Condition Monitoring of Induction Motor for Mechanical Unbalance Loading Fault Using Vibration Signature Analysis

[1]Sushant M. Nagare,
Department of Electrical Engineering, K.K.Wagh Polytechnic, Nashik.
[2]Prof.S.S.Dhamal
Department of Electrical Engineering, K.K.W.I.E.E.R, Nashik

Abstract-Condition monitoring of induction motor have been important task in industries as well as area of research. Fault diagnosis of rotating electrical machinery has received intense research interest. Many researcher yet fail to monitor fault which are related to mechanical fault though mechanical stresses are most faults are occurring. Recently, many researchers are developing technique for the condition monitoring of mechanical faults. Such bearing fault, load unbalance condition, air gap eccentricity. Mechanical load Imbalance is considered as the most potential cause of static or dynamic eccentricities or bearing faults propagation. Based on FFT, Motor current signature analysis (MCSA)is the reference method for diagnosisof induction machines rotor fault. Vibration Signature Analysis (MVSA) was mainlyinvestigated for limited critical rotor faults and exclusively for mechanical unbalancingload problems related. A diagnostic procedure taking induction motor as a machine inwhich the load fault is needed to be monitored. With the help of condition monitoringthe outage and failure of motor can be decrease with reduce cost required for maintenance. As mechanical unbalanced loading are one widely occurring mechanical faultin induction motor, there is need to develop a vibration based technique which can beimplanted for monitoring induction motor under fault condition

Keywords- *Induction motor, Mechanical fault, MVSA, vibration signature analysis, Mechanical Loading*

1. INTRODUCTION

Condition monitoring of electrical machines has become a very important technology in the field of electrical systems maintenance, functions of failure prediction, fault identification, and dynamic reliability estimation. They are very robust and highly reliable machines however, they may be subjected to different types of faults. Failure of such Induction motor may cause plant shutdown, personal injuries and waste of raw material [1].The main reason for the motor faults is mechanical and electrical stresses. Mechanical stresses are caused by overloads and abrupt load changes, which may cause bearing faults and rotor bar breakage. The electrical stresses may produce stator winding short circuits and result in a complete motor failure. Stator winding faults including: turnto turn, coil to coil, open circuit, phase to phase, or coil to ground, generally initiated by high-resistance connections. Rotor electrical faults which include rotor open phase, rotor unbalance due to short circuits or high-resistance connections for wound rotor machines, or rotor magnet demagnetization that can be caused by an over current onthe stator windings [4] [5].

Rotor mechanical faults such as broken bar(s) or cracked end-ring for squirrel-cage machines, cracked rotor magnet, bearing damage, static/dynamic eccentricity, and misalignment etc. During the last few years there has been a considerable amount of research into the development of new condition monitoring techniques for induction motors and drives, overcoming the drawbacks of traditional methods [2] [3].

Condition monitoring of induction motor are of great importance in the production lines. Condition monitoring means continuous evaluation of the health of the motor throughout its service life. There are many condition monitoring methods, including vibration monitoring, thermal monitoring, chemical monitoring, current monitoring techniques are usually applied to detect the various types of induction motor fault. Infact, correct diagnosis and early detection of faults result in fast unscheduled maintenance and short downtime for the process under consideration. They also avoidharmful, sometimes devastating consequences and reduce financial loss. Accurate measurements setup and methods are required [8] [9].

2. MVSA TECHNIQUE FOR FAULT DETECTION

When an induction motor is delivering a power output and torque to supply a given demand by the mechanical load under steady state conditions, it is assumed that the speed is constant for a given demand. The effect of changing the load of the motor on detecting these mechanical conditions. The induction motor therefore acts like a transducer which responds to mechanical disturbances in the drive system. Loading an induction machine typically affects the stator current in two ways. The first isthat it makes the motor runs stiffer. This dampens the overall motor vibration and the lower components of the stator current frequency spectrum. The second effect is that changing the load level is directly related to changing the slip. This causes thestator current frequency components associated with mechanical fault conditions to the shifted because these components are slip dependent. These two effects may influence the accuracy of indicating fault severity or the ability to detect the frequency harmonics associated with mechanical fault conditions [19].

Moreover, mechanical resonance may occur when changing the load level if theresulting rotor speed resonates with the machine or the machine mechanical system.

Mechanical resonance may cause the frequency components input and output increase drastically, and therefore, may he incorrectly diagnosed as a fault condition. In this, the effects of changing the load level on detecting mechanical fault conditions are to be examined.Therefore, it is important to validate that mechanical unbalances at these load levelsare detectable. Applications that operate under varying load conditions as well asvariable speeds, such as an elevator are not considered.In some applications such as aircrafts, the reliability of gears may be critical in safeguarding human lives. For this reason, the detection of load faults (especially related to gears) has been an important research area in mechanical engineering for some time. Motors are often coupled to mechanical loads and gears. Several faults can occur in this mechanical arrangement. Mechanical unbalance leads to a small displacement (vibration) that can be monitored by a suitable transducer (accelerometer) delivering a signal oscillating at rotational frequency. Mechanical unbalance loading affects the dynamics of the system revolving part. This unbalance appears primarily by the creation of an additional undesirable torque which is added to the torque imposed by the load. In addition, the total inertia of the revolving part is also modified and creates a non-uniform distribution of mass which, when the system rotates, generates a centrifugal force tending to move the rotor and creates, consequently, a dynamic eccentricity.

For low levels of mechanical unbalance, this effect on the machine eccentricity can be neglected. The load has been simulated by a magnetic brake which is stiffly coupledto the induction machine shaft and, via its control unit, allows user to apply different load torque levels and acquire speed and torque signals. This type of fault occur in motor when there unbalance loading as if the load is not divided equally at 120 degrees symmetrically on the axis of rotor. Because of initial manufacture and ageing phenomenon, rotating machines present an inherent mechanical disequilibrium. When a small mechanical unbalance fault affects the driving system part ensured by an induction machine, an additional undesirable torque will be superposed to the torque imposed by the load. This supplementary torque is a time varying signal according to rotor position. This time torque variation will be reflected on stator and rotor currents amplitudes by modulation behavior atrotational frequency. Stator current spectrum will contain sideband harmonics that are characteristic of mechanical unbalance defect. Moreover flux beaming around machinebody, which results of rotor and stator currents variations, will be affected.In addition, the total inertia of the revolving part is also modified and creates a non-uniform distribution of mass which, when the system rotates, generates a centrifugal force tending to move the rotor axis in radial direction. A suitable transducer allows themeasurement of vibration signal that can be a useful amount to detect the apparition of the considered defect.

3. TEST SETUP FOR UNBLANCED MECHAINCAL LOADING

A. Experimental Setup

Mechanical load unbalance is investigated for 0.5 H.P. three phase induction motor. In order emulate a realistic mechanical fault; a revolvingmass m is fixed on a disk mounted on the motor shaft aspresented in Fig. 1 (right).A 0-380 V is used as motor regulated supply. A accelerometer MPU6050 is used for the vibration measurement, mounted formeasuring radial movement of the shaft in core motors aspresented in Fig. 1 (left). An Arduino model ATmega328 as a signal conditioner is used. In this section, the detect ability of mechanical load unbalance using vibration signature analysisin frequency domain, is presented and discussed. A sampling rate of 3.2 kHz is adopted with a data acquisition window of 100 number of samples.

The sample from the Arduino is sampled using Matlab and analyzed sample are sampled.

The Arduino software version 1.6.9 is used in order to sample the signal.

Figure 1. Test bench details; (right on motor) positions of the accelerometer,(right) load unbalance introduced on the disc mounted on the motor.

3. RESULTS

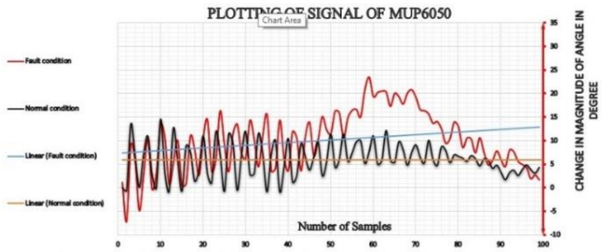

Figure 2.Radial vibration spectra at 1) load and 2) unbalanced condition for load of 0.75 kg with disc

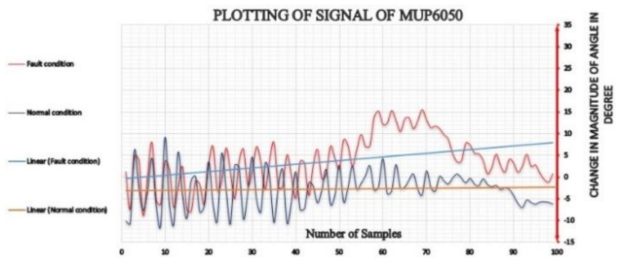

Figure 3.Radial vibration spectra at 1) load and 2) unbalanced condition 0.5 kg with disc

The proposed approach was applied to the to the radial vibration signal. The above result shown in the figure 2 and figure 3 shows about the change in spectra at load condition and unbalanced load condition.

The spectra is the also being linearized and a signal of both is showing the magnitude change in angle deflection of the vibration sensor.

The figure 2 suggests the result when the unbalanced load condition of weight measured is for 0.75 kg with weight of disc. The graph show that deflection of this signal in terms of angle and suggest that a 13 degree angle deflection is seen with respect to the normal load condition. This show for 0.5Hp motor show a significant deflection in change of magnitude. The accelerometer gives the deflection in terms of G- gravity force of rotating object. For 1 degree deflection it corresponds to 2.5g, there by showing significant change in the force for 13 degree deflection.

The figure 3 suggests the result when the unbalanced load condition of weight measured is for 0.5kg with weight of disc. The graph show the vibration deflection in magnitude. For both the condition of load and unbalanced load the signal are sampled and analysed. The deflection when compare to the0.75kg weight of unbalanced load the vibration deflection is significantly less. For the 0.5 kg the angle deflection is of 10 degree in magnitude. The linear value shown that with lesser load on the induction motor for unbalanced condition the magnitude also decrease and vice versa.

As the motor is more loaded the unbalanced force reaction increase and slight deflection can be also noted.

5. CONCLUSION

This dissertation describes the practical design and analysis of fault detection for mechanicalunbalanced load. The concept of using the vibration sensor for mechanicalfault was explained. A system is design in order to analyses the mechanical unbalanceload fault. It has been observed that the magnitude of the vibration in terms of angle increase when aninduction motor system is connected to the unbalanced load.

When the fault condition is taken into consideration a sustainable change is foundin the vibration of induction motor. This may result in the wear and tear of motorand thereby increase the cost of maintenance. The change in vibration were effectivelyobserved and this prove to be a viable tool for analysis for condition monitoring ofmachine.

Future research could be performed in detection by use more sensitive sensor technologyof more complex systems. Additionally, other fault such as electrical fault detectionand current signature analysis can be implemented. This will result in more accurateresult for fault detection. A better signal conditioner can be used for much betterspectrum. Wireless contact type sensor can be used for better flexibility. A MATLABsimulation comparing the result of vibration and current signature analysis togetherwill improve the accuracy for sensitive faults.

6. REFERENCES

[1] M. "Ojaghi and Yazdandoost", "Winding function approach to simulate inductionmotors under sleeve bearing fault," in *Industrial Technology (ICIT), 2014 IEEE International Conference on*, Feb 2014, pp. 158–163.

[2] Y. "Gritli, A. Di Tommaso, R. Miceli, C. Rossi, and Filippetti", "Diagnosis ofmechanical unbalance for double cage induction motor load in time-varying conditionsbased on motor vibration signature analysis," in *Renewable Energy Research and Applications (ICRERA), 2013 International Conference on*, Oct 2013, pp.1157–1162.

[3] S. "Seker, S. Gullulu, and Ayaz", "Transfer function approach based upon wavelettransform for bearing damage detection in electric motors," in *Industrial Electronics,2008. ISIE 2008. IEEE International Symposium on*, June 2008, pp. 749–752.

[4] G. "Maruthi and Hegde", "Preliminary investigation on bearing fault analysis in3 phase induction motor by mems accelerometer," in *Advances in Electronics,Computers and Communications (ICAECC), 2014 International Conference on*,Oct 2014, pp. 100–1000.

[5] Z. Ye, B. Wu, and A. Sadeghian, "Current signature analysis of induction motormechanical faults by wavelet packet decomposition," *Industrial Electronics, IEEE Transactions on*, pp. 1217–1228, Dec 2003.

[6] A. "Boudinar, N. Benouzza, A. Bendiabdellah, and Ferradj", "Improved stator current spectral analysis technique for bearing fault diagnosis," in *Power Electronics and Motion Control Conference and Exposition (PEMC), 2014 16th International*, Sept 2014, pp. 1228–1233.

[7] J. ”Seshadrinath, B. Singh, and Panigrahi”, “Investigation of vibration signaturesfor multiple fault diagnosis in variable frequency drives using complex wavelets,”*Power Electronics, IEEE Transactions on*, vol. 29, no. 2, pp. 936–945, Feb 2014.

[8] M. ”Blodt, J. Regnier, M. Chabert, and Faucher”, “Fault indicators for statorcurrent based detection of torque oscillations in induction motors at variable speedusing time-frequency analysis,” in *Power Electronics, Machines and Drives, 2006. The 3rd IET International Conference on*, April 2006, pp. 56–60.

[9] M. ”Blodt, J. Regnier, and Faucher”, “Distinguishing load torque oscillations andeccentricity faults in induction motors using stator current wigner distributions,”*Industry Applications, IEEE Transactions on*, vol. 45, no. 6, pp. 1991–2000, Nov2009.

[10] A. ”Ghods and H.-H. Lee”, “A frequency-based approach to detect bearing faultsin induction motors using discrete wavelet transform,” in *Industrial Technology(ICIT), 2014 IEEE International Conference on*, Feb 2014, pp. 121–125.

[11] A. ”Bellini, F. Filippetti, C. Tassoni, and Capolino”, “Advances in diagnostictechniques for induction machines,” *Industrial Electronics, IEEE Transactionson*, vol. 55, no. 12, pp. 4109–4126, Dec 2008.

[12] J. ”Sobra, M. Byrtus, V. Kindl, and Hruska”, “Analysis of rotor’s eccentricityinfluence on bearing load of induction machine,” in *Mechatronics – Mechatronika (ME), 2014 16th International Conference on*, Dec 2014, pp. 71–78.