INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Magnetic Field Analysis, Modelling and Vibration Control in Bridge Configured Winding Induction Machines

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SHORT ABSTRACT

Technological advancement in rotating machines demands integration of electrical motors or generators in high speed flexible rotors operating at a wide range of speeds. These machines present great rotordynamic challenges and at the same time they also present great opportunities through the ability to achieve transverse actuation (in two independent directions) without any significant sacrifice. These opportunities can be tapped by developing electrical machines which can produce controllable transverse force for active vibration control and also for fully levitating the rotor. The use of controllable transverse force for vibration reduction may lead to the high operating life of mechanical components.

Bridge configured winding scheme is a specialized winding scheme which can be used to generate transverse force efficiently in an electrical machine with a low power requirement along with its primary function as a motor or generator. This winding configuration consists of two power supplies and they are isolated from each other. One of the power supply is responsible for the torque production and the other is responsible for the transverse force production. However, the nature of the magnetic fields and the method of producing controllable transverse forces especially in an induction machine with bridge configured winding are not fully understood.

This thesis characterizes the presence of magnetic field components in a four pole bridge configured winding and proposes a bridge supply scheme which can be used for the generation of controllable transverse force of any desired frequency. The presence of eccentricity in parallel winding configuration electrical machines adds up an additional frequency component of the unbalanced magnetic pull in comparison with the series winding electrical machines. The bridge configured winding is also a parallel winding configuration and a detailed investigation of the generation of unbalanced magnetic pull is important to understand the phenomena of generation of the additional components of vibration. This thesis investigates the generation of unbalanced magnetic pull in a series and parallel winding configuration electrical machine by analyzing the air gap magnetic field. For this purpose, an electrical machine with series and parallel winding configurations has been modelled and analysed using COMSOL MULTIPHYSICS.

The force generation in bridge configured winding is directly related to the currents flowing across the bridge points. A coupled magnetic field and electric circuit model is developed in the MATLAB environment to analyze the behavior of bridge currents for static eccentricity, dynamic eccentricity and also combined both static and dynamic eccentricities.

A single or three phase of bridge supply leads to the generation of the force of multiple frequencies in a bridge configured winding electrical machine. A supply sequence is proposed based on the analysis of bridge configured winding orientation with respect to main and bridge supply which can be used for the generation of the force of particular frequency component.

Furthermore, the magnetic field and electric circuit equation model is coupled with the rotordynamic equation of the rotor bearing system to analyze the vibration patterns at different eccentricity conditions as well as at proposed bridge supply conditions. In addition to this, a simulation model is developed in MATLAB/SIMULINK to demonstrate levitation, and multiple frequency vibration suppression in a four pole bridge configured winding electrical machine using PID and convergent control algorithm.

Two experimental setups having induction machines with bridge configured winding have been developed to verify the results obtained from the numerical analyses.