Automation of Finite Element Aided Design Optimisation of Induction Motors Using Multi-Slice 2D Models

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Abstract **- With power of computers continuing to increase, opportunity to harness finite element analysis as part of the design process becomes more realistic; however, its use is still often the province of a specialist. In this contribution a general-purpose commercial 2D electromagnetic finite element analysis software package has been used – in conjunction with Matlab programming language and Microsoft Excel – to perform automated simulation, performance analysis and optimisation of induction motors. The paper provides details of the development of a design office tool employing time stepping analysis that encompasses 3D effects due to rotor bar skew.**

INTRODUCTION

It is common engineering practice for designers of small electrical machines to rely on empirical tools for prototyping and past experience to refine the design. Moreover, unless a device has some peculiar features necessitating a study of 3D effects, finite element (FE) analysis of the design is rarely employed. Consequently, expertise in the use of FE software for machine design tends to lie outside the design office.

This work is an attempt to prove an efficient and user-friendly tool that can be used by the designers. The package utilises commercially available 2D software in combination with Matlab and Excel and is capable of modelling some 3D effects due to rotor bar skew. The suite forms a practical design office tool where expertise in FE and extensive machine design knowledge are not prerequisites. High level of automation is achieved while the designer retains full control of the process. Performance prediction and optimisation are built-in features of the proposed system.

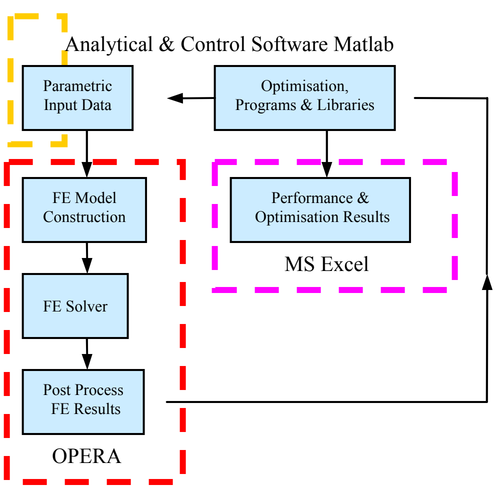

Fig. 1. Flowchart of the design / optimisation system.

DESCRIPTION

Basic design data in parametric form, typical of the information normally handled by the design engineer, is processed in an automated fashion within a main controlling program generating data suitable for use in the FE software (which is invoked as a subroutine from the main program). The resulting output from the performance module that characterises the machine using typical parameters is saved directly into MS Excel, thus avoiding the need for the designer to interrogate the FE solution.

As a further aid to the designer, the program employs an optimisation facility utilising Matlab optimisation algorithms available within its optimisation toolbox, together with the minimal function calls approach described in [1].

EXAMPLE

A 6 pole 400 Hz induction motor has been analysed and optimised for efficiency (with constrained torque) in terms of three design parameters: stack length, outer radius of the stator back iron and radial slot depth of the stator. The performance of the practical machine is shown in Fig. 2 with convergence of a typical optimisation process illustrated in Fig. 3.

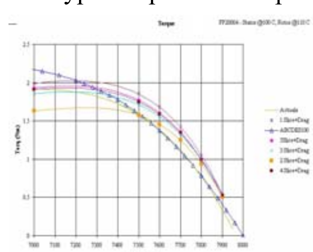

Fig. 2. Performance curves

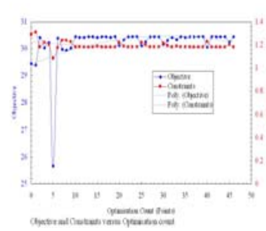

Fig 3. Optimisation process

CONCLUSIONS

The use of three commercial packages to form a single practical design tool has been introduced in this paper. The package provides designers with easier access to FE analysis and places less emphasis on design experience and prototyping to achieve optimum results. Testing continues but has already shown reliable performance and good accuracy.

REFERENCES

[1] J.K. Sykulski, A.H. Al-Khoury and K.F. Goddard, "Minimal function calls approach with on-line learning and dynamic weighting for computationally intensive design optimization," *IEEE Transactions on Magnetics,* 37(5), pp. 3423-3426, September 2001.