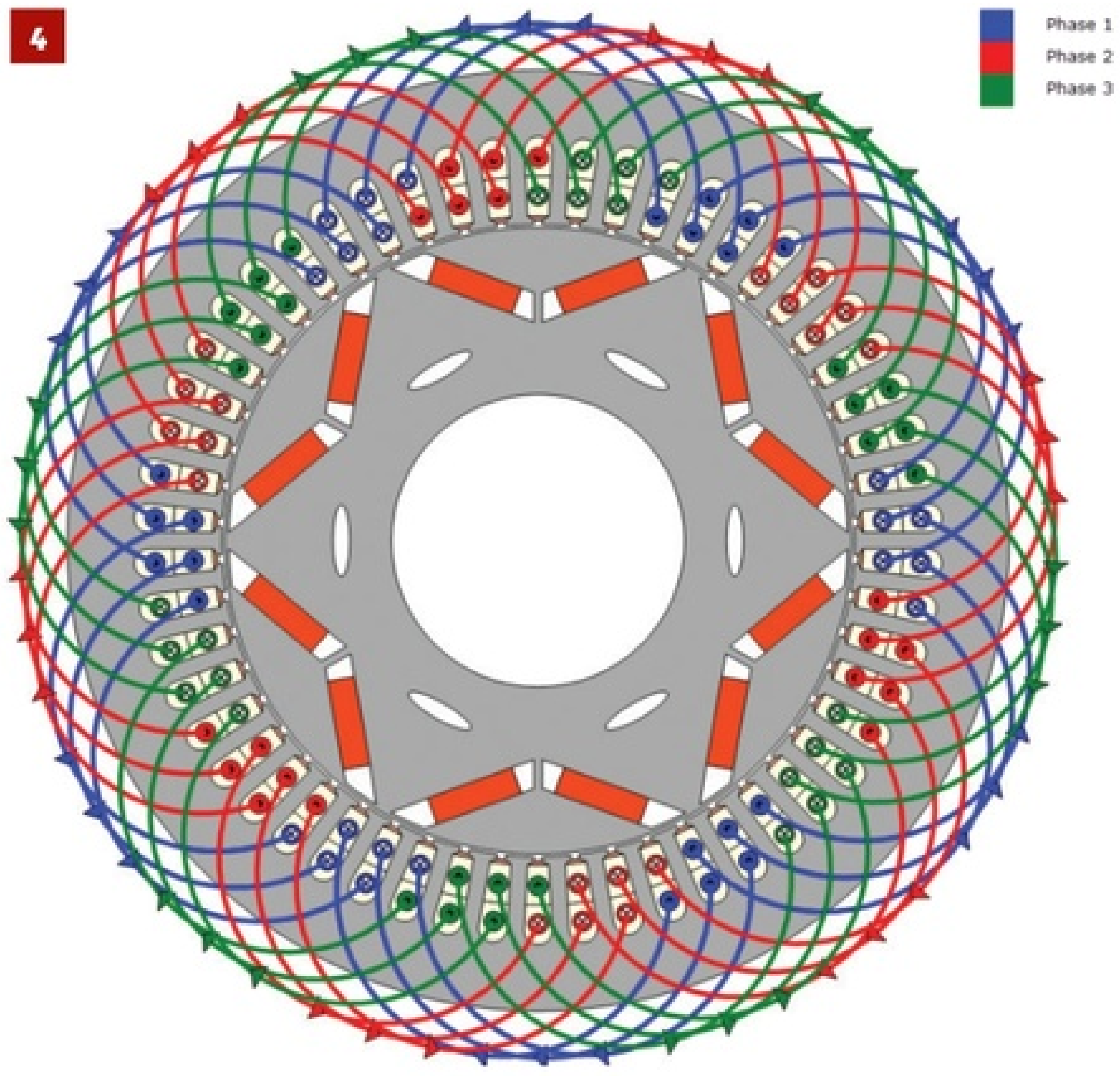

requires. Both static and dynamic eccentricity can also be included in the setup.

Load cases can be grouped and then analyzed individually or in parallel as part of the group. This allows quick and easy comparison of performance at multiple operating points. Also provided is the facility to generate map-based models for faster calculation of important machine characteristics such as speed-torque curves and efficiency maps. These are very important performance metrics for electric machines, and the ability to generate these results quickly speeds up the design process considerably.

For any individual load case analysis, results such as magnetic vector potential, magnetic flux density, air gap force density and lumped tooth forces can be visualized to aid understanding and provide insight into machine behavior. Many results are also available as customizable tables and charts, and all underlying data that is presented in this way is fully available to the user.

The user can use MASTA's scripting tools to automate many of these tasks to speed up model construction, parameterization, analysis and load case setup and simulation. Scripts can also be used to extract results and perform various additional post-processing tasks as desired. For example, a user may wish to conduct a study of the sensitivity of harmonic distribution of stator tooth forces to tooth tip width or slot opening dimensions. The input parameters can be set, each required analysis performed, and results extracted and processed by a single script.

OPTIMUM FLEXIBILITY

By offering the user a high degree of flexibility in geometry specification, winding configuration, material selection and specification, analysis setup, calculation methods, and presentation and extraction of results, and the ability to automate many of these tasks via scripting, MASTA's electric machine functionality can be used at any point in the design process, from the early concept stage, when a large potential design space needs to be explored quickly and efficiently, through to the late detailed design stage, when highly detailed refinement and optimization may be required.

3. High fidelity electric machine analysis can be achieved

4. Even highly complex winding arrangements can be accommodated

This combines the best features of the existing tools on the market that are more focused on early concept development and design space exploration with the tools that offer a high degree of control to model specific features of machine design at any required level of detail.

Furthermore, the effect of interactions with the transmission can be included at any point in the design process. For example, noise and vibration is an inherently coupled, system-level behavior due to the mechanical coupling between the rotor shaft and transmission input and the shared housing structures used by the transmission, electric machine and power electronics. In previous versions it was possible to import electric machine excitation forces from third-party electromagnetic tools into MASTA and obtain the dynamic response of the mechanical system to those excitations.

Now MASTA 12 makes it possible to design and analyze an electric machine in detail and link its torque ripple and stator tooth force outputs directly to the mechanical system model that incorporates that electric machine design, without the need for third-party tools. This enables engineers, working within a single MASTA model, to not only predict the dynamic response to electric machine excitation forces but also analyze and understand how the machine design itself affects the excitation forces driving the response.

In summary, to meet the challenges posed by the increased integration of electric vehicle powertrain subsystems, MASTA 12 introduces detailed electromagnetic design and analysis of electric machines.

This brings many new and exciting capabilities to MASTA, including a uniquely powerful workflow for the full NVH analysis of motor and gear excitations and the dynamic response of the full electric vehicle powertrain to those excitations.

Future updates to the software will aim toward powerful automatic optimization capabilities and further high-fidelity analysis of the coupling between electric machine and transmission. ⦿