QCIF Technology Diffusion Project

Final Report

For

The Magnetica Extension Project

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Application of Finite Element Techniques to the Development of MRI magnets

Technical Highlights of the Year

1. Prototyping and bucket testing of the first MRI magnet have been completed. The targeted field strength has been successfully reached in the test.
2. Based on the shimming algorithm proposed, a passive shimming optimization program to minimize magnetic field errors has been successfully developed. By using of the program, a field error of up to thousands ppm that is likely caused in practice can be reduced to less than 5 ppm. This is a major technical breakthrough in Magnetica.
3. Over the year we have developed a number of preliminary designs and on the basis of these, won a bid with our partner to develop a prototype for a new magnet product.

Major Achievements

This project is in collaboration with other staff at Magnetica Ltd to develop new and high performance MRI magnets. In the past year, a number of MRI magnet products with various field strengths and the full currents from 100-500 AMP have been designed and developed. In the design of these products, a large number of iterative stress analyses have been done, simulating the processes of cooling down from the room temperature (300K) to the working temperature (4K) and charging up to the full current, at differing levels of detail, from preliminary/macro to detailed/micro scales. In addition, a passive shimming optimization program to minimize magnetic field errors has also been developed.

Major achievements are summarized as below.

(1) Further improvement and modification of the stress analysis program has been undertaken in order to speed up the modelling procedure and to incorporate more material properties. The program is to perform nonlinear stress analysis of magnets under thermal, electromagnetic and/or vacuum pressure loads, with composite material properties taken into account.

(2) According to the test results, modification and redesign of the first MRI magnet product for cost and ease of manufacture have been completed. The redesigned magnet is now in testing.

(3) Thermal and mechanical stress analyses for the cryostat of the first magnet have been completed.

(4) Winding optimization for the specialist magnet has been completed by using of the winding optimization program developed in the first stage of the project in 1996. The optimization results have been applied to guide the winding procedure of the magnet.

(5) An optimization algorithm for passive shimming has been proposed to minimize field errors caused in practice due to manufacturing errors. Based on the algorithm, development of a shimming optimization program has been completed. By means of the program, a field error of up to thousands ppm that is likely caused in practice can be

reduced to less than 5 ppm, while iron piece thicknesses can be minimized to less than 1 mm with a limited number of iron pieces.

(6) A number of preliminary stress analyses for various field strengths of whole body magnets have been completed. Figure 1 shows the deformation of a magnet.

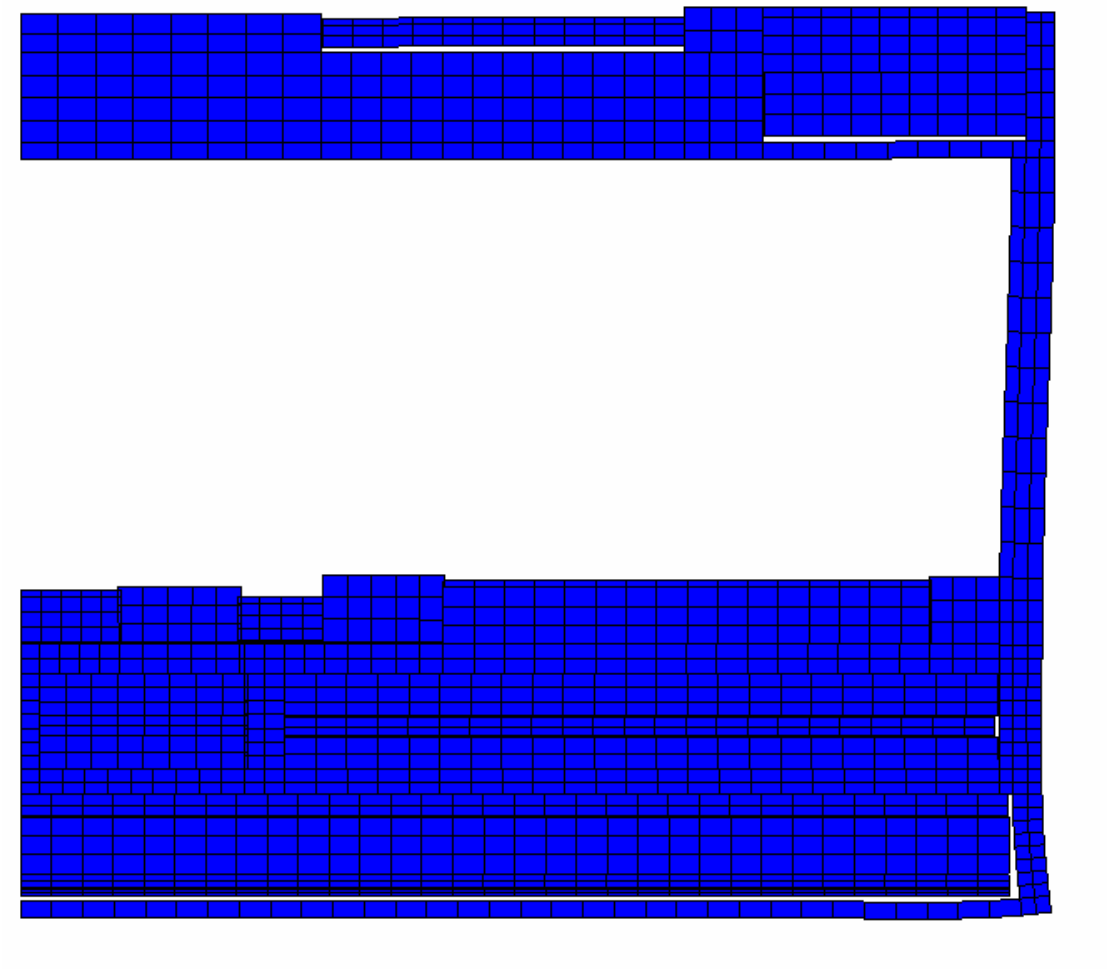

Figure 1. The Deformation of a Magnet