



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 4, April 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

Analysis of Study of Effect of Misalignment on Rotating Shaft

Gurav Shubhangi¹, Khan Waquas², Khan Yusuf², Jathar Akash², Bhat Meiraj²

Assistant Professor, Department of Mechanical Engineering, Bharati Vidyapeeth College of Engineering, Kharghar, Navi Mumbai, India¹

Student, Department of Mechanical Engineering, Bharati Vidyapeeth College of Engineering, Kharghar, Navi Mumbai, India²

ABSTRACT: Misalignment is the main cause of machine vibration. Understanding and repeating the fundamentals of rotating shaft parameters is the first step in reducing unwanted vibration, cutting down the maintenance costs and expanding machine uptime. In Industry 30% of the machine's down time is due to the poorly aligned machine. Rotor shaft misalignment is the common drawback within the operation of rotating machinery and is the heart of any industry. Unbalance, misalignment, mechanical looseness, shaft crack and other malfunction give rise to vibration in rotating Machinery. On the whole shaft misalignment is a crucial cause of vibration in machines. It is found that misalignment is available due to improper machine assembly and sometime thermal distortion of the bearing housing supports, resulting in an abnormal rotating preload. However, the complete alignment between the driving and driven shafts cannot be attained. Different type of misalignment s (parallel, angular, and combination of both parallel and angular misalignment) have significant influence on harmonic content of the system. Vibration spectra can be characterized mainly by 2X shaft running speed. 2X shaft running speed for parallel misalignment and 1X shaft running speed for angular misalignment. The bearing load is depending on the alignment condition, and the coupling type. Magnitude of vibration are found higher at bearing away from the motor and lesser at bearing near to the motor in both horizontal and vertical directions. The real-time analyzer is an effective tool to be used for diagnosing mechanical defects.

KEYWORDS

- Misalignment
- Shaft Bearings
- Vibration Spectra
- Parallel misalignment
- Angular misalignment

I. INTRODUCTION

In industry half-hour of the machine's down time is due to poorly aligned machine. Misalignment is the common drawback in the operation of rotating machinery. Considering the importance of the misalignment within the shaft, police work and diagnosis the misalignment remains elusive. Vibration in rotating machinery is generally caused by unbalance, misalignment, mechanical movability, shaft crack, and alternative malfunctions. Misalignment is due to improper machine assembly and someday thermal distortion of the bearing housing supports, leading to abnormal preload. However, the proper alignment between the driving and the driven shaft cannot be earned. It's calculated that fifty to seventy percentage of all vibration issues in machines area unit caused by misalignment. Rotating instrumentation, like pumps and motors, area unit found in just about each sort of industrial atmosphere and once the centerlines of their rotating shafts don't match up utterly, it will result in wasted power, accelerated part wear, and even the potential for harmful instrumentation failures. There are a unit 2 major sorts of misalignment, parallel and angular. Parallel misalignment implies that each shaft centerlines area unit parallel, however offset by a way. The larger the gap, the larger the misalignment. Angular misalignment, on the opposite hand, refers to a condition wherever the shaft centerlines aren't parallel and ran into at an angle. In most cases, shaft misalignment consists of each parallel and angular misalignment. This kind of misalignment is observed as combination misalignment. Several causes exist for shaft misalignment. to make sure an alignment is prospering, all the attainable causes of misalignment should be addressed. The subsequent area unit the foremost rife causes .

II. FACTOR DUE TO WHICH MISALIGNMENT CAN UNDERSTAND

1] Relative Movement - Thermal growth, or growth, will cause one piece of kit to manoeuvre proportionately to a different, inflicting relative movement misalignment. Totally different materials expand at different rates once heated. Thermal growth should be accounted for once instrumentation ordinarily operates higher than close temperature.

2] Strain - Strain iatrogenic by hooked up piping runs will force instrumentation out of alignment. Misalignment caused by strain will reoccur once a prospering alignment thanks to the continual action of forces caused by strained instrumentation.

3] Torsional Movement - The initial high force caused throughout startup will force shafts out of alignment, inflicting torsional movement misalignment.

4] Settling - Over time, foundations or base-plates will settle to lower positions, inflicting subsiding misalignment. The instrumentation may be realigned, however while not addressing the reason for the misalignment, the matter will reoccur.

5] Human Error – A blunder in an alignment procedure or not finishing and alignment procedure will cause human error misalignment. Mis bored Couplings – in producing defects ,making couplings that area unit misbored or otherwise distorted, will cause misbored coupling misalignment. This type of misalignment is generally found on new equipment but damaging a coupling throughout an alignment can cause similar issues.

Misalignment in rotating machinery may be detected in many alternative ways in which together with excessive vibration, excessive bearing temperatures, wear patterns, and noise. Some strategies area unit incorporated into a plant's preventive maintenance program. Others area unit inspections that might be used on an everyday basis, however typically area unit performed once the instrumentation has failing. The damaging effects of ungoverned misaligned shafts embody the following:

- Excessive Vibration - misalignment is one among the leading causes of kit vibration. In spite of self-aligning bearings and versatile couplings, it's troublesome to align 2 shafts and their bearings so no forces exist that may cause vibration. The numerous characteristic of vibration thanks to misalignment is that it will be in each the radial and axial direction.
- Noise - Like vibration, noise may be detected just by noticing a modification within the instrumentation sounds throughout operation. All running instrumentation produces a precise traditional quantity of noise. on condition that an operator is at home with traditional instrumentation noise can they be ready to sight abnormal sounds.
- Lost Production - misalignment will directly have an effect on the period of kit. With a shortened service life, instrumentation would force unplanned maintenance, thereby reducing the time accessible for production.
- Poor Quality of Products - Product quality will suffer directly from instrumentation misalignment. Misalignment will cause each the producing method to provide defects and directly harm product.
- Higher than traditional Repair Orders - Misalignment-induced failures can increase the quantity of unplanned maintenance, inflicting additional repair orders to be generated.
- Increased Inventory of Spare Parts - because the quantity of maintenance will increase thanks to misalignment-induced failures, additional spare elements can ought to be ordered. This leads to inflated

III. LITERATURE REVIEW

3.1 Introduction

This chapter discuss an extensive literature survey presented in the thesis that concern the effect of misalignment on rotating shaft on the performance of parallel, angular, coupling, bearing misalignment, etc , have been conducted and reported in the literature survey in the area of parallel, angular, coupling, bearing misalignment is quite vast and abundant, it is rather difficult to present all this information. Therefore, in the present work only relevant studies which concern with the present study have been reviewed. Although main emphasis have been laid to study the misalignment on rotating shaft, on the performance of parallel, angular, coupling, bearing misalignment, etc. The other studies related to the shaft misalignment which supports the theoretical and experimental background to present the work have been duly accounted for. The whole literature studies have been categories, compiled and presented into year wise data.

J.Wisley Hines and Stephen Jesse [1] has Studied "Effects Of Motor Misalignment On Rotating Machinery." The different shaft misalignment conditions and analyze the efficiency and bearing load measurements, the original inboard and outboard bearings have been replaced with smaller bearings and load sensor rings. They conclude that the

bearing load is dependent on the alignment condition, and the coupling type. Initial results indicate that even small misalignments cause increased loads on the bearings and precision alignment should be used to minimize these loads

Stephen Jesse, J. Wesley Hines, James Kuropatwinski, Andrew Edmondson, Thomas G. Carley [2] studied "Motor Shaft Misalignment Versus Efficiency Analysis". They performed experiment on respective setup to clearly discern the relationship between the motor shaft misalignment and motor efficiency. Watchful computation of motor position, motor power input, and motor power output have shown there to be no significant measurable correlation between motor shaft alignment and motor. The efficiency when the tested couplings were operated within their recommended ranges. However, these results in no way reduce the importance of precise motor alignment. Other motor performance characteristics such as vibration and coupling and

D.L. Dewell and L.D. Mitchell [3] has Studied "Detection of a Misaligned Disk Coupling Using Spectrum Analysis ". Performed an experiment to get the expected frequencies for a misaligned metallic-disk flexible coupling based on the analysis of the structural vibrations produced by misalignment. An abnormally misaligned metallic-disk coupling produces the vibration frequencies. The vibration measured at frequencies of two and four times shaft speed can be used to diagnose when a disk coupling is abnormally misaligned assuming that " baseline" vibration data for acceptable alignment is available. The vibration measured at shaft speed is not an indicator of abnormal disk coupling misalignment. The real-time analyzer is an effective tool to be used for diagnosing mechanical defects. The real-time analyzer has a digital measurement section which reads frequency, frequency difference, amplitude, amplitude difference, and identifies harmonics. These functions permit more rapid identification of vibration sources.

Vance (1988) [4] has studied "Rotor dynamics of turbo machinery ".observed that misalignment is present due to improper machine assembly and sometime thermal distortion of the bearing housing supports, resulting in abnormal rotating preload. However, the perfect alignment between the driving and driven shafts cannot be attained.

S.R. Bognatz [5] studied "Alignment of critical and non critical machines Preceded by unbalance, misalignment is the second major mechanical fault in rotating machine applications". In spite of using modern alignment techniques like laser alignment tool, the accidental misalignment arises over a period of continuous operation due to many reasons. This can lead to excessive forces on components of rotating systems, which ultimately greatly influence on its vibration spectrum. The study presents the results of Harmonic analysis of the Aluminum (Al) shaft rotor bearing system with rigid coupling, under parallel misalignment, using FEA. It show-cases vibration spectrum due to the misalignment.

A.S. Sekhar, B.S. Prabhu [6] Studied "Effects of coupling misalignment on vibration of rotating machines." The rotor-bearing system is modelled using higher order finite elements by considering deflection, slope, shear force, bending moment with eight degrees of freedom per node. The reaction forces, moments developed due to flexible coupling misalignment are derived and introduced in the model. The imbalance response in two harmonics is evaluated. The increase in harmonics with misalignment can easily be modelled by using FEM analysis.

B.S. Prabhu [7] Studied "An experimental investigation on the misalignment effects in journal bearings." Misalignment is one of the most common faults in any rotating machine. It can cause decrease in efficiency and in the long run may cause failure of machine. Most of the researchers, consider only vibration information for the misalignment. However, this paper inspects the different types of misalignments by using diagnostic medium such as stator current signature as well as rotor vibration signal and it is being found that current signature alone can predict the misalignment effect without use of vibration signal. Diagnostic features obtained by FFT related to misalignments have been explained. Orbit plots are effectively used to explain the unique nature of misalignment fault. In this study, shaft displacement and stator current samples during machine run up under aligned as well as misaligned conditions are measured and analyzed. Result shows that misalignment is the parameter that is more responsible for the cause of instability.

Y.S. Lee, C.W. Lee [8] studied "Modeling and analysis of misaligned rotor the transient response of a misaligned rotor—coupling—bearing system passing through the critical speed has been analysed by using the finite element method (FEM) for flexural vibrations. The coupling has been modelled in two ways: a frictionless joint and a joint with stiffness and damping. From the vibration analysis, the subcritical speeds at one-half, one-third and one-fourth the critical speed have been found when the misaligned rotor—coupling—bearing system passes through its critical speed. The continuous wavelet transform (CWT) has been used as a tool to extract the silent features from the time response

of the rotor system. A parametric study has been carried out to investigate the transient response of this rotor system for different angular accelerations in different types of misalignment.

A.T. Tadeo and K.L. Cavalc [9] has Studied “A Comparison of Flexible Coupling Models for Updating in Rotating Machinery Response. “. Analyzes the effects of the mathematical models of flexible couplings in rotating mechanical systems in terms of their vibrational behavior. They compare the simplified theoretical models of the couplings suggested by Kramer and Nelson and Crandall and the traditional model of the coupling as a rigid disk. After that, a model updating applying the minimum quadratic technique was carried out on a system composed of two flexible shafts, two rigid disks, a flexible coupling and four hydrodynamic bearings. The FEM of the rotor-bearings-coupling system analyses the bending vibrations of the system show how the values of the first and third natural frequencies of the system differ so much on the direct whirl as well as on the retrograde whirl effect.

Francois Combet, Nadine Martin, Pierre Jaussaud, Francois Leonard [10] has studied “Detection of a Gear Coupling Misalignment in a Gear Testing Device. “. Different signals measured on gear testing device are analyzed in order to attempt to find criteria for an early detection of faults that could appear in the gear coupling. Two signal processing methods are used. Frequency spectrogram, for analyzing slight frequency modulations in the acceleration signals. A time-frequency Prony analysis is applied to track the evolution of Prony's parameter. They observed from the beginning of the experiment to before the crack an increase of the 2x shaft speed modulation amplitude in the torsional vibration signal and in the acceleration signals close to the gear coupling. This could be an indication that the misalignment increased in the gear coupling, and the friction between the teeth due to the created moment finally led to the crack of the shaft in the coupling.

J.K. Sinhaa, A.W. Leesb, M.I. Friswell [11] studied “Estimating unbalance and misalignment of a flexible rotating machine from a single run-down”. These are presented a method to estimate both the rotor unbalance (amplitude and phase) and the misalignment of a rotor-bearing-foundation system. A sensitivity analysis for rotor unbalance and misalignment estimation was performed by introducing errors in the parameters of the rotor and fluid bearing models, to check the robustness of the proposed method. It has been observed that the maximum error in estimated unbalance amplitude is usually less than 45% for simultaneous random errors of 5% in the rotor model and 10% in the fluid bearing models. However, the phase estimation is quite robust which is very 10% in the fluid bearing models. However, the phase estimation is quite robust which is very promising for practical rotor balancing. In practice, the authors consider that the errors in the rotor model should be much less than 5% for many machines. The variation in the estimated linear and angular misalignment due to errors in the rotor modelling was also found to be small for the small rig. In general it has been observed that the estimation method is far less sensitive to errors in the fluid bearing modelling compared to the rotor modelling error, and rotor systems having fluid bearings are also less sensitive to modelling errors, compared to systems having rigid bearings.

P. Pennacchi and A. Vania [12] studied “Diagnosis and model based identification of a coupling misalignment”. They have used the Orbit shape analysis technique. The orbit shape analysis has allowed an angular misalignment in a generator of a small power plant to be identified. A model-based identification method has been used to estimate the bending moments that have enabled the 1X vibrations caused by the angular misalignment to be simulated. This investigation, as well as a machine visual inspection, proved that the high 1X vibrations that occurred at low rotating speeds were caused by a misalignment induced by the unsuitable mounting of gagging screws that locked solid the membrane unit of a flexible coupling between two shafts of the machine train.

Arebi, Lufti, Gu, Fengshou, Hu, Niaoqin and Ball, Andrew [13] studied Misalignment Detection using a Wireless Sensor Mounted on a Rotating Shaft. They made a model of the pin type coupling-roller-ball bearing system with misalignment and they developed integrated wireless sensor from Micro Electro Mechanical Systems (MEMS). They mounted a MEMS accelerometer wireless sensor directly on the second shaft connecting to the shaft of the motor. They conclude that the misalignment can be characterized primarily by spectral amplitudes at 2X, 3X and 4X of shaft running speed.

Dr. V. Hariharan and Pss Srinivasan [14] has Studied “vibrational analysis of parallel misaligned shaft with ball bearing system”. A self-designed simplified 3 pin type flexible coupling was used in the experiments. Experimental studies were performed on a rotor dynamic test apparatus to predict the vibration spectrum for shaft misalignment by giving different misalignment condition. According to them vibration spectra can be characterized mainly by 2X shaft running speed. However, misalignment is not close enough of the system appreciably. They say that the misalignment

effect can be amplified, and a high acceleration level at 2X shafts running speed is pronounced in the frequency spectrum.

K. Venkata Sivarao, G. Diwakar, Dr. M. R. S. Satynarayana [15] studied "Determination Of Misalignment Using Motor Current Signature Analysis In Rotating Machine". They inspect the misaligned motor and machine shafts by using diagnostic medium such as current, frequency and instantaneous power signal. They performed experiment using motor current signature analysis is for detecting faults and Mat lab software is for generating spectrum. They conducted experimental work on 0.5H.P motor with overhang rotor. They conclude that in misalignment condition the vibration reading are high and the amplitude of vibration are increases with increase load. Peak amplitudes are observed at 1X in axial direction. Phase angle measured between motor and coupled shaft end is 180 degree. The motor stator current is drawn in healthy and faulty conditions of setup and the current and frequency values are used to generate current spectrum using mat lab, the current spectrum indicates that reduction in peak amplitude and increase in side band Amplitudes for faulty motor. They also conclude that Motor Current Signature Analysis (MCSA) is the safest method.

Michael Montea, Florian Verbelena and Bram Vervisch [16] has Studied "The use of orbitals and full spectra to identify misalignment." A comparison is made between the classical spectral analysis, orbitals and full spectra. The vibrations caused by misalignment are measured by two accelerometers on the bearings and two eddy-current probes on the shaft itself. They performed experiment for different types of misalignment and got the results. Misalignment is not always as clear to detect compared to imbalance. For misalignment orbitals and full spectra can be used to make a proper analysis of the problem. The difference between parallel and angular misalignment can be seen in orbitals by the presence or absence of a twist in the contour. The presence of the twist indicates angular misalignment. Misalignment is evenly represented in the positive and negative frequency range.

Somnath Sarangi and Mahesh Kolekar [17] has Studied "Experimental Investigation of Misalignment Effects on Rotor Shaft Vibration and on Stator Current Signature." Inspect the different types of misalignments by using diagnostic medium such as stator current signature as well as rot or vibration signal. They investigated that Stator current signature alone can predict the misalignment effect without use of vibration signal. Misalignment of the rotor may excite both higher harmonics vibration and current; however, the harmonic content near the bending natural gets excited strongly compared to other harmonics of the vibration and current

A.C. Babar and A.A Utpat, [18] Studied " Vibration Analysis of Misaligned Rotating Shaft", Per formed experiment on a rotor bearing system to predict the vibration spectrum for shaft misalignment. Accelerometer is used along with a device called as Fast Fourier Transform (F.F.T.) Analyzer. Initially case of perfect aligned shaft is considered for measurement of vibration and then ca se of misaligned shaft is considered. After they conclude that the overall magnitude of vibration in RMS values of acceleration for various misalignment conditions such as parallel misalignment, angular misalignment and combination of parallel and angular misalignment are found higher at bearing away from the motor and lesser at bearing near to the motor in both the horizontal and vertical directions.

S M Khot and Pallavi Khaire [19] has Studied " The effect of misalignment with flexible flange coupling" Using the both experimental and simulation method. They deal with experimental investigation of faults such as parallel misalignment and angular misalignment with the help of FFT analyzer. Simulation study of misalignment effect in rotary system is also attempted in ANSYS. According to them misalignment can be characterized primarily by second harmonics that is 2X of shaft running speed for parallel misalignment and 1X of the shaft speed for angular misalignment. In case of align system, vibration spectrum shows low amplitude of vibration as compared to misaligned system in both experimental and simulation study. They also said that as excitation frequency increases amplitude of vibration also increases

S. P. Naik, D. P. Hujare, Dr. M.G. Karnik [20] studied "Experimental Study of Parallel Misalignment in Shaft Rotor System using Vibration Signature Analysis". They prepared a experimental model for vibration analysis of misaligned shaft rotor system. Vibration analysis for well aligned and misaligned condition were observed by using FFT analyzer. They were observed the vibration signal in RT pro software. They compared the vibration signatures for well aligned and misaligned conditions for motor radial and bearing block radial direction respectively. The acceleration value was found very low with respect to order or characteristics frequencies for aligned condition and there is sudden increase in acceleration value at 2x characteristic frequency for misaligned condition. This increase in acceleration value for misaligned condition shows the effect of misalignment in the system.

Xin lu, Junhong Zhang, Liang Ma, Jiewei Lin, Jun Wang, Jie Wang, Huwei Dai [21] Studied "effects of misalignment on the nonlinear dynamics of a two-shaft rotor-bearing- gear coupling system with rub-impact fault". Established a model of a rotor-ball bearing- gear coupling system with rub-impact and misalignment faults and analyzed the effect of misalignment on the rub-impact rotor system. Misalignment can strongly affect the stability of the rub-impact rotor system at high rotating speed. Both the starting point of quasi-period motion and the range of quasi- period/chaos motion are changed due to the development of misalignment. The motion, orbit and vibration spectrum of the rotor and the rub-impact force is highly related to the change of misalignment. Generally, the development of misalignment brings adverse effect on rotor stability, and the speed range of the unstable motion increases with increasing misalignment . However, the effect pattern still depends on the rotating speed.

Wang, H., & Gong, J. [22] Studied "Dynamic analysis of coupling misalignment and unbalance coupled faults" .In this paper, parallel and angular misalignment models are established. A rotor system is established by FEM considering coupling misalignments. In parallel misalignment simulation, $2X_{x0001}$ will appear in the horizontal and vertical misalignment forces, and there is $0X_{x0001}$ in the vertical force. In angular misalignment simulation, $2X$, $4X$, $6X_{x0001}$ will appear in the horizontal and vertical misalignment moments

Bouchra Abouelanouar, Ali Elkihel , Hassan Gziri [23] studied "Experimental study on energy consumption in rotating machinery caused by misalignment" .In there experimental setup, they introduced the two types of misalignment (parallel and angular) were created by inserting shims (0.25 mm thick) under various conditions. They concluded that there is strong correlation between vibration levels and the power consumption. It has been shown that vibration measurements are effective indicator for the monitoring of energy consumption. Thus, the reliability of machines is a major responsible for the increase of energy consumption and vibration analysis technique may present an effective solution for the evaluation of energy consumption.

A. M. Umbrajkaar, A. Krishnamoorthy and R. B. Dhumale [24] studied "Vibration Analysis of Shaft Misalignment Using Machine Learning Approach under Variable Load Conditions". A combined approach of Support Vector Machine and Artificial Neural Network is implemented successfully to obtain classification and prediction of shaft misalignment. The accuracy of Support Vector Machine is seen to a good level for all conditions viz. healthy, parallel, and angular misalignment. In tested results of trained artificial neural network, a 3-20-11 structure is observed as the best artificial neural network structure for offset and angular measure of misalignment. It is observed that the selection of epochs and learning rate has also an effect on minimizing the error. The different samples tested for parallel and angular misalignment have classified successfully with the implementation of support vector machine.

Mohamed Desouki, Sadok Sassi , Jamil Renno and Samer Abdelazim Gowid [25] studied "Dynamic Response of a Rotating Assembly under the Coupled Effects of Misalignment and Imbalance." They developed a numerical method and used to obtain the time and frequency responses of the rotor-coupling-bearing system to the simultaneous effect of imbalance and misalignment (parallel or angular) on the vibration spectra of rotating machinery. The system consisted of an assembly of two shafts interconnected by a flexible coupling and in total, the system's motion is described by a set of 12 degree of freedom (DOF). The effect of pure imbalance made the system oscillate in a harmonic way while the combined effects of imbalance and misalignment produced a nonharmonic response. Varying the parallel misalignment had practically no influence on the amplitudes of the $1X$ peaks in all radial directions. The amplitudes of the $2X$ peaks were found to increase linearly with an increase in the parallel Misalignment. The impact on the amplitude of the second harmonic of speed ($2X$) of adding 1° of misalignment was significant. Remarkable peaks at $1X$, $2X$, and $4X$ can be observed in the vibration spectra, with the $2X$ component being the strongest. Varying the angular misalignment had almost no effect on the $1X$ amplitudes. The amplitudes of $2X$ and $4X$ increased with an increase in the angular misalignment.

IV. CONCLUSION

In today's world where everything is dependent on machine. It is very important to have a machine in better condition for that we have to reduce unnecessary vibrations, reduce maintenance costs and increasing machine uptime. There are many problems arises while operating the machines. Misalignment is one of the main cause of machine vibration. In rotating machinery operations, rotor shaft misalignment is most common problem and is considered as heart of any industry. Misalignment is generally described by the primarily two times shaft running speed ($2X$). At high rotating speed, misalignment can strongly damage the stability of the rub-impact rotor system. There are many methods to determine misalignment but Finite Element Analysis (FEA) is the best method among all. Orbitals and full spectra are



very useful in detecting the faults from vibration measurements as misalignment is not always clear to detect. Due to presence of twist in contour we can differentiate between parallel and angular misalignment. The real time analyzer is very good tool to be used for detection of mechanical defects.

ACKNOWLEDGEMENT

I gratefully acknowledge department of Mechanical engineering of 'Bharati Vidyapeeth collage of engineering, Navi Mumbai for technical support and providing the research facilities. I would also like to thanks Assistant Professor S.N.Gurav for their help and dedication towards my research and related research, also thanks to my friends for their directly and indirectly help, support and excellent co-operation

REFERENCES

1. J.Wisley Hines and Stephen Jesse, "Effects of Motor Misalignment on Rotating Machinery Article: February 1970
2. Stephen Jesse, J. Wesley Hines, James Kuropatwinski, Andrew Edmondson, Thomas G. Carley, "Motor Shaft Misalignment Versus Efficiency Analysis". The University of Tennessee College of Engineering Maintenance and Reliability Center Knoxville, TN 37996.,John Kueck, Oak Ridge Center for Electric Machinery System Testing Y-12 Plant Bldg 9401-1 Oak Ridge, TN 37831.,
3. Dan Nower Computational Systems, Inc. 835 Innovation Drive Knoxville, TN 37932., Frank Hale Duke Power Corporation 610 Toddville Rd Charlotte, NC 28214.
4. D.L. Dewell and L.D. Mitchell "Detection of a Misaligned Disk Coupling Using Spectrum Analysis " Journal of Vibration, Acoustics, Stress, and Reliability in Design. January 1984
5. Vance JM (1988) Rotor dynamics of turbo machinery. New York , John Wiley & Sons
6. S.R. Bognatz, Alignment of critical and non critical machines. Orbit, 23-25 (1995)
7. A.S. Sekhar, B.S. Prabhu, Effects of coupling misalignment on vibration of rotating machines. J. Sound Vib. 185, 655-671 (1995)
8. B.S. Prabhu, An experimental investigation on the misalignment effects in journal bearings. Tribol. Trans. 40, 235-242 (1997)
9. Y.S. Lee, C.W. Lee, Modeling and analysis of misaligned rotor ball bearing systems. J. Sound Vib. 224, 17-32 (1999)
10. A.T. Tadeo and K.L. Cavalca "A Comparison of Flexible Coupling Models for Updating in Rotating Machinery Response."J. of the Braz. Soc. of Mech. Sci. & Eng. Copyright 2003 by ABCM July-Sep tember 2003, Vol. XXV.
11. Francis Combet, Nadine Martin, Pierre Jaussaud, Francis Leonard. "DETECTION OF A GEARCOU PLING MISALIGNMENT IN A GEAR TESTING DEVICE." Eleventh International Congress on So und and Vibration, ICSV11, Jul 2004 St Petersburg, Russia.
12. J.K. Sinha, A.W. Lees, M.I. Friswell "Estimating unbalance and misalignment of a flexible rotating machine from a single run-down." Received 6 December 2002; accepted 24 March 2003 Journal of Sound and Vibration 272 (2004) 967– 989
13. Paolo Pennacchi, A. Vania "Diagnosis and Model Based Identification of a Coupling Misalignment." January 2005 Shock and Vibration 12(4):293-308 DOI:10.1155/2005/607319
14. Arebi, Lufti, Gu, Fengshou, Hu, Niaoqin and Ball, Andrew (2011) Misalignment Detection using a Wireless Sensor Mounted on a Rotating Shaft. In: Proceedings of the 24th International Congress on Condition Monitoring and Diagnostics Engineering Management. COMADEM, Stavanger, Norway, pp. 1289-1299. ISBN 0954130723
15. Dr.V. Hariharan and Pss Srinivasan, "Vibrational Analysis of parallel misaligned shaft with ball. bear ing system." Article in Songklanakarin journal of Science and Technology, February 2011 DOI 10.1 7485/2009/v2i9/2952144
16. K.VENKATA SIVARAO, G. DIWAKAR, Dr. M. R. S.SATYNARAYANA, "Determination Of Misalignment Using Motor Current Signature Analysis In Rotating Machine". International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October – 2012 ISSN: 2278-0181
17. Michael Montea, Florian Verbelena and Bram Vervisch "The use of orbitals and full spectra to identi fy misalignment. "8 March 2014
18. Somnath Sarangi and Maheshkumar Kolekar, "Experimental Investigation of Misalignment Effects o n Rotor Shaft Vibration and on Stator Current Signature."Article in Journal of Failure Analysis and Prevention • April 2014 DOI: 10.1007/s11668-014-9785-7
19. A.C. Babar and A.A Utpat, " Vibrationl Analysis of Misaligned Rotating Shaft". International Journal Of Mechanical Engineering And Information Technology .June 2014



20. SM Khot and Pallavi Khair, "The effect of misalignment with flexible flange coupling" Journal of Vibration, Analysis, Measurement and control. Article: January 2015 DOI: 10.7726/jvamc. 2015.1009
21. S. P. Naik, D. P. Hujare, Dr. M.G. Karnik, "Experimental Study of Parallel Misalignment in Shaft Rotor System using Vibration Signature Analysis". International Engineering Research Journal Page No 1431-1434 (2016).
22. xin lu, junhong zhang, liang ma, jiewei lin, jun wang, jie wang, huwei dai study the "effects of misalignment on the nonlinear dynamics of a two-shaft rotor-bearing-gear coupling system with rub-impact fault". jve international ltd. journal of vibro engineering. Dec 2017, vol. 19, issue 8. issn 1392-8716
23. Wang, H., & Gong, J. (2019). Dynamic analysis of coupling misalignment and unbalance coupled faults. Journal of Low Frequency Noise Vibration and Active Control, 38(2), 363 – 376
24. Bouchra Abouelanouar, Ali Elkihel, Hassan Gziri "Experimental study on energy consumption in rotating machinery caused by misalignment". Received: 22 October 2019 / Accepted: 10 June 2020 / Published online: 15 June 2020 Springer Nature Switzerland AG 202
25. M. Umbrajkar, A. Krishnamoorthy and R. B. Dhumale "Vibration Analysis of Shaft Misalignment Using Machine Learning Approach under Variable Load Conditions". Received 7 February 2020; Revised 5 July 2020; Accepted 9 July 2020; Published 30 July 2020. Hindawi Shock and Vibration Volume 2020,
26. Mohamed Desouki, Sadok Sassi, Jamil Renno, and Samer Abdelazim Gowid, " Dynamic Response of a Rotating Assembly under the Coupled Effects of Misalignment and Imbalance". Hindawi
27. Shock and Vibration Volume 2020, Article ID 8819676, 26 pages
<https://doi.org/10.1155/2020/8819676> Received 9 May 2020; Revised 27 August 2020; Accepted 18 September 2020; Published 19 October 2020.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.118



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details