SCOPE OF THE THESIS

Theoretical and experimental investigations on Eddy Current Phenomena in Ferromagnetic materials have, for the past quarter of a century, confined themselves to the following aspects:

(1) Effects of eddy currents on wave-form distortion in magnetic cores subjected to a pulsating field, and

(2) The effects of eddy currents on the pulsation and other surface losses in laminated cores subjected to rotating magnetic fields.

The classic experiment of Brailsford[11] helps to an understanding of the first problem; whilst, the works of Carter,[12] Spooner and Kinnard[13], Gibbs[2], Bondi and Mukherjee[14], and Mukherjee and Greig[15] give an insight into the problem of surface losses in machines, mentioned in (2), and suggest methods of predetermining them. However, in either case, the problem is purely a linear one in the sense that the strength of the inducing field is limited to the linear region of the magnetisation curve of the material.

There is another important aspect of the problem with wide practical significance that is receiving great attention in recent years[1,2,3,4,5,6,7,8,9,10]. It is the electro-mechanical effects of eddy currents in solid cores when subjected to rotating or pulsating magnetic fields. The complexities of the problem are further enhanced when the core is saturated.

The scope of the present investigation is confined to a detailed study of the effects of eddy current phenomena in solid cores. The development of the thesis is on the following lines:

1. Maxwell's equations are applied for the determination of field distributions in solid cores subjected to different types of time-varying fields. On the basis of these, the eddy current loss in solid iron cores and the mechanical torque in solid iron rotors are evaluated. Such an analysis, although based on the assumption of constant permeability, helps to gain an insight into the concepts associated with flux-penetration, the rotor power factor and the eddy current distribution and the dependence of these on the electric and magnetic characteristics of the rotor materials. It also brings out the predominant influence of saturation for the lack of agreement between theory and test results.

2. As a preliminary to the study of the influence of saturation, the thesis examines the rise of flux and current in a solid core when its exciting winding is subjected to a sudden d.c. supply – the voltage sufficiently large to make the core operate far in the region of saturation. This investigation leads to a new concept that helps to

predetermine the eddy current distribution and its variation with time. The extension of the concept leads to an analysis that agrees closely with experimental results.

3. The thesis next takes up the determination of eddy current losses in a solid toroid when the strength of the inducing field is worked far into the region of saturation. This calls for a different mathematical formulation of the concept developed in (2) and its solution. The study of the differential equations arising out of it leads to an elegant normalised graphical construction. The results of this method can be applied with simple modification to materials of widely different electric and magnetic properties. Furthermore, an analytical solution has been discovered and simple expressions are obtained for eddy current losses, the depth of penetration of flux and the power factor.

4. Next, the thesis examines the problem of predetermination of the performance of solid rotor machines, when the rotating magnetic field strength is in the region of saturation. The results of (1), (2) and (3), are made use of and modified to arrive at a new method of predetermination. This method, when compared with existing methods, yields results that are sufficiently close to experimental data.

5. Finally, the thesis develops a graphical method of solving a type of two-dimensional field problem under linear conditions. This results in an original treatment. An extension of the method to take into account non-linearity is suggested and its implications examined.