9.1 Introduction

The induction machine is by far the most commonly used machine around the globe. Induction machines consume approximately one third of the energy used in industrialized countries. Consequently this type of machine has received considerable attention in terms of its design and handling.

The induction machine is one of the older electric machines with its invention being attributed to Tesla, then working for Westinghouse, in 1888. However, as with most great inventions there were many contributors to the development of this machine. The fundamental operation principle of this machine is based on the magnetic induction principle discovered by Faraday in 1831.

In this chapter we will look at this type of machine in some detail. As with the synchronous machine a simple symbolic and generic diagram will be discussed, which in turn is followed by a more extensive dynamic model of this type of machine. Finally, a steady-state analysis will be discussed where the role of the machine parameters will become apparent.

9.2 Machine configuration

The stator with its three-phase winding as given in figure 8.1 on page 194, is used to develop a rotating magnetic field in exactly the same way as realized with the synchronous machine.

The rotor of an induction machine usually consists of a steel laminated rotor stack as shown in figure 9.1. The metal shaft is through the centre of this stack. The rotor stack is provided with slots around its circumference which house the rotor bars of the so-called squirrel cage. This cage, which consists of rotor bars attached to end rings, is also shown (without the rotor stack) in figure 9.1. The cage can be copper or die-cast in aluminium [Hughes, 1994].
A recent development in this context has been the introduction of a copper coating on the rotor designed to replace the traditional cage concept. In some cases aluminium fan blades are attached to the end rings to serve as a fan for cooling the rotor. The cage acts as a three-phase sinusoidally distributed short-circuited winding which has a finite rotor resistance [Hughes, 1994]. The number of turns of these equivalent rotor windings can be chosen at random, in which case it is prudent to set the number of turns equal to that of the stator, i.e. \( n_r = n_s \). This simplifies the equation set (7.23) which corresponds with the symbolic generalized two-phase machine model.

Some induction machines have a wound rotor provided with a three-phase winding where access to the three-phases is provided via brushes/sliprings (similar to the type used for the synchronous machine). This type of machine known as a ‘slipring’ machine, allows us to influence the rotor circuit e.g. to alter the rotor resistance (and therefore the operating characteristics) by adding external rotor resistance.

The squirrel cage type rotor is very popular given its robustness and is widely used in a range of industrial applications.

### 9.3 Operating principles

The principles are again discussed with the aid of section 7.3 on page 178. This type of machine has no rotor excitation hence the current source shown in figure 7.9 is removed and the rotor is connected to a resistance \( R_r \). This resistance is usually the resistance of the rotor winding itself. The rotor current is in this case determined by the induced voltage \( e_{m}^{xy} \) and the rotor resistance...