

# Mechanical Vibration Analysis on a Testing Bench using Visualization Software

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**Abstract:** *The analysis of vibrations in the industrial sector is a very expensive technique. This article shows an analysis that may assist in the investigation of the development of low cost equipment for the detection of mechanical vibrations. The main objective is to analyze an analog signal sent by an accelerometer and by means of a data acquisition card observe that signal in a visualization software, this to detect faults in a roto-dynamic equipment. In the same way, three test methods were implemented in a testing bench: one with balanced load, another with unbalanced load and in the last, the load was uncoupled to the motor shaft. These tests were performed to be able to interpret the generated signals in each case, thus establishing failure parameters in the testing bench motor.*

**Keywords:** accelerometer, vibrations, analysis, visualization software, data acquisition card

## 1. Introduction

This topic deals with mechanical vibrations in roto-dynamic equipment which are more affected by vibrations, which leads to the generation of machine failures. To perform a mechanical vibration analysis, high-cost equipment is required that some companies cannot afford, so it is difficult to have predictive quality maintenance.

Every machine is under mechanical vibrations. To reduce vibration the following factors must be analyzed: bad design, poor fit, bad calibration and misalignment, among others. These factors can cause machine failures that can lead to large stops in production and economical losses.

This research will be able to perform low cost predictive maintenance, so that companies can reduce downtime in their production lines; due to mechanical failures that may occur. Tests will be performed where analog signals are linked and interpreted in software. For this link we will use sensors and a data acquisition card, for the interpretation of the signals will be used a visualization software.

In the frame of the analysis of mechanical vibrations was made the storage of analog signals and the interpretation of graphs. To store the signals, a data acquisition card was used which, through an interface to the visualization program, could observe the signals.

The limitations of the work are the lack of reliability of the companies in new prototypes, the lack of information on the applications of the sensors and the lack of interest in investing in new techniques of preventive maintenance, as well as that several companies opt for a maintenance corrective.

## 2. Theory

### Rotary Unbalance

A visual source of vibrations is rotating equipment. Small irregularities in the mass distribution of a rotating component can cause high vibrations. This is known as rotary imbalance

(Rao, 2012). The typical unbalance pattern y shown below in the figure 1.

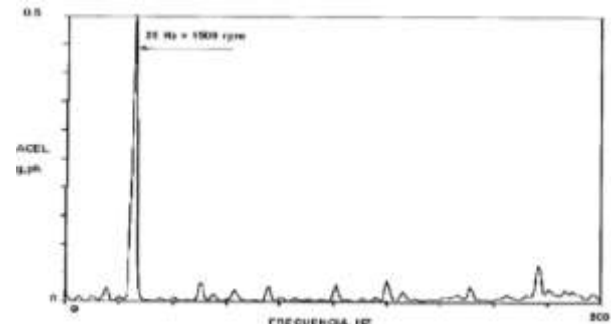


Figure 1: Typical unbalance pattern.

### Roto-Dynamic

Rotodynamic is a branch of mechanical engineering that has been developed mainly by the need for rotating equipment to achieve high speeds of rotation. Thanks to the developments in rotodynamic, the design of rotary equipment has focused on devising more flexible rotors and supports that absorb vibrations without damaging them, and include damping the system to reduce vibration amplitudes (Rojas, 2012).

### Testing bench

Installation used to measure the performance of the motors and their performance characteristics. The test bench is used both to obtain important data on the development of prototypes and for the determination of certain fundamental data necessary for the testing of motors manufactured in series, (Diccionario.motorgiga.com, 2017).

### Display Software

The visualization of Software (VS), has to do with the visual representation of the information provided by the software systems. This representation is based on its structure, history or behavior. It is a discipline of software engineering that simplifies the analysis and compression of software systems to maintain, re-use, and re-engineer those (Miranda, 2011).

### Data acquisition

Data acquisition (DAQ) is the process of measuring with a PC an electrical or physical phenomenon such as voltage,

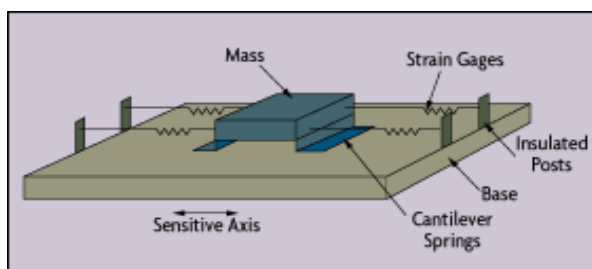
current, temperature, pressure or sound. A DAQ system consists of sensors, DAQ measurement hardware and a PC with programmable software. Compared to traditional measurement systems, PC-based DAQ systems leverage the processing power, productivity, visualization and connectivity skills of industry-standard PCs by providing a more powerful, and flexible and cost-effective measurement solution (Halvorsen, 2012).

### Sensor

The measurement of a physical phenomenon, such as the temperature of a room, the intensity of a light source, or the force applied to an object, begins with a sensor. A sensor, also called a transducer, converts a physical phenomenon into an electrical signal that can be measured. Depending on the type of sensor, its electrical output may be a voltage, current, resistance, or other electrical attribute that varies with time. Some sensors may require additional components and circuits to correctly produce a signal that can be read accurately and safely by a DAQ device (Halvorsen, 2012).

### Accelerometer

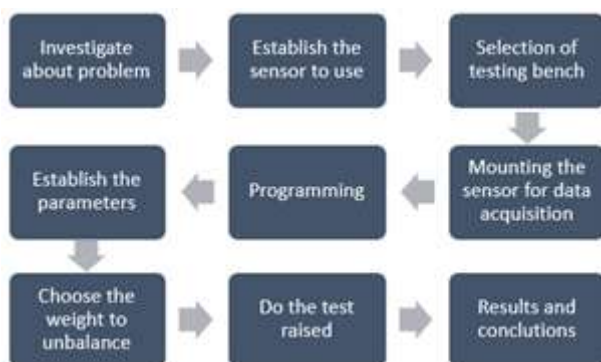
An accelerometer is a device that measures the vibration or acceleration of movement of a structure. The force generated by the vibration or the change in motion (acceleration) causes the mass to "compress" the piezoelectric material, generating an electric charge that is proportional to the force exerted on it (Es.omega.com, 2017). Below is a schematic of the operation of a basic accelerometer in the figure 2.



**Figure 2:** Schematic of the operation of a classical accelerometer

## 3. Methodology

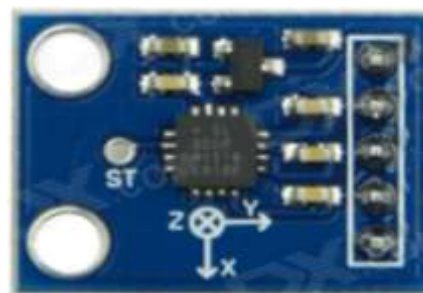
The method was created by a process of activities that were carried out in chronological form. Activities did in this analysis are shown in the diagram below (Figure 3).



**Figure 3:** Methodology

### 3.1 Establish the sensor to use

The accelerometer that was chosen is an ADXL335, since this sensor can measure the acceleration in three axes, called "X", "Y" and "Z" but to perform the tests only we will use the axes "x", "y". This sensor has an error margin of  $\pm 3$  G and operates with 3 volts DC. It can be connected to any type of data acquisition card, since each axis of the sensor returns a voltage proportional to the acceleration, with which it will be possible to easily interpret the signal and therefore through its own criteria to establish if the bank testing is failing. The accelerometer is shown in Figure 4.



**Figure 4:** Accelerometer ADXL 335

### 3.2 Choose of the testing bench.

The testing bench was acquired from the predictive maintenance laboratory of the Tlaxcala Technological University. The test bench has a DC motor, a speed variator, a shaft and two bearings. The testing bench used is shown in figure 5.



**Figure 5:** Testing bench

### 3.3 Mounting the sensor

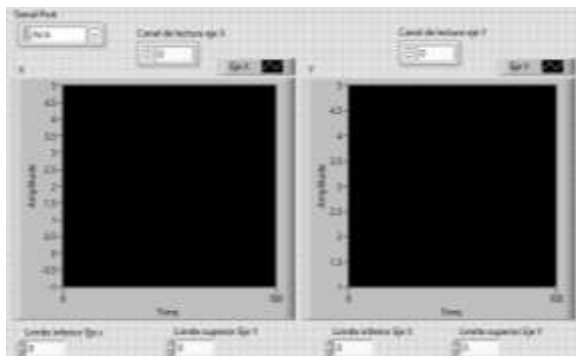
A metal base was designed and manufactured to couple the accelerometer on the cover of motor because it is the place where the vibration occurs with more intensity (Figure 6).



**Figure 6:** Accelerometer in the testing bench

### 3.4 Programming

The program to do the analysis of vibration was done with graphical programming. This program has two parts, a visualization screen and the block diagram. The visualization screen has two monitors to observe the graphics of vibration of the axes x and y. The "X" axis will tell us the behavior of the motor horizontally and the "y" axis vertically. Each monitor has two controls to establish vibration limits. The visualization screen is shown below in the figure 7.



**Figure 7:** Visualization screen.

### 3.5 Establish parameters in the display program

The accelerometer has a pressure of  $\pm 3$  G. The parameters are set according to the precision provided by the sensor. The ranges for each are shown in Table 1 and Table 2.

**Table 1:** Axis X limits

Axis X		
	Minimum limit	Maximum limit
Without load	0.5	3
Balanced load	0.5	3
Unbalanced load	0.5	3

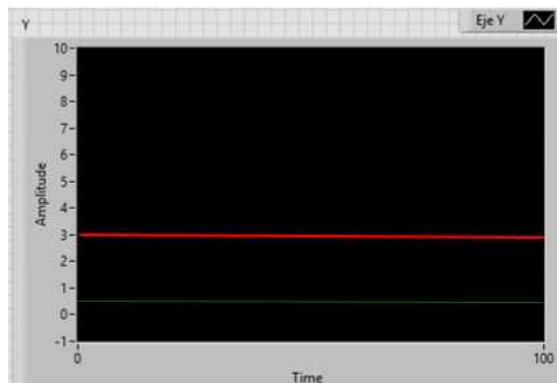
**Table 2:** Axis Y limits

Axis Y		
	Minimum limit	Maximum limit
Without load	0.5	3
Balanced load	0.5	3
Unbalanced load	0.5	3

The maximum limit in the visualization screen is red line and the minimum limit is green line. Figures 8-9 show the display panels in the program with the set parameters.



**Figure 8:** Display panel of the "X" axis.



**Figure 9:** Display panel of the "Y" axis.

### 3.6 Choose the weight to unbalance

Nuts and bolts were used to unbalance and balance the load. Each bolt with three nuts weighs 50 g. The weight chosen to unbalance the load was 150 g and the weight chosen to balance the load was 200 g. The used bolts and nuts are shown in the figure 10.



**Figure 10:** Bolts and nuts.

## 4. Vibration test

Three tests were done under different conditions. The first test without load, the second with balanced load and the third with unbalanced load. The purpose is to analyze the operation of the motor under different operating conditions.

### 4.1 Test without load

In this test, the axis of the motor load disc is decoupled. This is to obtain the parameters of acceleration without load and thus to know if the engine is in the correct conditions of operation, (Figure 11).



**Figure 11:** Motor decoupled

#### 4.2 Test with balanced load

In this test, the motor runs under balanced load, this will be used to compare the behavior with balanced load and no load on the engine. To balance the load, four bolts with three nuts were used and placed in the holes of the loading disk, (Figure 12).

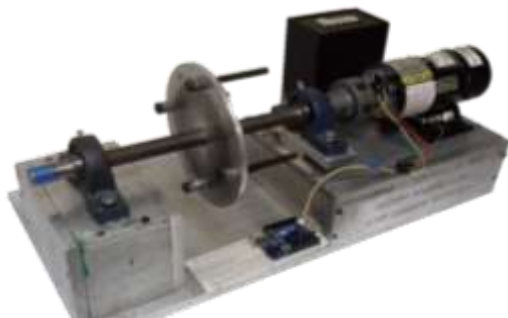


Figure 12: Testing bench with balanced load

#### 4.3 Test with unbalanced load

To determine a fault in the motor in this test will unbalance the load disk to drastically alter the behavior of the engine. If such behavior exceeds the set acceleration parameters, it may be determined an error, which in this case will be unbalanced, (Figure 13).



Figure 13: Testing bench with unbalanced load

### 5. Results and interpretation of the three tests

#### 5.1 Test results without load

According to the graph of the signal obtained in the axes "X" and "Y" of the test without load. The motor is in optimum operating conditions as there are no variations in acceleration. This determines that the results in the two tests with balanced and unbalanced load are more reliable. The graphs obtained according to the test are shown below (Figure 14-15).

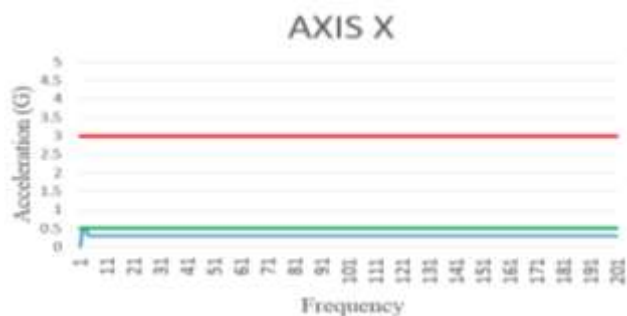


Figure 14: X-axis, no-load test

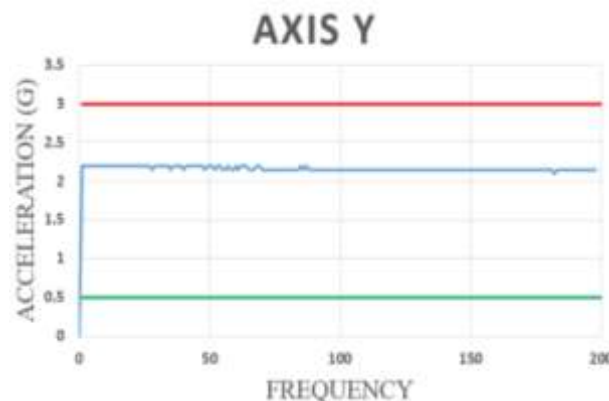


Figure 15: Y-axis, no-load test

#### 5.2 Test results with balanced load

In this test, the results of the "x" axis presented a greater acceleration in the starting of the motor, but decreased when the speed increased, whereas in the "y" axis the acceleration was constant. Both results increased acceleration, but this did not exceed the established limits. This states that if the motor runs under a balanced load, there will be no faults in the components of the test bed. The graphs obtained according to the test are shown below (Figure 16-17).

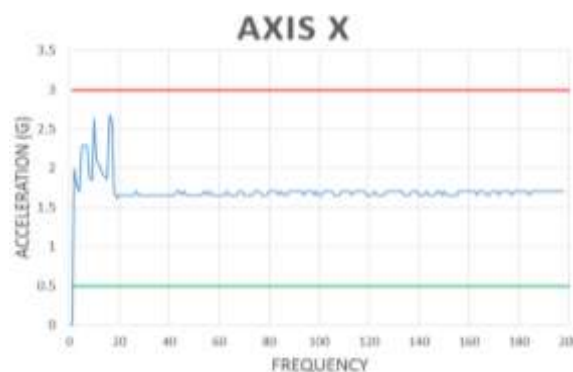


Figure 16: X-axis, balanced load test.

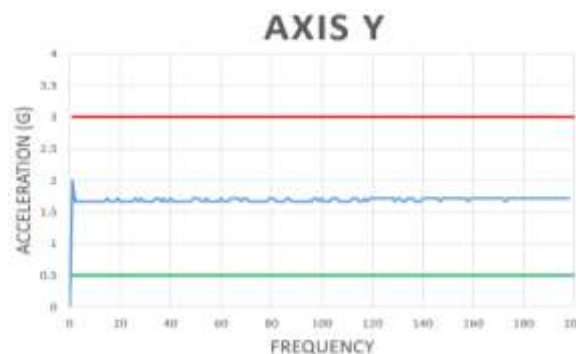
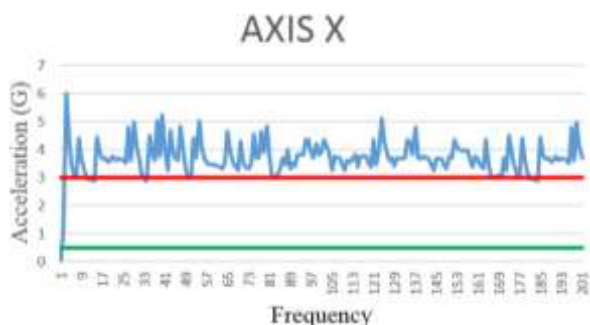


Figure 17: Y-axis, balanced load test.

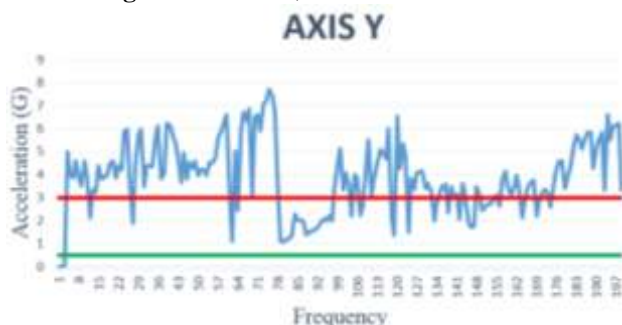
#### 5.3 Test results with unbalanced load

In this test, it is clearly seen that the acceleration results exceeded the established operating limits, so that it can be determined that there is a fault in the equipment, in this case the fault is due to the imbalance. The graphs obtained according to the test are shown below (Figure 18-19).





**Figure 18:** X-axis, unbalanced load test.



**Figure 19:** Y-axis, unbalanced load test

## 6. Conclusion

According to the results obtained in the three tests were able to set the nominal conditions operating under different loads, It was determinate that one of the leading cause of a motor fails is the unbalance, as it can be seen in figure 18 and 19 the vibration is excessive which produces as a result that the axis of motor is hot because of the friction, also bearings suffer excessive wear which makes life is less.

With this analysis can be concluded that this can help to the development of teams to analysis vibrations with components very economic on the market. For companies that have industrial machinery and it have not the economic resources need to acquire a team of analysis of mechanical vibrations is very viable create your own analysis system because through a personal discretion are set limits vibration also may have control of the operation of machines and to establish a preventive maintenance plan and so be able to extend the life of machinery.

Temperature and current are other variables that could analyze to have the optimum performance motorto have an analysis more complete in roto-dynamic equipment.

## References

- [1] H.P. Halvorsen, Introduction to LabVIEW, Porsgrunn, Norway: Faculty of Technologic 2012.
- [2] M.L. Adams, Rotating Machinery Vibration from analysis to troubleshooting, Cleveland, Ohio, 2001.
- [3] S.S. Rao, Mechanical vibrations (fifth edition), Pearson Inc., Mexico, 2012.
- [4] J.E. Shigley, Design in Mechanical Engineering, Mc Graw-Hill, State of Mexico. 1985.
- [5] Es.omega.com. (2014). Acelerometro | Omega engineering. [online]. Available:

<https://es.omega.com/prodinfo/acelerometro.html>.

[Accessed: Sept. 12, 2017].

- [6] Diccionario.motorgiga.com. (2013). BANCO DE PRUEBAS. [online]. Available: <https://diccionario.motorgiga.com/diccionario/banco-de-pruebas-definicion-significado/gmx-niv15-con193089.htm>. [Accessed: Sept. 12, 2017].

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