Coupled Computation of Electric Motor Design and Control Parameters based on Ant Colonies Speed Trajectory Optimization

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The multiplicity of operational and technical specifications, characterizing the design of electric drives, favors the application of coupled computation techniques. When the combined optimization of steady-state and transient-state operation is required in terms of energy efficiency versus speed performance, the coupled computation of electric motor design and control parameters can be utilized. In this paper, a particular electric motor design technique is introduced, based on the simultaneous optimization of motor steady-state performances and speed controller transient responses. The proposed methodology has been applied for the optimization of a Permanent Magnet Synchronous Machine (PMSM) drive and offered practical reduction of the complex optimization criterion cost when compared to the decoupled approach. Implementation of the resulting drive system has been undertaken, and overall performance improvements have been experimentally validated.

***Index Term*— Ant colony optimization, Design optimization, Energy efficiency, Performance evaluation, Permanent magnet machine.**

I. Introduction

DESIGN and control of traction motors based on multi operating points performance and efficiency criteria is nowadays a common place. This has been the result of numerous contributions, on the enhancement both of the design and control methodologies, applicable to electric drives [1]. Despite the extensive diffusion of methodologies, little work has been done on the integration of these tools on a system-design suit [2]. Moreover, a coupled optimization of the overall system is yet to be addressed.

In this paper a particular design concept is introduced, for the coupled computation of design and control parameters of electric motors, based on the optimization of the motor speed transient response. Specifically, an Ant Colony Optimization (ACO) routine has been developed for the computation of optimum motor speed trajectories, based on an integral drive system model. The latter has been coupled to a 0th order Rosenbrock-based motor design optimization routine, presented in previous work [3].

The proposed algorithm offered improved convergence characteristics, when compared to the decoupled motor geometry and controller gain optimization. The resulting drive system configuration has been experimentally tested under several control input profiles and efficiency improvements have been experimentally validated.

II. System Layout and Operation

The optimization suit comprises of the motor geometry and the speed trajectory optimization modules (modules "A" and "B" respectively), as illustrated in Fig. 1 and eq. (1).

At k-iteration, each module contributes to a subset of the objective function terms. For the evaluation of these terms, iterative calls to particular system models are generated by the optimization modules A and B. More specifically, module A iteratively calls the 2D FEM of the PMSM in order to compute its steady-state performance characteristics, through a two-step analysis, described in paragraph II-A. Module B, respectively, calls an integral Matlab/Simulink model of the vector controlled, Maximum Torque Per Ampere (MTPA), PMSM drive, in order to assess the dynamic performances of the motor, in terms of energy consumption versus speed response time (paragraph II-B). This has been achieved by interfacing an ACO routine with the drive system model that enabled the computation of optimum acceleration paths for each geometry under consideration.

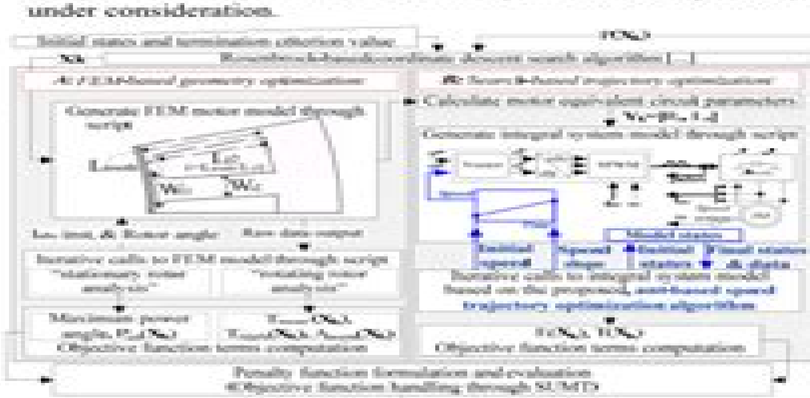

Fig. 1. Optimization system layout.

$$F^{k}(\mathbf{X}_k) = G_1 \frac{T_{mean}(\mathbf{X}_k)}{T_{mean}(\mathbf{X}_0)} + G_2 \frac{T_{ripple}(\mathbf{X}_k)}{T_{ripple}(\mathbf{X}_0)} + G_3 A_{turns}(\mathbf{X}_k) + G_4 \frac{T_{mean}(\mathbf{X}_k)}{\sqrt{P_{cs}(\mathbf{X}_k)}}$$

$$\left(\frac{T_{mean}(\mathbf{X}_0)}{\sqrt{P_{cs}(\mathbf{X}_0)}}\right)^{-1} + G_5 \frac{C(\mathbf{X}_k)}{C(\mathbf{X}_0)} + G_6 \frac{E(\mathbf{X}_k)\big|_{\min(G_7 E(\mathbf{X}_k) + G_8 T(\mathbf{X}_k))}}{E(\mathbf{X}_0)} + \quad (1)$$

$$+ G_7 \frac{T(\mathbf{X}_k)\big|_{\min(G_7 E(\mathbf{X}_k) + G_8 T(\mathbf{X}_k))}}{T(\mathbf{X}_0)} + R^k \sum 1/(g_i(\mathbf{X}_k)), \quad R^k > 0$$

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Optimization Of Design And Computation Of Control Networks

Jochen Bundschuh,Mario César Suárez A.

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solutions of the corresponding mathematical models The book also presents the form in which specific useful models can be generated and solved The text is introductory in the sense that it explains basic themes of the systems mentioned in three areas engineering physics and mathematics All the laws and equations introduced in this book are formulated carefully based on fundamental physical principles This way the reader will understand the key importance of mathematics applied to all the subjects Simple models are emphasized and solved with numerous examples For more sophisticated and advanced models the numerical techniques are described and developed carefully This book will serve as a synoptic compendium of the fundamentals of fluid solute and heat transport applicable to all types of subsurface systems ranging from shallow aquifers down to deep geothermal reservoirs The book will prove to be a useful textbook to senior undergraduate and graduate students postgraduates professional geologists and geophysicists engineers mathematicians and others working in the vital areas of groundwater and geothermal resources **Surveying and Mapping** ,1981

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