STUDY & VIBRATION ANALYSIS OF WORM AND WORM WHEEL GEAR BOX BY USING FFT ANALYZER

Ganesh Survase, SurajSutar, TusharPawar and AkshayRajmane

ABSTRACT

Gears are important element in a variety of industrial applications such as machine tool and gear boxes. An unexpected failure of gear may cause significant economic losses. For that reason fault diagnosis in gears has been the subject of intensive research vibration signal analysis has been widely used in the fault detection of rotation machinery. The vibration signal of gear box carries the signature of the fault in gears and early fault detection of gear box is possible by analyzing the vibration signals using different signal processing techniques. Review is made of some current vibration analysis techniques used for condition monitoring in gear fault. Each unit of mechanical equipment has a different signature in the frequency spectrum. The vibration spectrum shows the areas of stress and undue energy. Vibration measurements trend changes at different locations along the units to predict the problems. The key benefits include:- Monitoring equipment life, increasing equipment uptime, managing and scheduling maintenance work. Vibration analysis can determine misalignment, unbalanced, mechanical losses, eccentric shafts, gear wear, broken teeth & bearing wear. Using laser vibrometer it is possible to get the data that are processed in different methods like FFT Analysis.

Index Terms—Wheel, Gear Box, FFT, Gravitational Energy; Mechanical work;

Reference to this paper should be made as follows:

Ganesh Survase, SurajSutar, TusharPawar and AkshayRajmane (2020), "STUDY & VIBRATION ANALYSIS OF WORM AND WORM WHEEL GEAR BOX BY USING FFT ANALYZER" Int. J. of Mechanical, Robotics and Production Engineering, Vol. 7, No. 1, pp. 34-40.

Biographical notes:

Ganesh Survase, SurajSutar, TusharPawar and AkshayRajmane are scholars in Department of Mechanical Engineering, TSSM's BhivarabaiSawant College of Engineering & Research, Narhe Maharashtra, India.

1. INTRODUCTION

The monitoring of a gearbox condition is a vital activity because of its importance in power transmission in any industry. Therefore, to improve upon the monitoring techniques and analysis tools for finding the gear ratios, gear faults, shaft misalignments in the gearbox and the current passing through the motor running the gearbox, there has been a constant improvement in these monitoring techniques. Techniques such as wear and debris analysis, vibration monitoring and acoustic emissions require accessibility to the gearbox either to collect samples or to mount the transducers on or near the gearbox [1,2,3].

But dusty environment, background noise, structural vibration etc. may hamper the quality and efficiency of these techniques. Hence, there is a need to monitor the gearbox away from its actual location, which can be achieved through Motor current signature analysis (MCSA) which has already been successfully applied to condition monitoring of induction motor. Gearbox is an important machinery component in any industry. Any defect in gears lead to machine downtime resulting in a loss of production [4,5,6]

2. PROBLEM STATEMENT

All machines with moving parts give rise to sound and vibration. Each machine has a specific vibration signature related to the construction and the state of the machine. If the state of the machine changes the vibration signature will also change. A change in the vibration signature can be used to detect incipient defects before they become critical. Nowadays the demands for condition monitoring and vibration analysis are no more limited trying to minimize the consequences of machine failures, but to utilize existing resources more effectively [7,8,].

Fig:- 1 Worm & worm wheel gear box

3. DESIGN OF GEAR BOX

1. WORM WHEEL

No. of teeth (Z_2) = 21, Module (m) = 3mm, PCD (d_2) = 63mm Outer Dia. = 72mm

2. WORM

No. of threads = 6, PCD (d_1) = 26.6mm, Outer Dia. = 32.6mm

Center Distance = 44.45mm, Worm Wheel Bearing = 30205*2

Worm Bearing = 30204*2, No. of threads = 6

A pair of worm gears is specified and designated by four quantities in the following manner; z_1 / z_2 / q / m

Dimensions of worm and worm wheel

$l = 3.14 * \text{no. of threads in worm diametric pitch}$

$l = 3.14 * 6 = 18.84\text{mm}$

$P_x = \pi * m = \pi * 3 = 9.425\text{mm}$

$l = P_x * Z_1 = 18.84$; $Z_1 = 1.99 = 2$

Lead angle of worm:

$\tan \gamma = l / (\pi * d_1)$

$\gamma = 12.71^\circ$; $\gamma + \psi = 90^\circ$; $\psi = 77.30^\circ$ = helix angle of worm

$\tan \gamma = Z_1 / q$; $q = 8.86$; Speed Ratio = $Z_2 / Z_1 = 21 / 2 = 10.5$

Dimensions of Worm

$ha_1 = m = 3\text{mm}$; $hf_1 = 3.438\text{mm}$; $c = 0.5852\text{mm}$

$da_1 = 32.60\text{mm}$; $d_1 = 26.6\text{mm}$

Dimensions of Worm Wheel

$ha_2 = 2.85\text{mm}$; $hf_2 = 3.58\text{mm}$; $da_2 = 72\text{mm}$; $d_2 = 63\text{mm}$

Effective face width of worm wheel (F)

$F=18.84\text{mm}$

Power of Motor = 0.5HP= 373W

4. EXPERIMENTAL SETUP

In order to diagnosis the fault of gear box, FFT analyzer is used. Block diagrams of these two experimental setups are as shown in figure. Experimental setup consists of single phase DC motor, single stage worm and worm wheel gear box, data acquisition system(PC,dewsoftX). DweSsoftX software is used to analyze the signals. It is easy to take any measurement with DweSoftX. The measurements can be automated from several devices and data can be analyzed spontaneously with this software. Data acquisition card are used to acquire the current samples from the motor under load.

After the manufacturing of gear box, fabrication is done to do assembly of experimental setup which consist of Oldham couplings, pulley shaft, key, hooks, motor, rope, bearing with pillow block cast mounting and weighing machine. Now to assemble these components together frame is prepared on when these components are assembled.

Input of gearbox is coupled with motor through shaft and output is coupled with shaft and bearing with pillow block cast mounting is used to give support to output shaft.

Fig. 2 Experimental setup

A. Worm & worm wheel gear

Fig 3 Gear box

5. MOTOR CURRENT SIGNATURE ANALYSES

A common approach for monitoring mechanical failures is vibration monitoring. Due to the nature of mechanical faults, their effect is most straightforward on the vibrations of the affected component. Since vibrations lead to acoustic noise, noise monitoring is also a possible approach. However, these methods are expensive since they require costly additional transducers. Their use only makes sense in case of large machines or highly critical applications. A cost effective alternative is stator current based monitoring since a current measurement is easy to implement. Moreover, current measurements are already available in many drives for control or protection purposes. However, the effects of mechanical failures on the motor stator current are complex to analyze. Therefore, stator current based monitoring is undoubtedly more difficult than vibration monitoring. Another advantage of current based monitoring over vibration analysis is the limited number of necessary sensors. An electrical drive can be a complex and extended mechanical systems. For complete monitoring, a large number of vibration transducers must be placed on the different system components that are likely to fail e.g. bearings, gearboxes, stator frame, and load. However, a severe mechanical problem in any component influences necessarily the electric machine through load torque and shaft speed. This signifies that the motor can be considered as a type of intermediate transducer where various fault effects converge together. A literature survey showed a lack of analytical models that account for the mechanical fault effect on the stator current. Most authors simply give expressions of additional frequencies but no precise stator current signal model. In various works, numerical machine models accounting for the fault are used. However, they do not provide analytical stator current expressions which are important for the choice of suitable signal analysis and detection strategies. The most widely used method for stator current processing in this context is spectrum estimation. In general, the stator current power spectral density is estimated using Fourier transform based techniques such as the period gram. These methods require stationary signals i.e. they are inappropriate when

frequencies vary with respect to time such as during speed transients. Advanced methods for non-stationary signal analysis are required.

6. CONCLUSION

For node 1, 2, 3, and 4.

- Axial Direction: As load increases there is decrease in acceleration with decrease in value if maximum frequency attained for corresponding maximum acceleration.
- Horizontal Direction: As load increase there is initial decrease in acceleration to its minimum and then again starts increasing with same behaviors in trends of corresponding maximum frequency value.

For node 5 and 6

- Vertical direction: As load increase there is initial decrease in acceleration to its minimum and then again starts increasing with same behaviors in trends of corresponding maximum frequency value.

REFERENCES

- [1] Neelam Mehala, Ratna Dahiya, "Motor Current Signature Analysis and its Applications in Induction Motor Fault Diagnosis", international journal of systems applications, engineering & development Volume 2, 2007, pp29-35.
- [2] Adam Docekal, Marcel Kreidl, Radislav Smid, "Rotating Machine Vibration Analysis using Group of Adaptive Models Evolution", department of measurement, faculty of electrical engineering, czech technical university in prague 6, czech republic, Volume 5, 2008, pp231-238.
- [3] J. Rafiee a, M.A. Rafiee a, P.W. Tse b, "Application of mother wavelet functions for automatic gear and bearing fault diagnosis" Department of Mechanical, Aerospace and Nuclear Engineering, Jonsson Engineering Centre, 110 8th Street, Rensselaer Polytechnic Institute, USA, Volume 37, 2010, pp 4568–4579.
- [4] Nguyen Van Khang, Thai Manh Cau, Nguyen Phong Dien, "Modelling parametric vibration of gear-pair systems as a tool for aiding gear fault diagnosis", technischemechanik, Volume 24, 2004, pp 198-205.
- [5] Enayet B. Halim, Sirish L. Shah, Ming J. Zuo and M. A. A. Shoukat, "Fault Detection of Gearbox from Vibration Signals using Time-Frequency Domain Averaging", vol. 17, 2003 pp. 787–804.
- [6] Babak Eftekharijad, A. Addali, D. Mba, "Shaft crack diagnostics in a gearbox", vol. 73, 2012 pp. 723–733
- [7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
- [8] Mostafa A., El-Baky, Mousa M., 'Heat pipe heat exchanger for heat recovery in air conditioning' Milan, Italy, 14-17 May, 2006, Vol. 2, pp. 659-668.
- [9] S. Nozu, T. Fujii, H. Honda, "A method for estimating tube length and pressure drop of air-cooled condensers", Vol. 92, No. 2934, 1986, C.P. ARORA, Refrigeration and air conditioning, 3rd edition 2000.
- [10] James M. Calm, "Emissions and environmental impacts from air-conditioning and refrigeration systems", Vol 25, pp- 293–305, 2002.
- [11] R. Cabello, E. Torrella, J. Navarro-Esbri, "Experimental evaluation of a vapour compression plant performance using R134a, R407C and R22 as working fluids", Vol 24, 2004, pp- 1905-1917.