Torque Control for Brushless AC Motor using Finite Element Technique Simulation

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Abstract— In the present research a new method to measure and control the torque produced by Brushless AC motor is introduced. In the proposed technique, a new Finite Element Analysis is used to model the Permanent Magnet Synchronous Machines PMSM motor and its sensors. The vector field oriented control for a surface mounted PMSM used for controlling the torque. The control loop could successfully control the torque produced by the motor. Our new method showed persuading results of the good performance of the PMSM.

Keywords: Synchronous motors, Permanent magnet motors, Variable speed drive, Finite Element, Electric machines.

1. INTRODUCTION

Permanent magnet AC machines are synchronous motors with permanent magnets mounted on the rotor and poly-phase armature windings located on the stator. Since the field is provided by the permanent magnets, the PM machine has higher efficiency than other AC machines such as induction and switched reluctance motors. It also draws better power factor and has higher power density. The advantages of Permanent Magnet Synchronous Machines (PMSM), combined with the decreasing cost of permanent magnets and the advancement in the area of modern power electronics has allowed researchers a great deal of flexibility in implementing complex control routines. Consequently, these have led to a widespread use of PMSM in many variable-speed drives such as robotic actuators, computer disk drives, domestic appliances, automotive applications, and heating-ventilating-air conditioning (HVAC) equipment (Gieras and Wing, 1989).

Several control techniques have been introduced and implemented to enhance the operation and the performance of AC machine drives (Gieras and Wing, 1989). However, with the advent of vector control techniques inverters, the development of AC motor drives enters a new era. The control of AC machine acquires every advantage of DC machine control and frees itself from mechanical commutation drawbacks. Therefore, PMSM are becoming more and more popular in high-performance industrial AC drive applications (Ong, 1998).

The analysis and design of complex motor drive systems such as (PMSM) drives is usually done utilizing modern simulation software which can provide accurate predictions of the system's behavior in reality (Ong, 1998, Shahian and. Hassul, 1993; Bimal and Bose; 2002, De Gersem et al., 2000; Ho et al 2001; Jabbar et al., 2003, Pedro et al., 2003; Petkovska and Cvetkovski 2006; Vas, 1998). Consequently, computer modeling of such systems at a desired level of accuracy becomes an essential part of the design process. A satisfying system model usually serves as a prototype for the system behavior simulations, as well as the small signal analysis and control design.

In this paper, the vector field oriented control for a surface mounted PMSM will be introduced. And the implementation of this model using the Matlab and Finite Element Analysis (FEA) will be presented.

2. FINITE ELEMENT MODELING OF PMSM

The finite element method is a direct numerical computational method which provides an approximated solution to a large number of complicated engineering and physical problems, which can be described by partial differential equations.

In the coupled system, the known input is terminal voltage (or current) and terminal current (or voltage) is computed as unknown quantity. In case of the electric motor, the Mexwell's equations of electromagnetic are coupled with the stator circuit equations and rotor motion equations. These equations are solved simultaneously at each time step. The solution of each step is not independent; each solution is

