ESTIMATION OF THE INDUCTION MACHINE PARAMETERS FOR SIMULATION OF A MIXED-FREQUENCY TEST.

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ABSTRACT.

Mixed-frequency testing of large induction machines is established as a method of causing full-load losses to occur in the machine without the need for a load on the shaft so that temperature rise can be measured. The conventional arrangement for mixed-frequency testing uses a 1.0 p.u. 50Hz voltage waveform drawn from the main supply on which, typically, a 0.2 p.u. 40Hz waveform is superimposed using an auxiliary supply. This paper reports on a convenient set of tests and associated processing of results which can be performed to evaluate the parameters of the induction machine before a suitable mixed-frequency test is performed to determine the full-load temperature rise. The induction machine in this case is driven from a standard inverter which uses PWM to produce a sinusoidal component of voltage whose amplitude and frequency can be modulated by an external function-generator.

INTRODUCTION.

There is an established body of literature based on the estimation of the parameters of an induction machine. This can be divided broadly into two areas; machine testing for full-load steady-state running of the machine, and dynamic machine testing which is associated with the field-oriented control of the induction machine. On the one hand the contributions indicate how various tests can be used to determine the machine parameters in the established "T" equivalent circuit for induction machine [1,2,3]. On the other hand, the machine dynamics are expressed in terms of a d-q axis model and emphasis is placed on determining the rotor time-constant T_R as well as the angle of the rotor flux [4,5]. Though excellent work has been done in the two distinct areas, the problem addressed in this paper has not been directly addressed before to the authors' knowledge-namely to identify those machine parameters relevant to the behaviour of a machine on mixed-frequency test. Among these are the machines rotor inertia, core loss characteristics and the saturation characteristics of the stator and rotor iron cores [6,7]. The simulation model of the machine uses the phase-equations of necessity rather than d-q axis modelling [8].

This paper focuses largely on the simulation model used and experimental data are presented which support the use of this model. The experimental study begins with determining approximate values for the important parameters as found from the conventional locked-rotor and no-load tests. The no-load and locked rotor tests are then repeated using the inverter in order to investigate the motor parameters over a variety of conditions. A set of parameters is found which matches the experimentally determined behaviour of the machine. Once the parameters are found, series of simulations can be carried out to establish the details of a mixed-frequency test which will cause the requisite losses on the both stator and rotor and thereby provide a true temperature-rise test for the machine.

THE MACHINE MODEL.

The equations governing the dynamic behaviour of the induction machine are ordinarily expressed in terms of vectors (phase voltages, currents and flux linkages) containing 6 entries each and 6x6 matrices for resistance and inductance. Sarkar and Berg [8] present a typical treatment. It is more appropriate for our purposes initially to separate the variables associated with the stator and rotor. The machine model used here incorporates the effects of saturation and core losses both of which are known to be important effects in transient circumstances. The development of this model is presented fully in another paper [9] by the authors. There have been several papers dealing with the incorporation of saturation into the simulation of induction machine but these have dealt with the machine in d-q co-ordinates.

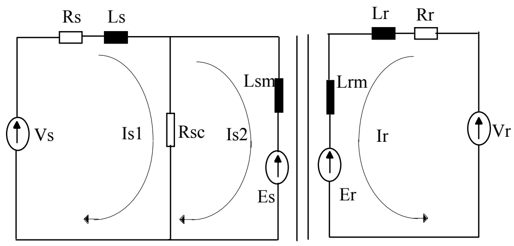

Fig. 1 Equivalent circuit of induction machine.

The present authors have shown that there is, in fact, little penalty to be paid for modelling the machine using the phase variables, and the advantages of using the phase variables are well known.