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An Experimental Investigation of Effects of Misalignment of Shaft of AC Motor Using Vibration Analysis

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Abstract — *Any defect in machine will affect vibration behavior & nature of this effect is different for different faults. Understanding & practicing the fundamentals of rotating shaft parameters is the first step in reducing unnecessary vibrations, reducing maintenance cost & increasing machine uptime. Hence vibration measurements can be used to identify those defects qualitatively. Vibration signals give early indication of mechanical failures such as misalignment, unbalance & bent shaft etc. The present study deals with experimental investigation of misalignment with the help of FFT analyzer & its unique vibration spectrum for different coupling stiffness & for Varying load condition.*

Keywords- *Shaft, Coupling, Stiffness, Misalignment, FFT, Vibration spectrum*

I.INTRODUCTION

Misalignment is one of the most common source of trouble of rotating machinery. Misalignment means that the components of an object are not coaxial. Particularly in industrial process electric motors experience a wide range of mechanical problems. It causes over the 70% of rotating machinery vibration problems. Misalignment causes a decrease in motor efficiency & misaligned machinery is more prone to failure due to increased loads on bearings & couplings. Misalignment is the second common mechanical fault in induction machine after unbalance. Misalignment may be present due to various factors such as improper assembly of machines, thermal distortion of machines, asymmetry in applied loads, unequal settlement of foundation, etc. Practically misalignment is always present in the machine thus perfect alignment between rotors shafts cannot be achieved. However it will be within acceptable limits. Hence more study is required on vibration characteristics will be very useful in diagnosis & analysis of the misalignment to avoid any damage or failure that may occur. This paper deals with the experimental analysis of shaft rotor system for varying stiffness condition which is under parallel, angular & combined misalignment.

II. LITERATURE REVIEW

A. S.P.Naik, Prof.D.P.Hujare,et.al,

This paper has examined the effects of misalignment problem in rotating system using its vibration signature analysis. Parallel misalignment was given to the well aligned shaft rotor system. They studied experimentally the performance of a shaft rotor system to predict the misalignment in system. In this, analysis of shaft rotor system with parallel misalignment is done by using FFT analyzer. In experimental results acceleration pick occurs which shows misalignment in system. In this study they compared vibration signature for aligned & misaligned conditions for motor radial & bearing block radial direction respectively.

B. Carlos Verucchi, Jose Bossio, et.al,

Earlier studies have suggested that the characteristics of the coupling device are not considered in case of both angular & radial misalignment between motor & load. In this work it is studied a mechanism in which the power transmission between the motor & load is performed by means of different types of coupling, mainly those most frequently used in industry. This paper provides data of interest for the development of algorithms or diagnosis. The experimental study presented allows to state that the sensitivity of fault indicators strongly depends on the coupling features.

C. Paolo Pennacchin, Andrea Vania, Steven Chatterton, et.al,

In this paper the author dealt with coupling misalignment of a hyper static-shaft line equipped with journal bearings. This proposed method is suitable for every type of shaft line supported by journal bearings. In this study a Finite shaft model is used for the hyperstatic shaft line ,while bearing characterists are calculated by integrating Reynolds equation as a function of the instantaneous load acting on the bearings, caused also by coupling misalignment. The results obtained by applying the proposed method are shown by means of the simulation in the time domain of the dynamical response of a hyperstatic shaft line. The non-linear effects are highlighted & the ratios between higher order harmonic components & synchronous vibrations are analyzed. These results allow giving diagnostic information about the signature of this type of fault.

D. Redmond,

This paper presented a model which enables dynamic analysis of flexibly coupled misaligned shaft. This model is setup to account for both angular & parallel misalignment in the presence of mass unbalance & incorporates a coupling having

angular, torsional & axial flexibility. In this study the equations of motion are derived for the linear system, extended to include non-linear bearing effects & subsequently transformed into non dimensional form for general application. A Series of numerical analyses are performed & the influence of important system parameters assessed thereby providing insight to the resulting static & dynamic forces & motions. It is found in this study that static preload induced by both types of misalignment can play a key role in producing complex vibrations resulting from its interaction with rotating element anisotropy & bearing nonlinear n to alt. The rotating elements are subjected alternating forces which could affect fatigue life. It is concluded from this study that in all cases the coupling stiffness was found to be major controlling factor in determining the system dynamic response. Increasing coupling stiffness results in the imposition of grater static bearing forces, Static shaft displacement & rotating element alternating forces.

E. Ankur Saxena, Anand Parey, et.al,

This paper proposes a computer simulation approach to study the effect of shaft misalignment & friction on total effective mesh stiffness for spur gear pair. The results showed clearly that misalignment & friction affect TVMS of gear pair.The effect of misalignment & friction has also been studied for cracked gear pair & results are discussed. Despite the complexity in gear geometry, formulas for modeling of these newly included factors are all analytically derived. It presents a computer simulation based approach to study the effect of shaft misalignment & friction on the total effective mesh stiffness for spur gear pairs..

F. Vaggeeram Hariharan and PSS. Srinivasan, et.al,

In this paper experimental studies were performed on a rotor dynamic test apparatus to predict the vibration spectrum for shaft misalignment. A self designed simplified 3 –pin type flexible coupling was used in the experiment. Vibration accelerations were measured using dual channel vibration analyzer for baseline & the misalignment condition. The experimental & numerical frequency spectra were obtained. The experimental predictions are in good agreement with the numerical results. Both the vibration spectra show that misalignment can be characterized primarily by 2X shaft running speed. However, misalignment is not close enough to one of the system natural frequency to excite the system appreciably. The rigid & pin type flexible coupling with shaft parallel misalignment is simulated & studied using the both experimental investigation & simulation .The experimental & simulated frequency spectra are obtained & found to be similar. The experimental predictions are in good agreement with the ANSYS results. Both the experimental & simulation results proved that misalignment can be characterized primarily by second harmonics (2X) of shaft running speed. By using newly designed flexible coupling the vibration amplitudes due to shaft parallel misalignment are found to reduce by percentage.

G. M. Chandra Sekhar Reddy, A.S. Sekhar

Rotor faults such as misalignment, shaft crack, rotor rub, bearing fault etc. lead to high vibration and are major cause of machinery shut down. Misalignment in rotating machinery shafts develops reaction forces and moments at the coupling. Conventionally, misalignment diagnosis is carried through vibration measurements. Especially, the existence of strong 2x component is widely accepted. However, there are other rotor-bearing faults which lead to significant 2vibrations. Hence distinguishing misalignment is a challenging task using vibration signals alone. In view of these limitations by employing vibrations signals, present study focuses on torque measurements for misalignment diagnosis. Experimental results using torque sensor for different cases of misalignment at different frequency of operation are reported. Fourier and wavelet transforms are used to detect the misalignment faults.

In this paper an alternative method to detect misalignment using torque measurements is presented. It is also observed that the angular misalignment torque signature and parallel misalignment torque signatures will have different spectral characteristics. The wavelet spectrum of the torque signals is continuous which signifies that the 1x component of the torque is steady and hence qualifies well for measurement. It has been observed that compared to FFT, the wavelets representation is more sensitive to the misalignment fault and is useful for monitoring the fault. This study shows the possibilities of torque measurements as a useful additional technique for detection of misalignment.

H. Juan Luis Ferrando Chacon, Estefania Artigao Andicoberry, et.al,

Shaft angular misalignment (SAM) is a common and crucial problem in rotating machinery. Misalignment can produce several shortcomings such as premature bearing failure, increase in energy consumption, excessive seal lubricant leakage and coupling failure. Vibration analysis has been traditionally used to detect SAM; however, it presents some drawbacks i.e. high influence of machine operational conditions and strong impact of the coupling type and stiffness on vibration spectra. This paper presents an extensive experimental investigation in order to evaluate the possibility of detecting SAM, using acoustic emission (AE) technique. The test rig was operated at under different operational conditions of load and speed in order to evaluate the impact on the AE and vibration signature under normal operating conditions. To the best of the author‘s knowledge, this is the first attempt to use AE for the detection of SAM under varying operational conditions. A comparative study of vibration and AE was carried out to demonstrate the potentially better performance of AE. The experimental results show that AE technique can be used as a reliable technique for SAM detection, providing enhancements over vibration analysis.

In this work, the detectability of SAM using AE technique and vibration analysis with variable operating conditions has been presented. This is the first attempt to evaluate the detection of SAM using AE technique with varying operational conditions. The shaft displacement detected with proximity sensors has been compared with vibration analysis and AE technique. AE combined with envelope analysis has shown the capability and reliability to detect SAM. Vibration analysis has been traditionally used to detect misalignment fault in rotating machinery. However, this paper shows that AE offers more reliability and stability and higher SNR in the detection of SAM under varying operational conditions.

However, the authors suggest further experiments assessing the impact on the AE envelope spectra for varying misalignment severity. It is worth noting that although the proximity sensor signals show that the shaft displacement keeps nearly constant with changing load and speed, the impact of load and speed in AE and particularly in vibration signals is rather high. Nonlinear correlation between the different techniques can be observed in the results shown in this investigation. Although this investigation was carried out for SAM detection, any other type of rotor dynamic faults such as unbalance and looseness could be detected using the proposed method since they also cause a periodic displacement of the shaft. The application of the proposed method to other types of rotor dynamic faults would be an interesting subject for further investigations.

III. CONCLUSION

From the study of literature available it is seen that, the study of vibration signature analysis as tool of machine fault diagnosis, requires high experience & skill. Based on long experience in this field, the experts have prepared standard guidelines for machine fault diagnosis in the form of tables & Charts & discussed in preceding paragraphs. The limitations with the use of these guidelines are that, they can only be used to predict the possibility of the presence of faults in a machine. But fails to pinpoint precisely the type of any fault & also its degree of severity for different couplings. These guidelines are generally followed in routine checkups. The use of these guidelines for entirely new problem is not recommended. These can be used directly when there is not enough time & resources available to tackle the new problem. Because of these limitations many of machine fault diagnosis problems needs separate analysis. Lot of research work is going on for finding various methods of vibration signal analysis dedicated to particular problems.
There is a need to study the effects of coupling stiffness on misalignment output response of shaft connected to AC motor. Misalignment output response is to be analyzed with study of vibrations produced in the system with the help of FFT analyzer & FEA using Software.
This analysis will be useful for machine fault diagnosis which will help for condition monitoring of any rotary system and their predictive maintenance.

IV. REFERENCES

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