Multiphysics simulation tools for designing motors for traction applications in hybrid and electric vehicles

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ABSTRACT

Many of the issues involved in motor design have a complex nature which requires multiple fields of physics such as electromagnetics (EM), mechanical and thermal. All these physics are usually interdependent and have to be considered collectively in order to obtain optimal performance for a particular scenario. To address this situation, a multiphysics analysis that can link several EM, thermal and stress analyses has been implemented in the Opera FEA software suite [1]. Opera's Machines Environment (parameterised template software for designing motors and generators) has been extended to allow easy setup of coupled multiphysics analyses such as EM – thermal and EM – stress. These developments were part of a collaborative development programme named Rapid SR project [2] between Cobham Technical Services, Jaguar Land Rover and Ricardo.

The multiphysics analysis developed in the Opera FEA suite automatically transfers results from any particular stage for direct use as input to any subsequent stage. For example, in a multiphysics analysis where an EM stage is followed by a thermal one, all the losses evaluated from the EM analysis will be automatically transferred to the thermal analysis in order to evaluate the temperature rise in the machine. In order to further facilitate the coupling of different analyses, a link to the Python programming language was embedded in Opera FEA software. The embedded Python facility offers options to perform certain post-processing operations during the solving stage and hence allow data transfer between different stages of the multiphysics analysis. For instance, for the above example the losses are evaluated using a Python script, which does the post-processing over multiple time-steps in one steady state cycle from an EM transient analysis and passes this information to the thermal stage. It also serves as a tool for transferring data between Opera FEA and 3rd party scientific programs.

The Machines Environment has also been extended to offer a multiphysics analysis where the EM and stress stages are coupled. Forces obtained from the EM stage are used in the stress stage to calculate deformations; the deformed mesh thus obtained from the stress stage is fed back to the EM stage and the solution is recalculated. This is carried out in an iterative manner until user-defined convergence criteria are met. Simulation results capturing the multiphysics design process for traction machines are being developed as the part of the Rapid SR project and will be presented in the full paper.

REFERENCES

[1] Cobham Technical Services, "Opera Electromagnetics Finite Element Software Suite". www.operafea.com.

[2] Technology Strategy Board Collaborative R&D Project 400233 http://motor-design-software.com/news/research-programme-targets-nextgeneration-electric-motors-luxury-automobiles/