Review of the Testing Methods for Full-Load Temperature Rise Testing of Induction Machines

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Abstract

Determination of the temperature rise as well as the power dissipated inside induction machines as heat is a matter of interest to both customers and manufacturers. This is important since it affects the insulation materials, the cooling systems and the efficiency of the machine. In this paper, some of established methods of full-load temperature rise testing of induction machines, such as direct loading test, back-to-back test, phantom loading test, forward short circuit test, variable inertia test and mixed-frequency test, have been reviewed. The experimental and simulation results of the mixed-frequency test using an inverter have then been analysed in detail.

Introduction

The testing of induction machine to determine the temperature rise as well as the power dissipated inside the machines as heat is a matter of interest to both customers and manufacturers. This is important since it affects the insulation materials, the cooling systems and the efficiency of the machine.

There are many established methods of full-load temperature rise testing of induction machines:

- Direct loading test
- Back-to-back test
- Phantom loading test
- Forward short circuit test
- Variable inertia test
- Mixed-frequency test

The most accurate and basic heat run of the induction machine is to load the machine shaft directly with a mechanical or an electrical load. This test is capable of producing the full-load current flowing into the machine and the full-load mechanical losses occurring inside the machine as well as the full-load rotor current flowing in the rotor bars at rated rotor speed. However coupling of a load to the machine shaft is not easy and hence the test is expensive due to the following reasons:

- The different size of half-couplings is needed for the different shaft size of machines.
- The load for the large machines occupies space and costs a lot of money.
- The load consumes energy.
- A large amount of current is drawn from the supply during the test.

Apart from the direct loading test, the back to back test, the phantom loading test, the forward short circuit test and the variable inertia test also require the mechanical coupling of the test machine to any other load machine. But the mixed-frequency testing method does not require any mechanical connection of the test machine to a load machine. In the following section, these testing methods are summarised.

Review of the established methods for the full-load temperature rise testing of induction machines

The back-to-back test is one of the testing methods for the full-load heat run of an induction machine. This test has two distinct merits, which are the economy and the accuracy. Because, in this test, the full-load size plant is not needed for loading and the major part of the test power is circulated rather than dissipated. Further, the loss is measured as a net input rather than as the small difference between two separately measured large powers. However, it requires coupling of two induction machines which will run at different speeds when generating or motoring. Thus direct coupling of two induction machines is not possible if two induction machines are operated from a constant frequency supply.

Christofides and Adkins [1] suggested a method of back-to-back test to overcome this problem as shown in Fig. 1, in where, the two induction machines are fed from the same power supply and coupled to two DC machines which are fixed on a stationary bedplate. As the stators of the two induction motors are strapped together and are free to rotate on their own bearings, the induction machine 1 is driven as generator at speed of ω_G while the induction machine 2 runs as a motor at speed of ω_M.The speed of these two induction machines can be adjusted until the stator frames have no tendency to rotate, which means that the torques in two couplings are equal. They concluded that, the input power P_{ac} supplies the stator losses and very nearly the whole of the load losses.