GENERATE HIGH FREQUENCY MECHANICAL VIBRATION

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Mac 2007

"I have read this work and from my view this work is adequate on scope and quality for the purpose of awarding Bachelor of Mechanical Engineering (Design and Innovation)"

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Date : 8-5-2007

"I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been undertaken or done by unspecified sources or persons"

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ABSTRACT

The main objective of this project is to generated high frequency mechanical vibration. Actually, in the industries today, high vibration is something that industries want to avoided. This is because high vibartion can cause damaged and give a bad condition to whole system and machine. For the author thesis, the author will used the sources of mechanical vibration as a sources to generated high frequency mechanical vibration. During the thesis done, the author made analysis and refer to the book and make contact to the experts in this area. Although the purpose is to generated high vibration, the important think to ensure is to find that the high vibration about the machine or system do not surpass the limit of machine condition (ISO standard). The mechanical way that the author decide to use and made analysis are selected rolling element bearing, unblance force, teeth gear, stiffness anfd number of blades and vanes.

ABSTRAK

Tujuan utama projek ini dijalankan adalah bertujuan untuk mengkaji dan menganalisis getaran terhadap suatu mesin. Kebiasaanya di industri, getaran terhadap mesin merupakan elemen yang ingin dielakkan. Pihak industri dengan sedaya mahu mengurangkan getaran yang ada pada mesin merek. Getaran berkaitan dengan amplitud. Walaubagaimanapun untuk Projek Sarjana Muda saya ini, tajuk saya ialah " Generated High frequency Mechanical vibration". Dengan maksud lain ialah meninggikan getaran dengan sengaja pada satu mesin. Bagi mencapai objektif tersebut saya perlu mengkaji dan menganalisis cara-cara yang tepat untuk meninggikan dan meningkatkan getaran satu sistem. Kaedah yang digunakan adalah dengan menjadikan punca-punca getaran tinggi sebagai sumber utama dalam meningkatkan getaran sistem. Walaubagaimanapun, setiap analisis dan kaedah yang dibuat mestilah mematuhi etika kejuruteraan dalam getaran iaitu dengan memastikan getaran yang sengaja ditinggikan tidak memudaratkan sistem tau mesin terlibat. Antara kaedah dan cara-cara yang dijangkakan mampu meningkatkan getaran ialah pemilihan bearing, pemilihan gear, meletakkan imbangan, jumlah bilah kipas dan ketebalan komponen.

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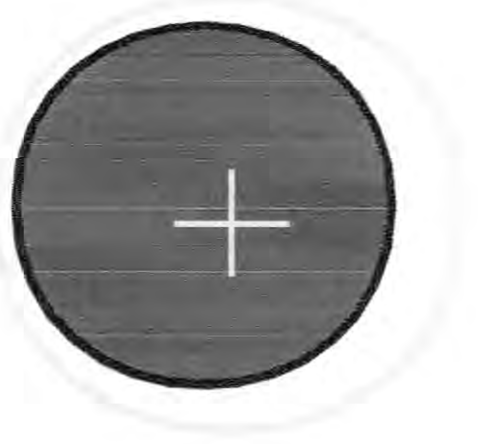
CHAPTER 1

INTRODUCTION TO VIBRATION.

Vibration refers to mechanical oscillations about an equilibrium point. The oscillations about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. In this chapter the author will discuss about the vibration environment in engineering industries.

1.1 Vibrations in general.

Nowadays people and engineering industries are looking forward and paid attention about the vibration criteria. This is because; vibration characteristic can give effect to whole system of machine if the industries or engineer try to not care and take an easy action about this area. Vibration is a repetitive, periodic or oscillatory response of mechanical system. The rate of vibration cycles is termed "frequency". Repetitive motions that are somewhat clean and regular, and that occur at relatively low frequencies are commonly called oscillations, while any repetitive motion even at high frequencies, with low amplitudes, and having irregular and random behaviour falls into the general class of vibration. Vibrations can naturally happen in an engineering system and may be representative of its free and natural dynamic behaviour. There are "good vibrations," which serve a useful purpose. Also, there are "bad vibrations," which can be unpleasant or harmful. For many engineering systems, operation at resonance would b undesirable and could be destructive. Suppression or elimination of bad vibrations and generation of desired forms and levels of good vibration are general goals of vibration engineering.



Shaft Vibration;
Caused by the shaft moving about the centerline of a journal bearing.

As stated in [1] vibrations are oscillatory response of dynamic systems. Natural vibrations occur in these systems due to the presence of two modes of energy storage. This is happen when the stored energy is converted from one form to the other, repeatedly back and forth, the resulting time response of the system is oscillatory in nature. In mechanical system, natural vibrations can occur because kinetic energy, which is manifested as velocities of mass (inertia) elements, can be converted into potential energy and back to kinetic energy, repetitively, during motion. Mechanical vibrations can occur as both free (natural) responses and forced responses in numerous practical situations. More often, vibration is undesirable, wasting energy and creating unwanted sound--noise. For example, the motions of engines, electric motors, or any mechanical device in operation are usually unwanted vibrations. Such vibrations can be caused by imbalances in the rotating parts, uneven friction, the meshing of gear teeth, parts that are dragging together, etc. Careful designs usually minimise unwanted vibrations

Vibration refers to mechanical oscillations about an equilibrium point. The oscillations may be periodic such as the motion pendulum or random such as the movement of a tire on a gravel road. Vibration is occasionally desirable. For example the motion of rotation of a tuning fork, the reed in a woodwind instrument or harmonica, or the cone of a loudspeaker is desirable vibration, necessary for the correct functioning of the various devices.

More often, vibration is undesirable, wasting energy and creating unwanted sound-noise. For example, the motions of engines, electric motors, or any mechanical device in operation are usually unwanted vibrations. Such vibrations can be caused by imbalance in the rotating parts, uneven friction, the meshing of gear teeth, parts that are dragging together, etc. careful design usually minimise unwanted vibrations.

In other words, a vibration system, in general, includes a means for storing potential energy (spring or elasticity), a means for storing kinetic energy (mass or inertia), and a means by which energy is gradually lost (damper). The vibrations are related to frequency.

1.2 Types of vibration

1.2.1 Free vibration

Free vibration occurs when a mechanical system is set off with an initial input and then allowed to vibrate freely. Examples of this type of vibration are pulling a child back on a swing and then letting go or hitting a tuning fork and letting it ring. The mechanical system will then vibrate at one or more of its natural frequencies and damp down to zero.

1.2.2 Forced vibration

Forces vibration is when an alternating force or motion is applied to a mechanical system. Examples of this type of vibration include a shaking washing machining due to an imbalance, transportation vibration (caused by truck engine, springs, road, etc), or the vibration of a building during an earthquake. In forced vibration the frequency of the vibration the vibration depend on the frequency content of the force motion applied, but the magnitude of the vibration is strongly *dependent on the behaviour of the mechanical system.*

1.3 Applications area

The science and engineering of vibration involve two broad categories of applications:

- Elimination or suppression of undesirable vibrations

  These types of vibration include structural motions generated due to earthquakes, dynamic interactions between vehicles and bridges or guideways, noise generated by construction equipment, vibration transmitted from machinery to its supporting structures or environment, and damage, malfunction and failure due to dynamic loading, unacceptable motions and fatigue caused by vibration.

  Example:

  Dynamic interactions between an automated transit vehicle and bridge can cause structural problems as well as degradation in ride quality.

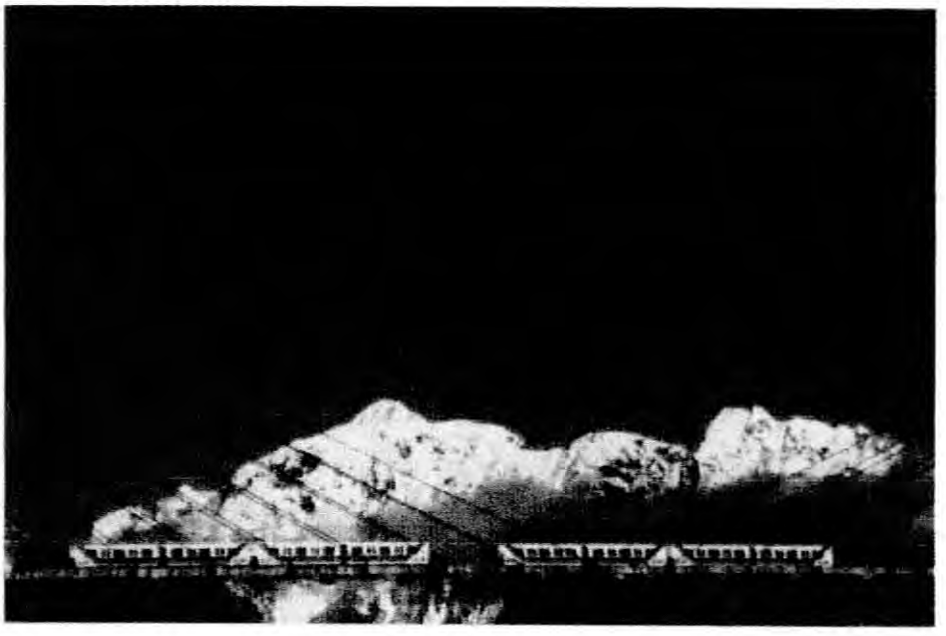


Figure 1.1: The SkyTrain in Vancouver, Canada, a modern automated transit system.

- Generation of the necessary forms and quantities of useful vibrations
  As stated in (2) these types of vibration include those generated by musical instruments, devices used in physical therapy and medical applications, vibrators used in industrial mixers, part feeders and sorters, and vibratory material removers such as drills and polisher (finisher).
  Example:
  Product alignment for industrial processing or grading can be carried out by means of vibratory conveyors or shakers.

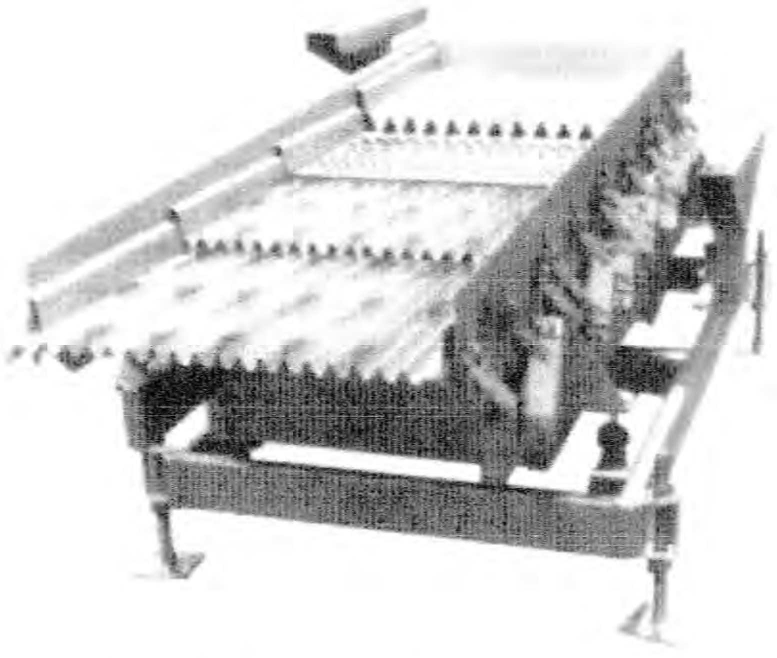


Figure 1.2: An alignment shaker.

From the statement above, we can conclude that vibrations can be needed and not necessary depend on the situation that industries faced with. There have a situation that vibrations can give benefit to the industries and there also have situations that vibrations can cause damage to the industries. It is depend to engineer and the person in charge to monitor and control the level of vibration by their skills and experience also knowledge, so they can manage the situation.

1.4. Vibration units and dimension.

Basically there are three units and dimension that are related to vibrations. The general rule for dimensions and units:

- **Displacement:** The speed is less than 600 RPM and the machine has journal bearings (m).
- **Velocity:** The speed is between 1,000 RPM and 10,000 RPM (ms^{-1}).
- **Acceleration:** The speed is greater than 10000 RPM (ms^{-2}).

1.5 Vibration Instrument and simple measurement vibration system

There are five ways to make analyse and measured the vibrations amplitude levels. These five ways can be analyzed and get from the data produced from the vibrations equipment. Those 5 ways are:

- Peak to peak (pk-pk)

In measuring the level of a signal wave form, the peak-to-peak value is the difference between the highest positive peak level and the lowest negative peak value. In machine vibration, displacement generally measured in peak-to-peak units.

- Zero to peak (0-pk)

See peak, as in peak value. Half of the peak-to-peak value.

- RMS (root mean square)

RMS stands for Root Mean Square, and is a measure of the level of a signal. It is calculated by squaring the instantaneous value of the signal, averaging the squared values over time, and taking the square root of the average value. The RMS value is the value which is used to calculate the energy or power in a signal. The RMS value of a sine wave is .707 times the peak value, but the RMS value of a complex signal is difficult to predict without measuring it. It is accepted convention to measure the RMS value of acceleration when performing vibration analysis of machines.

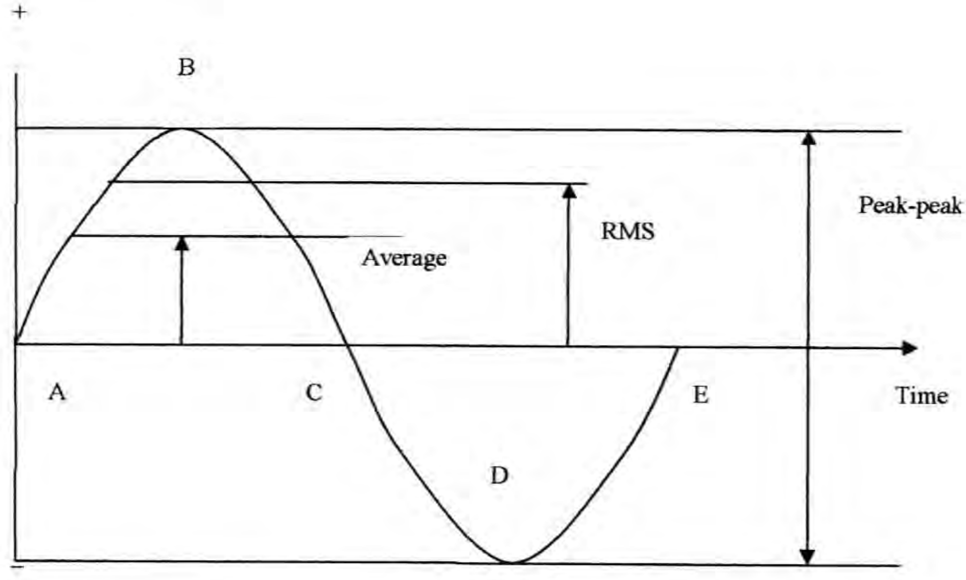
- Average

Averaging is very important when performing spectrum analysis of any signal which changes with time and this is usually the case with vibration signals of machinery. It is especially important for low frequency measurements, which require long averaging times to achieve a good statistically accurate estimate of the spectrum. Linear averaging smoothes out the spectrum of the random noise in a spectrum making the discrete frequency components easier to see, but it does not actually reduce the noise level.

- Crest factor

The crest factor is the ratio of peak value to the RMS value. This parameter is used as a trending value to alert when a vibration signals has many "peaks" or "spikes", as many be the case when bearings begin to fail.

Harmonic motion:

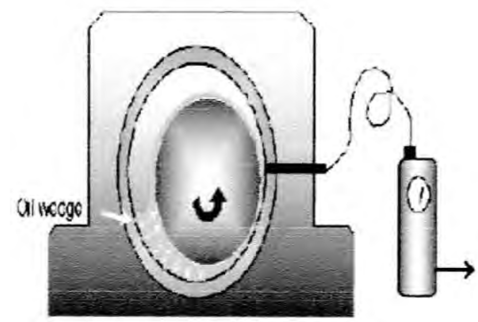


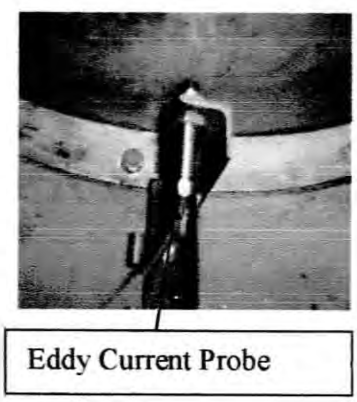
1.6. Vibration equipments:

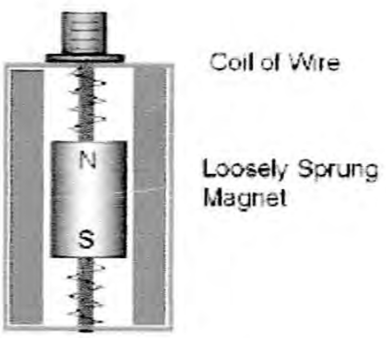
1.6.1 Transducer:

A transducer is a device which converts one type of energy, such as vibration or sound, into a different type of energy, usually an electric current or voltage. Transducers are at the centre of instrumentation systems, and are usually also the weakest links. They contribute noise to the measured signals and also generate distortion because of non-linearities. They are subject to changes in their sensitivity, and therefore require regular calibration. Some types of transducer are much more reliable and linear than others; an example is the piezoelectric accelerometer, which is by far the best type for general vibration measurement.

1.6.1.2 Types of transducer:



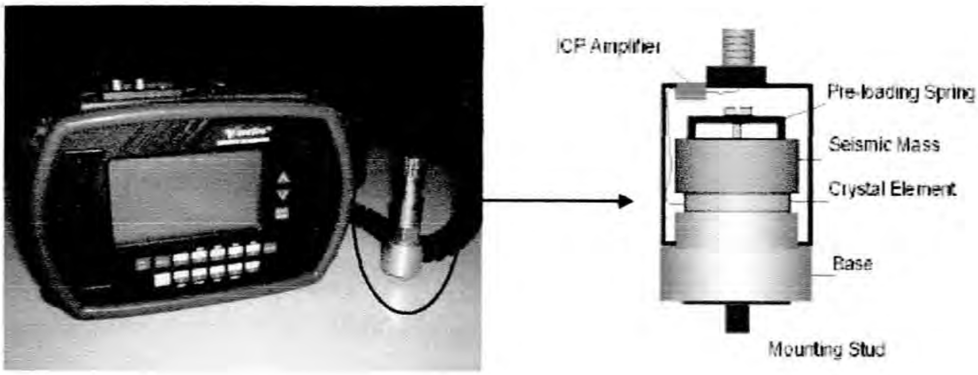




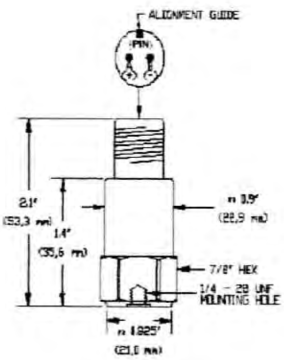
The Velocity Probe-

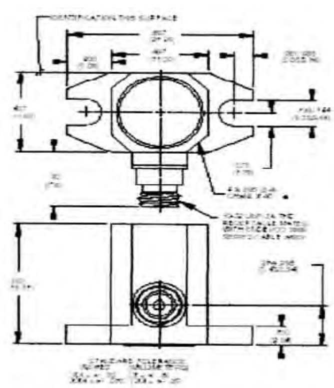
Figure 1.3: Type of transducer.

1.6.1.2 Types of accelerometer:



-Commtest Analyzer- -Accelerometer-





Portable transducer and Piezoelectric Model 2248/2248AM1.

Figure 1.4: Type of accelerometer.

2.5 Fast Fourier Transform, (FFT)

In industry, a machine will have a number of sources of vibration. The bearings, cooling fan blades, motor rotor bars, and resonances all generate vibration at different frequencies.

The Fast Fourier Transform (FFT) is an algorithm, or digital calculation routine used in the FFT analyzer, which calculates a spectrum from a time wave form. In other words it converts, or "transforms" a signal from the time domain into the frequency domain. If were to look at the waveforms from the side, so that we could only see their height, we would have a spectrum. FFT is simply breaking the waveform up into those individual sine waves, then representing them as a spectrum. FFT was used by vibration analysis to study the pattern of the vibration and allows us to see exactly how the vibration is changing from one moment to the next.

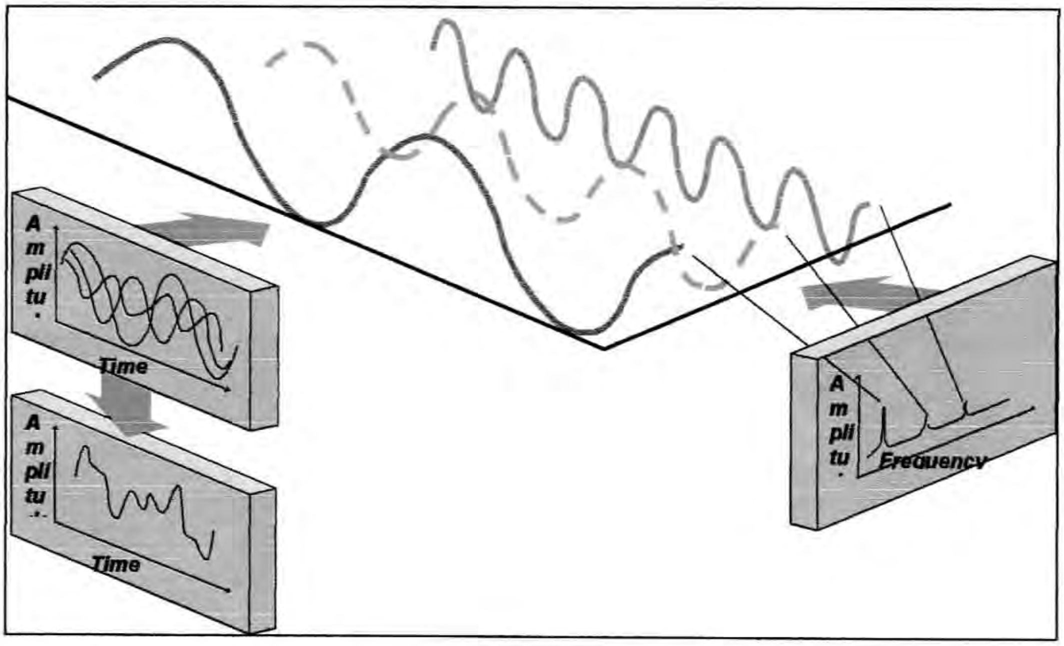
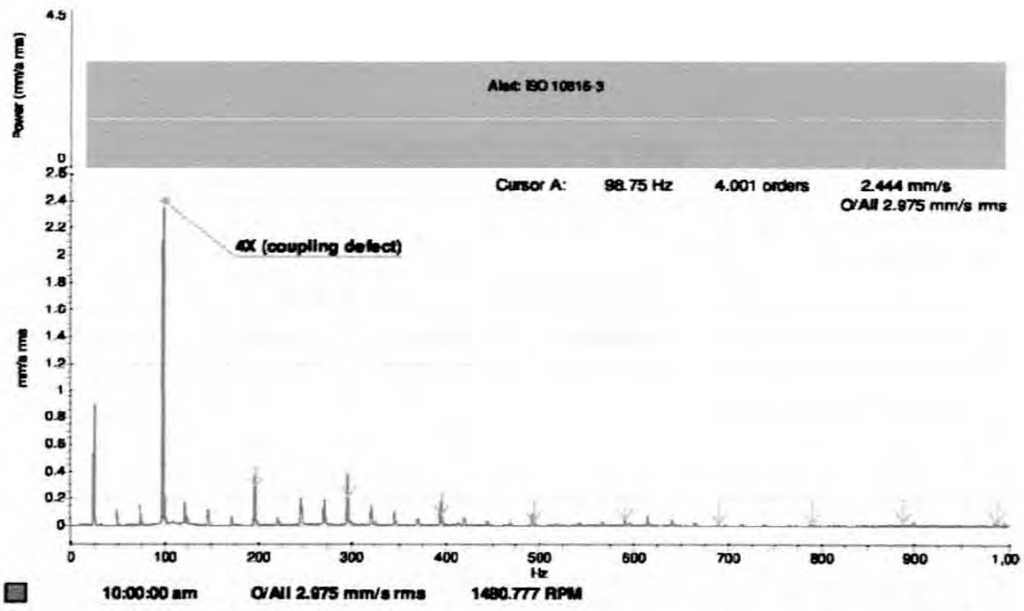


Figure 1.5: The FFT diagram.



In the diagram above is an actual example of a modulated signal from a machine. The signal is one of the example FFT (Fast Fourier Transform) is derived from the waveform. We can see this signal on the analyzer-commtest.

1.8 Basic measurement vibration system:

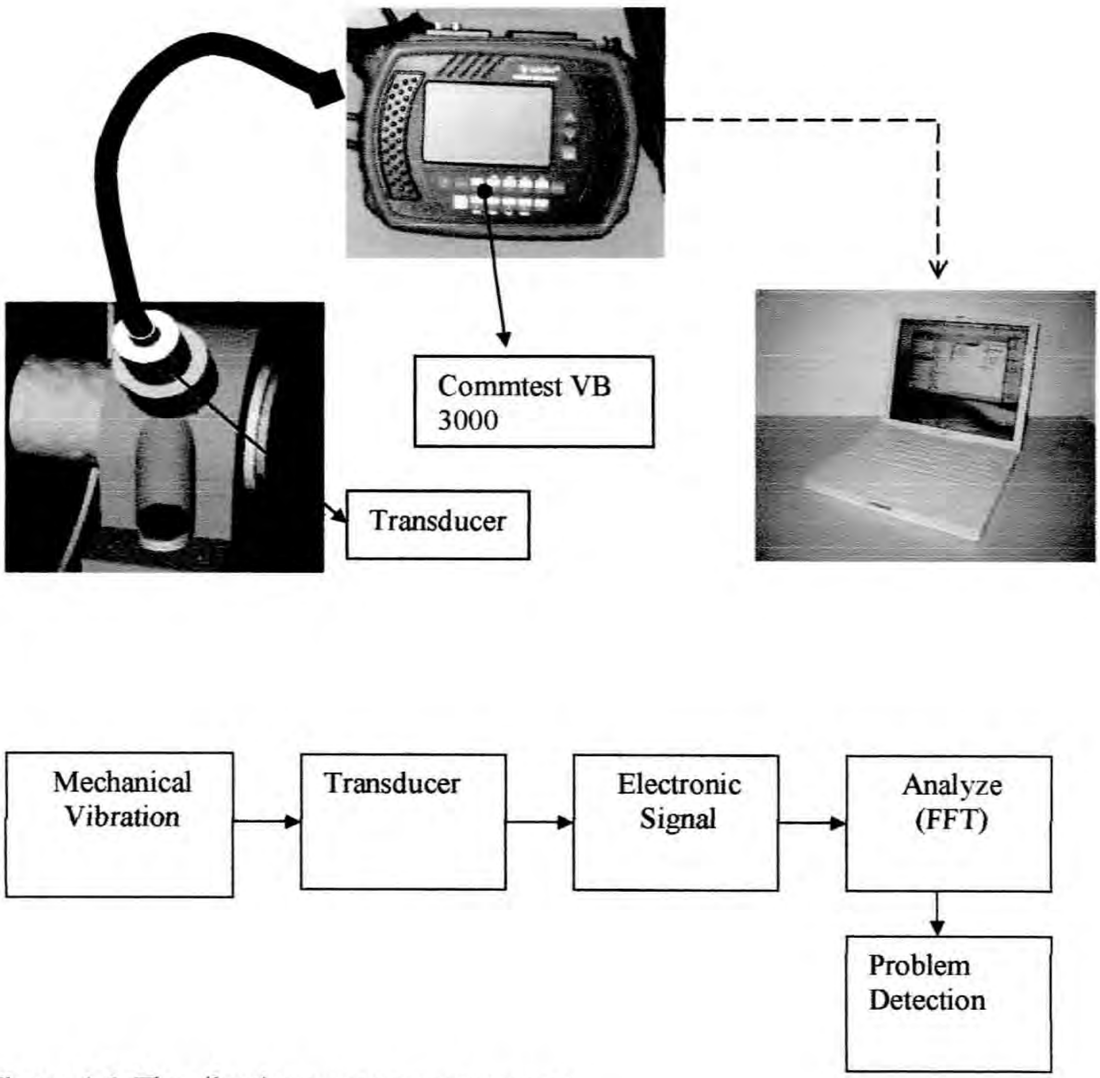


Figure 1.6: The vibration measurement process.

The diagram showed the flow and the process of the vibration measurement. This is basic steps that can be referred or as a revision to the person in charge to measured vibration system. The producer describes how vibration signals can be detected and transform into Fast Fourier Transform (FFT). From FFT, we can analyze and determined the machine situations and conditions. Therefore we can decided what action must taken to control and monitor the machine vibration whether to increase or reduced the vibrations depends on the environment condition and industries demands.