Case Study : CSIRO

Using ANSYS to Design Electrical Machines for Hybrid Electric Vehicles

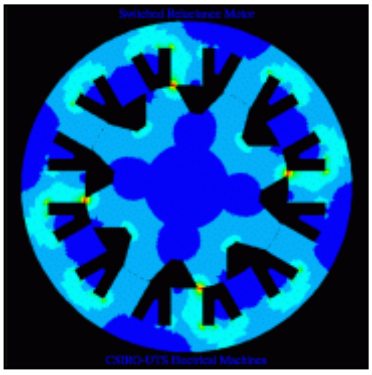
Background

Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed hybrid electric vehicles (HEVs) in conjunction with the Australian automotive industry.

The resultant two vehicles are the parallel hybrid GM Holden ECOmmodore and the series hybrid aXcess. Their website can be viewed at http://www.tip.csiro.au/Machines.

In combination with experience from previous designs, simple lumped-parameter thermal models, and computer search techniques, CSIRO used ANSYS electromagnetic, thermal and structural analysis to optimise the designs.

Promising engine solution



HEVs offer a promising compromise solution to fill the gap between the conventional internal combustion engine vehicle and purely electric vehicles of the future, powered by fuel cells. HEVs generally have a combustion engine and an electrical energy storage system.

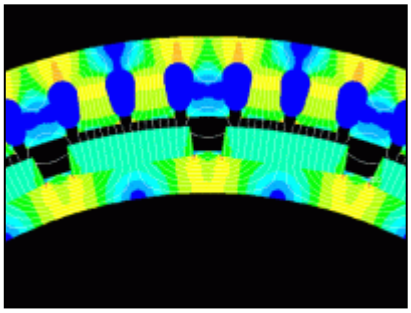
The basic principle of the HEV is that the electrical energy cuts in and the combustion engine switches off when the latter would otherwise have to operate inefficiently, eg at traffic lights or at low part-loads.

The use of supplemental electrical energy leads to a smaller combustion engine, improves fuel consumption (with a consequential reduction in pollutant emissions) and overcomes range limitations and recharging problems associated with battery electric vehicles.

A switched reluctance motor (SRM) is well suited to the electric propulsion of a hybrid electric vehicle (HEV), due to its simple and rugged construction, low cost, and ability to operate over a wide speed range at constant power.

Using ANSYS to help optimise the design

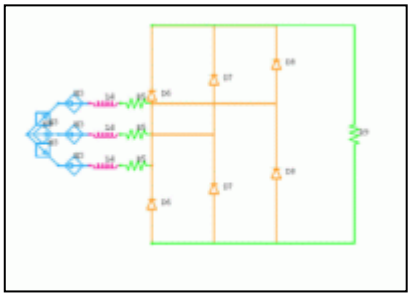
The design procedure CSIRO used for their motors was based on computer search techniques to minimise the total cost of the motor. The first stage is a thermal calculation to determine the maximum current.



Historically these calculations have been based on a lumped parameter thermal model but they now employ ANSYS thermal analysis.

With the current determined, they then use ANSYS electromagnetic analysis to predict the performance and occasionally run an ANSYS mechanical analysis to assess vibration behaviour.

With the results of these analyses, CSIRO could then run automated computer search techniques to optimise the design against the penalty function and within constraints. CSIRO would typically run about 1000 trials on the computer before finalising a design.



CSIRO also used ANSYS circuit modelling capabilities to analyse the whole machine with its electrical circuit. With this approach, they could check the operation of the generator at fault conditions like short-circuit.

Although the design example was optimised for minimal cost, it nevertheless exhibited a high efficiency in operation.

Validation of design process

Test results of the prototype SRM have shown that the design goal was achieved and the design optimisation routine validated.

The experience obtained from tests on the prototype was used to improve the thermal design of the SRMs for two HEVs.

The two cars have demonstrated excellent performance with the optimised SRMs. CSIRO have found ANSYS to be a comprehensive and accurate tool for many stages of the engineering design process.