Int J Syst Assur Eng Manag (Apr-June 2013) 4(2):118–128
DOI 10.1007/s13198-013-0164-7

ORIGINAL ARTICLE

Static eccentricity fault diagnosis using the signatures analysis of stator current and air gap magnetic flux by finite element method in saturated induction motors

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Received: 26 March 2013 / Revised: 27 May 2013 / Published online: 8 May 2013

Abstract Static eccentricity produces low frequency air gap flux components, however they can be observed in stator current spectrum only under mixed eccentricity, and for high degrees of rotor shifting. Unlike motor current signature analysis, the air-gap magnetic flux signature analysis allows to detect small degree of purely static eccentricity. The simulation results are obtained by using time stepping finite elements method. In order to indicate the influence of the magnetic saturation upon the analysis of the faulty induction motor, two constant and non-liner permeability; are included in this paper. It is shown that the fault index amplitudes of obtained signals from the constant permeability are larger than that of the real case. In this paper the amplitudes of characteristic frequency components $f_{ecc} = |f_s \pm kf_r|$ with low degrees of purely static eccentricity fault are detected using air-gap magnetic flux signature analysis. Moreover, new index signatures are detected around the third time harmonics in air-gap magnetic flux density spectrum for saturated motor, those components are expressed by $f_{ecc} = mf_s \pm f_r$.

Keywords Induction motor · Static eccentricity (SE) · Time stepping finite elements method (TSFEM) · Motor current signature analysis (MCSA) · Air-gap magnetic flux signature analysis (FSA) · Magnetic saturation

Abbreviations

UMP	Unbalanced magnetic pull
SE	Static eccentricity
DE	Dynamic eccentricity
ME	Mixed-eccentricity
FEM	Finite element method
TSFEM	Time stepping finite elements method
FFT	Fast Fourier Transform
MCSA	Motor current signature analysis
FSA	Air-gap magnetic flux signature analysis
PSHs	Principal slot harmonics
PSH1	Lower (first) principal harmonic
PSH2	Upper (second) principal harmonic

1 Introduction

The unbalanced magnetic pull (UMP) is a very important issue in induction motors which brings mechanical stress on some part of the shaft and bearing. After a prolong operation, these factors can snowball into broken mechanical part or even stator to rotor rub, causing major breakdown of the machines, the UMP is caused by unequal air gap which called eccentricity fault (Arkkio and Lindgren 1994; Tenhunen 2001; Li et al. 2007; Dorell 2011; Werner 2012). In general, there are two types of air-gap eccentricity, the static air-gap eccentricity (SE) and the dynamic air gap eccentricity (DE), mixture of both forms

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