ASPECTS OF MIXED-FREQUENCY TESTING OF INDUCTION MACHINES

LES ASPECTS DES ESSAIS FREQUENCIES MIXTES DES MACHINES INDUCTION

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Abstract

Testing of induction machines to determine the full load temperature rise is an essential part of the acceptance tests for large machines. There are several established alternatives to mechanically coupling the induction machine to a load machine, all of which give approximate results for the temperature rise. A suitably flexible inverter can provide a wide range of control over instantaneous voltage and frequency and hence, losses can be accurately disposed inside the machine. However, although the rms current flowing in the stator windings for a correctly-designed mixed-frequency test is (almost exactly) equal to the rated rms stator current, the mean power factor associated with the machine currents during the mixed-frequency test is virtually zero.

This paper gives a detailed analysis of experimental and simulation results for a mixed-frequency test on a 4 kW squirrel cage induction motor. A comparison is made between the temperature rises on normal full-load test and the corresponding temperature rises obtained from the mixed-frequency test. In addition, this paper proposes an economical set-up whereby the mixed-frequency testing can be conducted on a large induction machines without drawing substantial currents from the supply.

Introduction

There are several established methods of testing the induction machine for full-load temperature rise without coupling it mechanically to a load machine, all of which give approximate results for the temperature rise. Some of these methods involve feeding the stator with a non-sinusoidal voltage with the result that the rotor accelerates and decelerates alternately and the rated rms current can be made to flow in the stator. Different names have been given to these methods depending on the authors' preference and the particular voltage waveform employed. "Continuously-Varying-Frequency Tests" [1], "Mixed-Frequency Tests" [2], "Dual-Frequency Tests" [3] and "Superimposed-Frequency Tests" [4] all appear in the literature along with some more unlikely sounding names such as "Novel Machineless Dynamometer..." [5].

In recent years inverters have been proposed as the sole supplies for these tests and the advantages of using an inverter as the power supply have been discussed [2]. An inverter can be designed to provide a wide range of control over instantaneous voltage and frequency. If an accurate simulation model for the electromechanical aspects of the machine is available, then it is possible to use such an inverter to produce not only the correct total full-load power loss within the machine but also to obtain the correct disposition of the losses inside the machine between stator and rotor, copper and iron.

The essence of the mixed frequency test involves the test machine running alternately as a motor and as a generator. The long term rms current flowing between the supply and the machine is very high. Therefore, although the net average power flowing into the test machine is equal to the total losses of the machine, the connection to the supply must be rated for currents which may be twice the rated current of the machine. if the correct rms currents are to flow in the rotor of the induction machine, there is no alternative to transmitting energy across the airgap. The ideal testing-station for large induction machines in a manufacturers' works would be one which did not involve drawing large currents from the supply. This requires that the testing-station itself has some facility for the controlled storage and release of significant amounts of energy.

In this paper, the ability to model an induction machine on mixed-frequency test is demonstrated by the comparison of experimental and simulation results for a small (4kW) machine. The validity of the mixed-frequency test is also demonstrated by comparing the true full-load temperature rise of the test machine with the temperature rise from the mixed-frequency test. Then one possible design of the ideal testing-station for a manufacturer of large induction machines is proposed and the issues associated with operating such a testing-station are briefly addressed.

Temperature Rise Testing of an Uncoupled Induction Machine Using a Voltage Source Inverter

Full load temperature rise testing of induction machines can be achieved by using a voltage source inverter, as shown in Fig. 1. Four different modes of temperature rise testing of an uncoupled induction machine using a voltage source inverter have been suggested by the present authors [2]. Due to the constraints imposed by the particular inverter used in the laboratory, which is a PWM voltage source inverter having a voltage-frequency characteristic curve as given in Fig. 2, only two out of these four modes are tested on a 4 kW squirrel cage induction machine; the varying voltage, varying frequency (VVVF) test and the constant voltage, varying frequency (CVVF) test. Both tests were carried-out with the machine running freely. In order to make the tests more representative of the behaviour of large induction machines, the inertia of the rotor was increased by