Different approaches for Fault Diagnosis of Permanent Magnet Synchronous Motors with Eccentricity and Demagnetization Faults

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1. Introduction

Recently, permanent magnet synchronous motors (PMSMs) are one of the electric motors used in a wide range of applications such as electric vehicles and wind turbine system due to their high torque, high efficiency and ease of control. The rotor of the PMSM is one of the critical components related to the efficiency, performance and reliability. Fault in the rotor causes the irreversible degradation in their performance and efficiency of motor [1-3]. Therefore, it is necessary to monitor the health state of PMSMs and to provide the information of potential faults in early stage to users.

Types of faults in PMSM are shown in Fig.1 and these can be caused by initial manufacturing defects, harsh operating stresses and mis-operation [4],[5]. Among these, we focus on failure prognostics for static and dynamic eccentricity and demagnetization.

In this study, we apply and evaluate two existing methods for fault prognostics of PMSM. Toward this end, the method of using motor current signature analysis (MCSA) and magnetic saturation effect are applied and results are compared. In order to verify the feasibility, experiments were carried out using motors made by artificially inserting different types faults such as static and dynamic eccentricity and demagnetization.

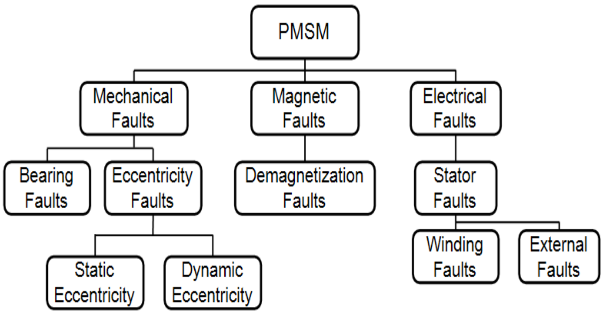

Fig.1 PMSM fault classifications

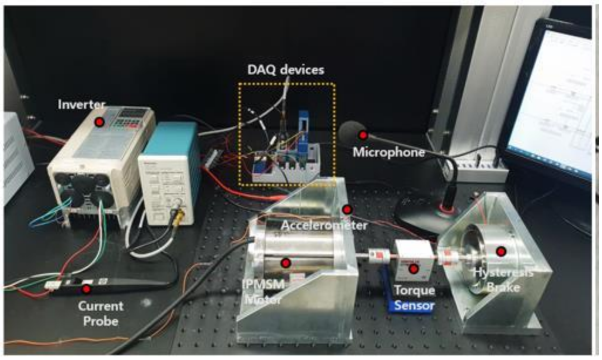

Fig.2 Experimental setup for fault detection of PMSM

2. Fault Detection and Classification of PMSM

The main concept of the proposed technique is to extract the current signal from PMSM stator to detect and classify PMSM faults. To analyze the current signal, several theories are used.

MCSA is proposed as the first method to diagnose faults in the PMSM. The experimental setup for extracting current signature from the PMSM is as shown in Fig.2. Sideband components which are one of factors used to classify faults are extracted from PMSM with healthy and faulty motors at a frequency of

$$f_{pattern} = \left(1 \pm \frac{k}{p}\right) \cdot f_s \qquad (1)$$

where $f_{pattern}$ and f_s are the rotor fault and fundamental frequency components, k is an integer, and p is the number of pole pairs. Stator currents were analyzed based on time domain as well as frequency domain converted from time domain by fast fourier transform (FFT).

Monitoring the d-axis inductance of PMSM is proposed as the second method to detect the faults in PMSM. In this method, inverter is used to provide the signal into the PMSM under standstill to diagnose demagnetization and eccentricity faults [2]. The stator is excited with the AC and DC field in the direction of the d-axis. Then a d-axis magnetic flux ϕ_d is made by the stator and PM. A d-axis flux linkage λ_d is given as follows:

$$\lambda_d = \mathrm{N} \cdot \phi_d \qquad (2)$$

where N is a number of d-axis stator winding turns. The inductance L'_d which is a factor used to classify faults in PMSM is given as follows:

$$L'_d = d\lambda_d / di_d \qquad (3)$$

where i_d is a d-axis stator current flow. Demagnetization and eccentricity in PMSM have a differential L'_d and it is possible to detect and classify PMSM faults by extracting L'_d.

Detailed experimental results and comparative analysis of the two approaches for fault detection and classification will be presented at the conference.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2016R1D1A1B03936165) and Hyundai NGV.

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