SYNOPSIS

The performance of Induction Machines with solid mild-stee rotors is purely characterized by the electromagnetic torque resulting from the eddy currents in the rotor reacting with the inducing field of the stator. These eddy currents have a distri bution and a definite depth of penetration beyond which the fiel quantities are negligibly small. It should, therefore, be of considerable interest to examine also the performance of rotors which are hollow, the wall thickness corresponding to nearly the depth of penetration. Finally, when the rotor is reduced to a thin cylinder, the iron is highly saturated resulting in a unifo distribution of the flux density across the section and the magne tising current for this situation is extremely large. It is wor examining the effect of a web of magnetic material in reducing the magnetizing current.

The scope of the thesis is to examine the behaviour of induction machine, (a) with solid rotors and (b) with hollow rotors with and without magnetic webs, when run as a d.c. dynamic brake or as an induction motor. For each class of machines both types of rotor terminations (i) without copper end rings, and (ii) with copper end rings are considered. The development of the subject matter is on the following lines:

1. The magnetic field distribution inside the rotor is governed by Maxwell's equations, and the electric and magnetic properties of the material. The existing linear theories[1][10] for analysing the performance of solid rotor machines have the

serious limitations in that, they fail to account for both the observed increase in loss and increase in power factor for the machine. Consequently, the analysis has to take account of the non-linearity of the magnetisation characteristic of the material of the rotor. Methods[2],[3],[9],[11] are available, to take account of saturation and these methods theoretically establish the increase in power factor and loss due to saturation.

However, no method is available for experimentally verifying the validity of these non-linear theories in the sense of experimentally determining directly the power factor and the equivalent circuit of the rotor. This is a special feature of this Chapter. Performance equations of the rotor worked both as a d.c. dynamic brake and as an induction motor are obtained and applied to test results.

2. For the study of hollow rotors, the existing linear theory for solid-rotors requires considerable modification in view of the fact that a definite value of the magnetising force exists in the inner surface of the rotor, the value increasing as the wall thickness of the rotor decreases. This has been attempted. Furthermore, although the current in the magnetising winding is restricted to only one direction, it creates a general two-dimensional current density distributions in the rotor in planes parallel to the plane of the magnetising winding. For such a situation it is difficult to visualise the impedance of the rotor. A new concept of power factor of the rotor is introduced leading to expressions for both the power factor and the impedance. Next, to take account of saturation, the linear theory is applied

to a rotor of definite wall thickness by choosing a suitable value of the permeability corresponding to the surface magnetizing force. On this basis, performance calculations have been made and compared against test results.

3. To account for the effects of saturation, the performance of the hollow-rotor induction machine is analysed by the following methods:

(i) the limiting non-linear theory[3], and (ii) the step-by-step graphical construction[9]. These are compared against test results. The experimental technique discussed in Chapter 1 has now to be modified to take account of the existence of a definite value of the magnetizing force on the inner surface of the rotor. The experimental results are extensive and cover a range of thicknesses varying from 3/4" to 1/8" in steps of 1/8". An overall review of the investigations included in Chapters 1, 2 and 3, bring out forcibly an important aspect of the saturation phenomena. Consider, for example, the rotor power-factor. For a solid-rotor, that is, for the case when the wall thickness far exceeds the depth of penetration of the flux, the linear theory does not predict a power factor greater than 0.707. When the permeability is chosen as $\mu = \left(\frac{dB}{dH}\right)_{H=0}$, the experimentally observed power factor exceeds this value. On the other hand, when the wall thickness is decreased, the experimentally observed power factor <u>falls short of</u> that predicted by the linear theory for the corresponding thickness. A similar conclusion holds good for all other quantities, namely torque etc. The virtue of the non-linear methods presented is that, that they predict these quantities over the entire range of thicknesses in reasonable conformity with the test results.

4. It is obvious from the results of Chapter 3 that a large magnetizing current exists for a purely hollow-rotor. In order to reduce this and its undesirable effects, a thin web of magnetic material was provided in the hollow region. An improvement in performance is observed. An analysis to take account of the discontinuity in the magnetic circuit by the presence of the web is extremely complicated, but an attempt is made to analyse such cases by extending the methods discussed in Chapters 2 and 3.

5. The foregoing analyses for the prediction of the performance have been based on assumed field distributions and verified on the basis of overall effects in the form of torque-speed characteristics, etc. However, an experimental determination of the distribution of field quantities themselves and their possible modes of attenuation will be of fundamental importance, but very little progress has so far been made along these lines[13]. A special feature of this Chapter is to determine these quantities experimentally. Enough experimental evidences are presented to warrant the conclusion that there is a real need to examine afresh the problem of flux penetration in magnetic cores which would give an insight into the secondary effects observed.