CHAPTER - ONE

EXPERIMENTAL SET UP AND REVIEW OF EARLIER WORKS

1.1 INTRODUCTION

Eddy current brakes, magnetic as well as nonmagnetic, are in use for more than seventy years and several investigators have presented different methods of analysis to predict their performance[1,2,4,5,6,14,15,16,17,18,19,21,23,24,30].

Among the investigations on nonmagnetic brakes, those of Rogowski[17], Rudenberg[19] and Smythe[23] are particularly significant. Rogowski has analysed the performance of energy meter disc brakes with permanent-magnet rectangular poles. In these brakes the reaction effects of the induced currents can be neglected because of the hard magnetic nature of the poles and low speeds of operation. The main contribution of Rogowski's analysis lies in finding the effective resistance of the disc on the assumption of uniform flux distribution under the pole. Smythe has dealt with the same problem but with circular poles. He has also extended his analysis to electro-magnetic brakes by approximately accounting for the demagnetizing effects of the induced currents, thus making the results applicable over a wide range of speed. The analyses of Rogowski and Smythe are specifically intended for brakes with a single pole pair or when the pole pairs are far apart.

For nonmagnetic brakes, excited by several pole pairs, Rudenberg has presented a different method of approach. In his analysis, the air gap flux density is expressed as Fourier series in appropriate space coordinates and due attention is paid to take into account reaction effects of the induced currents as well as the edge effects of the conducting sheet on the eddy current distribution.

Among the investigations on magnetic brakes, the works of Rudenberg[19], Rosenberg[18], Gibbs[4] and Davies[1,2] are significant. Hansen and Timmler[5] and Pansenkov[12] have also contributed towards the analysis of such brakes. With magnetic brakes the nonlinear nature of the B-H curve of the material introduces additional difficulties in the analysis. Rudenberg assumes a constant permeability for the material and this results in prediction of maximum torque which is much lower than experimental value. Gibbs and Davies have taken into consideration the nonlinearity of the B-H curve but not in a satisfactory manner. Further, in most of the analyses on magnetic brakes the fundamental component of the air gap flux alone is taken into consideration in calculating the brake force. At high speeds of operation and particularly with salient poles, the air gap field is severely distorted and the effects of harmonics cannot be ignored.

To check the validity of the different analyses listed above it is necessary to have a complete set of test results both on nonmagnetic and magnetic brakes. Regarding magnetic brakes, Davies has presented a valuable set of experimental data. Unfortunately such exhaustive test results are not available in literature in case of nonmagnetic brakes.

In this chapter a typical set of test results pertaining to nonmagnetic as well as magnetic disc brakes are presented along with the predicted values obtained on the basis of existing analyses.

1.2 DESCRIPTION OF THE EXPERIMENTAL SET UP

1.2.1 Nonmagnetic brakes: The nonmagnetic disc (made of copper or aluminium) is keyed to a phosphor bronze shaft supported by pedestal bearings at the ends. Arrangements are made to excite the brake either with a single pole pair or several pole pairs. For single pole pair excitation, Fig. 1.1, a U-shaped electromagnet (having 5066 turns) which can be fitted with either square or circular pole pieces is used. Suitable mechanical arrangements are made to vary the air gap and the distance of the pole centre from the centre of the disc.

For exciting the brake with several pole pairs the following construction is used. Six circular pole pieces are screwed to an annular iron ring. Field coils having 225 turns are pushed on to each pole and are connected so as to give alternate north and south poles. Another identical ring with the same number of poles and exciting coils is also made. These two rings are kept on either side of the nonmagnetic disc, Fig. 1.2, and are aligned in such a way that the poles of opposite polarity face each other and the air gap is nearly uniform on either side of the disc.

The brake is driven by a d.c. motor run by a Ward-Leonard set. The torque developed is measured with the help of a dynamometer mounted on the swivelling stator frame of the driving motor. Keeping the speed constant at any desired value, the torques are measured with ~~the~~ and without exciting the brake and the difference is taken as the brake torque.

The torque speed characteristics are obtained over the speed range of 0 to 1500 r.p.m. with different exciting currents and with copper and aluminium discs of different thicknesses. The temperature of the disc is measured by a thermometer immediately after obtaining the torque-speed characteristic over the full range of speed with constant excitation. A temperature drop of 5°C is assumed between the surface and the interior of the disc.

To measure the flux per pole a search coil of one or two turns of the same area and shape of the pole face is glued on to a thin card board which is pasted to the pole face. Also coils of smaller width (about 0.5 cm) are similarly used to measure the flux density distribution under the pole face. The ends of these search coils are carefully twined and connected to a flux meter. The flux is measured at any particular speed by reversing the exciting current.