CONDITION MONITORING OF FACULTY AIR CONDITIONING SYSTEM

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A report submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

This thesis writing deals with the study of Condition based maintenance, CBM, defined as preventive task is performed at certain condition of the equipment. This strategy is much more cost effective than maintenance on failure. When running to failure, an unplanned interruption to production or service is induced. Also a collateral damage may lead to costly consequences. Pump mostly has cause energy loss low performing during task time. The cause of the pump error is because of the vibration in the pump itself. Lack of the information and the knowledge of the vibration error can cause damage on the pump. The prediction technique can ensure the safety of the pump. One way to check the errors occur on the pump is using DASYLAB software. DASYLAB software will calibrate with the tri-axis accelerometer sensor to grab the data and convert it into a measureable data. Some condition indicators are monitored to observe deterioration and detect onset of failures. With exception of vibration analysis, there is a deficiency of experimental studies that investigate diagnosis of rotor related faults. To see the errors on the pump, the vibration data will be converting into the FFT graph and the pattern of the error can be seeing based on the ISO 10816-3. The result should show the problem occur base on the FFT vibration graph. In the future plan, the, the technique can be implement around the Faculty of Mechanical

ABSTRAK

Tesis ini menulis berurusan dengan kajian ‘Condition based maintenance’, CBM, ditakrifkan sebagai tugas pencegahan dilakukan pada keadaan tertentu peralatan. Strategi ini adalah kos lebih berkesan daripada penyelenggaraan kegagalan. Apabila menjalankan kegagalan, gangguan tidak dirancang untuk pengeluaran atau perkhidmatan adalah disebabkan. Juga kerosakan cagaran boleh membawa kepada kos pembaikian yang mahal. Pump kebanyakannya mempunyai sebab tenaga kerugian yang rendah berbayar dalam masa tugas. Punca kesilapan pam adalah kerana getaran dalam pam itu sendiri. Kekurangan maklumat dan pengetahuan kesilapan gegaran yang boleh menyebabkan kerosakan pada pam. Teknik ramalan boleh memastikan keselamatan pam. Salah satu cara untuk memeriksa kesilapan berlaku pada pam menggunakan perisian DASYLAB. DASYLAB perisian akan menentukur dengan sensor ‘tri-axis accelerometer’ untuk merebut data dan menukar ia ke dalam data diukur. Beberapa penunjuk keadaan dipantau untuk melihat kemerosotan dan mengesan permulaan kegagalan. Kecuali analisis getaran, terdapat kekurangan kajian eksperimen yang menyiasat diagnosis kesalahan berkaitan pemutar. Untuk melihat kesilapan pada pam, data getaran akan menukar ke dalam graf FFT dan corak kesilapan boleh melihat berdasarkan ISO 10816-3. Hasilnya perlu menunjukkan masalah yang berlaku berdasarkan graf getaran FFT. Dalam rancangan masa depan,, teknik boleh melaksanakan sekitar Fakulti Kejuruteraan Mekanikal**.**

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Pumps are the largest single consumer of power in industry .pumps causes a high rate of energy loss with associated performance degradation, high vibration levels and significant noise radiation (Courrech, 1989). The pump is used for pumping of cooling water to condenser. The pump also had a mechanical problem before install. Failure on the centrifugal pump would potentially result in the total shutdown.

The current methods for monitoring (simple vibration analysis) are not adequate enough to predict incipient faults in a pump and avoid frequent breakdowns and outages that are causing the shutdown of large pumps. The condition of components such as pump shafts and impellers, roller bearings and drive parts is monitored by evaluation of specific machine vibrations, vibrations due to flow excitation, and structure borne sound in roller bearing. Condition information is automatically transmitted to the system (Kryter, 1989)

1.2 PROBLEM STATEMENT

The problem occurs when there is high vibration at the centrifugal pump cause failure. Besides that, lack of the information and equipment was the factors that influence the diagnosis to centrifugal pump. Condition monitoring and prediction also need to be improve because of the critically failure situation of pump. There will be a similar pattern failure occurred in the pump every time it fail. The management obviously requires edification on the root cause to the pump failure and the system design problem need to be justifying such as a long term solution improved pump reliability.

1.2 OBJECTIVES

The objective of the thesis has defined as follows:

1. To study and investigate the characteristic of common fault experience in the centrifugal pump.

2. To investigate parameter that could be used to predict the main fault in the centrifugal pump.

3. To analyze the pattern on the failure that could occurs in the centrifugal pump based on vibration analysis.

1.3 SCOPE

To achieve the objective, the scope of the work generally involved the investigation of the vibration occurs at the centrifugal pump. The error can be present by referring the previous study of the title. The parameter can be use is the velocity (mm/s) base on the ISO-10816-1to justify the error occur on the pump.

CHAPTER 2

LITERATURE REVIEW

2.1 VIBRATIONS IN CENTRIFUGAL PUMP

Failures of the centrifugal pump often occur without due to the warning from the installed sensors and monitor it. The reason is the lack of the transducers mount where they can reliably sense the condition of the pump. In the industrial, there are no standard require for sensors. The sensors are most often mounted on the motor, some distance from the pump (Mukhopadhyay, 2005). In today economic climate, industries are pressured to operate their equipment longer and at improved efficiencies, while maintaining safe reliable operation (Benbouzid, 1998). This can be achieved in part by monitoring and trending of parameters such as vibration, lube oil condition, performance, etc. Vibration is probably the most important tool in these programs and has become accepted and proven worldwide in various industries (Igor, 1960).

2.1.1 Vibration analysis

Vibration analysis is used to determine the operating and mechanical condition of equipment. A major advantage is that vibration analysis can identify developing problems before they become too serious and cause unscheduled downtime (Downham, 1980). This can be achieved by conducting regular monitoring of machine vibrations either on continuous basis or at scheduled intervals.

Regular vibration monitoring can detect deteriorating or defective bearings, mechanical looseness and worn or broken gears. Vibration analysis can also detect misalignment and unbalance before these conditions result in bearing or shaft deterioration. Trending vibration levels can identify poor maintenance practices, such as improper bearing installation and replacement, inaccurate shaft alignment or imprecise rotor balancing (Courrech, 1989).

Some parameter can be monitored, such as oil debris analysis, temperature, and pressure flow, to determine the condition of the machine (Courrech, 1989). Vibration analysis is the most efficient monitoring approaches based on the Table 2.1. There is a large amount of information contained in the vibration signal can be obtained by monitoring. However, the signals can be complex and even with today state-of-the-art measurement techniques, the signal need to be study in order to be able to measure, display, and utilize the vibration data to the full potential for predictive maintenance purposes (Mukhopadhyay, 2005).

Table 2.1: Machine Fault vs. Parameter

Parameter / Machine Fault	Vibration	Temperature	Pressure	Flow	Oil Analysis
Unbalance	✓				
Misalignment/ Bent shaft	✓	✓			
Damaged Rolling Element Bearings	✓	✓			✓
Damaged Journal Bearings	✓	✓	✓	✓	✓
Damaged or Worn Gears	✓				✓
Mechanical Looseness	✓				

Monitoring of the health of the machine should be used using the combination of the techniques, because sometime the use of the vibration measurements will not perfectly assess the condition of machine due to a lack understanding of the machine dynamics and signal processing techniques (Dailly, 1989)

Predictive of condition based maintenance requires regular checks of key performance parameters like vibration, temperature, pressure, and oil analysis (Casada, 1995). The signals from the accelerometers are measured and stored with the trended to predetermine warning and alarm levels before remedial action is taken.

2.2 PREDICTIVE MAINTENANCE TECHNIQUE

In predictive maintenance technique, it have a maintenance philosophies employed by different process plant. The maintenance philosophies can usually be divided into four different categories that is breakdown or run to failure maintenance, preventive or time-based maintenance, predictive or condition–based maintenance and proactive or prevention maintenance (Downham, 1980). These categories can be seen in Figure 2.1

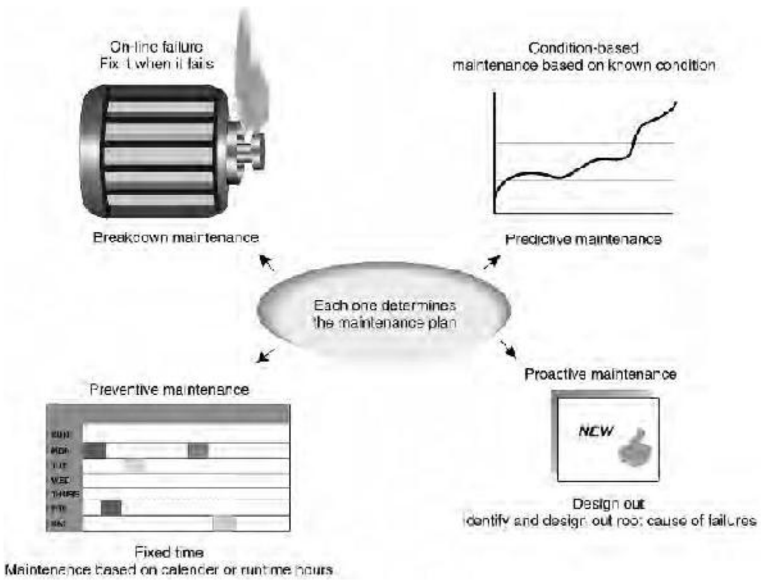

Figure 2.1: Maintenance Philosophies

2.2.1 Breakdown or run to failure maintenance

The basic philosophy behind breakdown maintenance is to allow the machinery run to failure and only repair or replace damaged components just before or went the equipment come to a complete stop (Downham, 1980). This approach work well if the machine is shutdowns not affect the production. It have disadvantage that is department did not planed the crisis happen. When unexpected production interruptions occur, the maintenance activities require a large inventory of spare parts to react immediately.

The technique is most inefficient way to maintain a production. The personnel generally have a low morale in such cases as they tend to be overworked, arriving at work each day to be confronted with a long list of unfinished work and a set of new emergency jobs that occurred overnight.

2.2.2 Preventive or time-based maintenance

Preventive maintenance is to schedule maintenance activities at base on calendar day or runtime hours of machines (Downham, 1980). This is a good approach for machine that thus not runs continuously. The personnel have enough skill, knowledge and time to perform the preventive maintenance.

The main disadvantage is that scheduled maintenance can result in performing maintenance tasks too early or too late. It is possible that, without any evidence of functional failure, components are replaced when there is still some residual life left in them. It is therefore quite possible that reduced production could occur due to unnecessary maintenance (Courrech, 1989). In many cases, there is also a possibility of diminished performance due to incorrect repair methods. In some cases, perfectly good machines are disassembled, their good parts removed and discarded, and new parts are improperly installed with troublesome results.

2.2.3 Predictive or condition-based maintenance

Predictive maintenance consists of scheduling maintenance activities only when a functional failure is detected. Mechanical and operational condition is continuously monitored and after unhealthy trends are detected, the troublesome parts in the machine are analyzed and reschedule for maintenance (Downham, 1980). The machine would then be shut down at a time when it is most convenient, and the damaged components would be replaced. If left unattended, these failures could result in costly secondary failures.

The advantages of the predictive maintenance are that the maintenance events can be scheduled in an orderly. It allows for some lead-time to purchase parts for the necessary repair work and thus reducing the need for a large inventory of spares. Since maintenance work is only performed when needed, there is also a possible increase in production capacity.

A possible disadvantage is that maintenance work may actually increase due to an incorrect assessment of the deterioration of machines. To track the unhealthy trends in vibration, temperature or lubrication requires the facility to acquire specialized equipment to monitor these parameters and provide training to personnel (Kryter, 1989). The alternative is to outsource this task to a knowledgeable contractor to perform the machine-monitoring duties.

It is very important that the management supports the maintenance department by providing the necessary equipment along with adequate training for the personnel. The personnel should be given enough time to collect the necessary data and be permitted to shut down the machinery when problems are identified.

2.2.4 Proactive or prevention maintenance

Proactive maintenance is the lays primary emphasis on tracing all failures to their root cause. Each failure is analyzed and proactive measures are taken to ensure that they are not repeated (Downham, 1980). As in the predictive-based program, it is possible to schedule maintenance repairs on equipment in an orderly fashion, but additional efforts are required to provide improvements to reduce or eliminate potential problems from occurring repeatedly.

By orderly scheduling of maintenance allows lead-time to purchase parts for the necessary repairs. This reduces the need for a large spare parts inventory, because maintenance work is only performed when it is required. Additional efforts are made to thoroughly investigate the cause of the failure and to determine ways to improve the reliability of the machine (Mitchell, 1981). All of these aspects lead to a substantial increase in production capacity.

The disadvantage is that extremely knowledgeable employees in preventive, predictive and prevention maintenance practices are required. It is also possible that the work may require outsourcing to knowledgeable personnel who will have to work closely with the maintenance. Proactive maintenance also requires procurement of specialized equipment and properly trained personnel to perform all these duties.

2.3 DATA ACQUISITION

To measure machinery or structural vibration, a transducer or a vibration pickup is used. A transducer is a device that converts one type of energy, such as vibration, into a different type of energy, usually an electric current or voltage. Commonly used transducers are velocity pickups, accelerometers and Eddy current or proximity probes. Each type of transducer has distinct advantages for certain applications, but they all have limitations as well. No single transducer satisfies all measurement needs. One of the most important considerations for any application is to select the transducer that is best suited for the job (Casada, 1995).

2.3.1 Velocity pickup

The velocity pickup is a very common transducer for monitoring the vibration of rotating machinery. This type of vibration transducer installs easily on most analyzers, and is rather inexpensive compared to other sensors. For these reasons, the velocity transducer is ideal for general purpose machine-monitoring applications. Velocity pickups have been used as vibration transducers on rotating machines for a very long time, and these are still utilized for a variety of applications today. Velocity pickups are available in many different physical configurations and output sensitivities (Casada, 1995).

When a coil of wire is moved through a magnetic field as shown in Figure 2.2, a voltage is induced across the end wires of the coil. The transfer of energy from the flux field of the magnet to the wire coil generates the induced voltage. As the coil is forced through the magnetic field by vibratory motion, a voltage signal correlating with the vibration is produced.

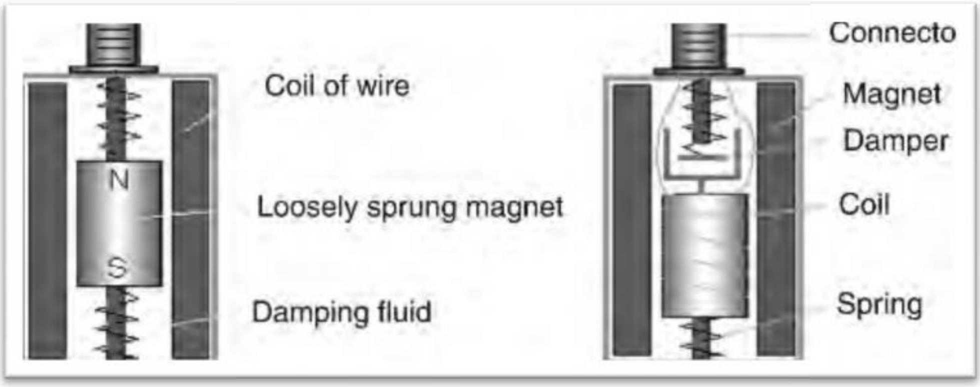

Figure 2.2: Two basic types of velocity pickups employing principle of motion of magnet-in-coil and coil-in-magnet

Source: Cournelius, 2004

2.3.2 Acceleration transducers/pickup

Accelerometers are the most popular transducers used for rotating machinery applications in Figure 2.3. They are rugged, compact, lightweight transducers with a wide frequency response range. Accelerometers are extensively used in many condition-monitoring applications. Components such as rolling element bearings or gear sets generate high vibration frequencies when defective (Kryter, 1989). Machines with these components should be monitored with accelerometers.

The installation of an accelerometer must carefully be considered for an accurate and reliable measurement. Accelerometers are designed for mounting on machine cases. This can provide continuous or periodic sensing of absolute case motion in terms of acceleration. Accelerometers are inertial measurement devices that convert mechanical motion into a voltage signal (Casada, 1995). The signal is proportional to the vibration's acceleration using the piezoelectric principle. Inertial measurement devices measure motion relative to a mass. This follows Newton's third law of motion: body acting on another will result in an equal and opposite reaction on the first.

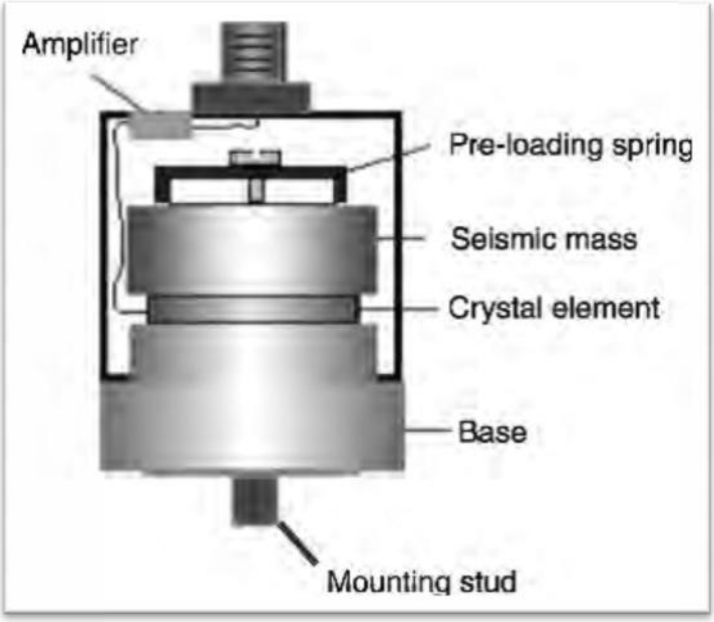

Figure 2.3: Accelerometer

2.4 Machinery fault diagnosis

Present day requirements for enhanced reliability of rotating equipment are more critical than ever before, and the demands continue to grow constantly. Due to the progress made in engineering and materials science, rotating machinery is becoming faster and lightweight (Kryter, 1989). They are also required to run for longer periods of time. All of these factors mean that the detection, location and analysis of faults play a vital role in the quest for highly reliable operations. Using vibration analysis, the condition of a machine can be constantly monitored.

2.4.1 Unbalance

Vibration due to unbalance of a rotor is probably the most common machinery defect. It is luckily also very easy to detect and rectify. The International Standards Organisation (ISO) defines unbalance as the condition, which exists in a rotor when vibratory, force or motion is imparted to its bearings as a result of centrifugal forces (Igor, 1960).

For all types of unbalance, the FFT spectrum will show a predominant 1× rpm frequency of vibration. Vibration amplitude at the 1× rpm frequency will vary proportional to the square of the rotational speed. It is always present and normally dominates the vibration spectrum base on Figure 2.4.

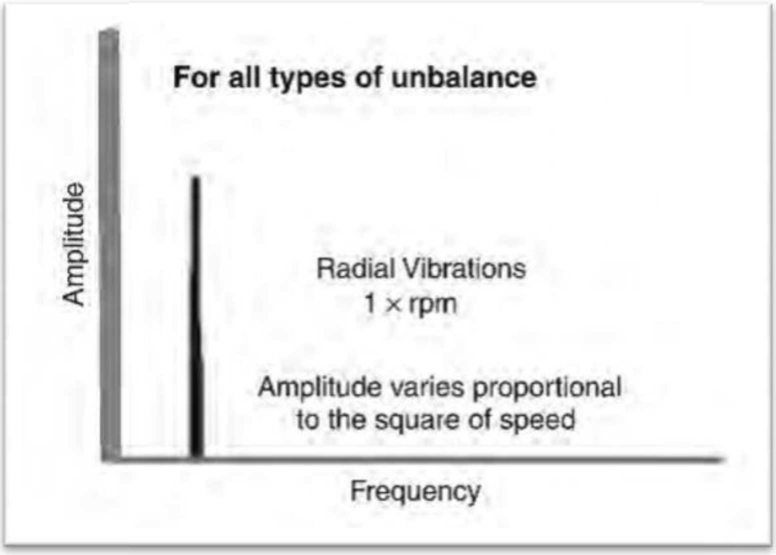

Figure 2.4: FFT analysis – unbalance defect

In this case, the FFT spectrum displays a single 1× Rpm peak as well, and the amplitude again varies proportional to the square of the shaft speed. It may cause high axial and radial vibrations (Taylor, 1980). The axial phase on the two bearings will seem to be in phase whereas the radial phase tends to be unsteady. Overhung rotors can have both static and couple unbalance and must be tested and fixed using analyzers or balancing equipment as shown in Figure 2.5.

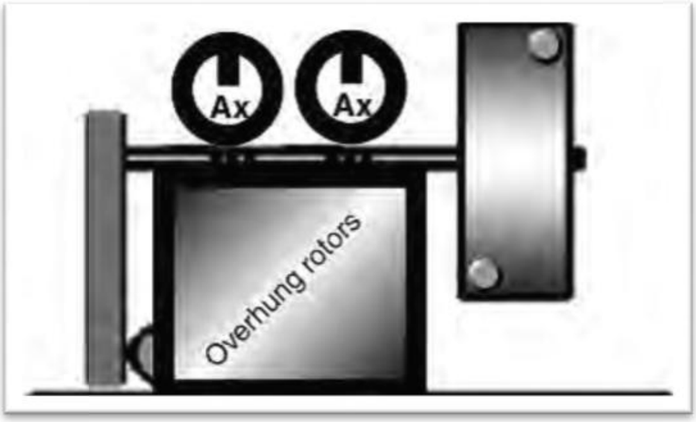

Figure 2.5: A belt-driven fan/blower with an overhung rotor – the phase is measured in the axial direction

Source: Cournelius, 2004

2.4.2 Bent shaft

When a bent shaft is encountered, the vibrations in the radial as well as in the axial direction will be high (Taylor, 1980). Axial vibrations may be higher than the radial vibrations. The FFT will normally have 1x and 2x components. The specification of the fault can be justify went Amplitude of 1x rpm is dominant then the bend is near the shaft centre from Figure 2.6 and amplitude of 2x rpm is dominant then the bend is near the shaft end.

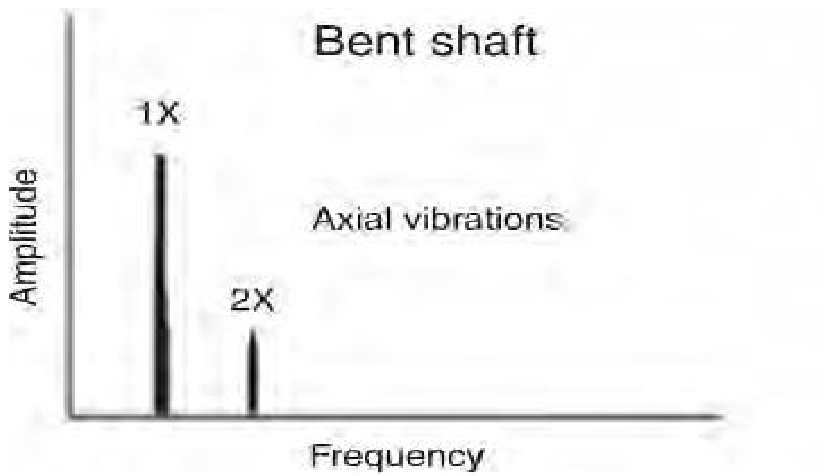

Figure 2.6: An FFT of a bent shaft with bend near the shaft center

The phase will be 180° apart in the axial direction and in the radial direction. This means that when the probe is moved from vertical plane to horizontal plane, there will be no change in the phase reading shown in Figure 2.7.

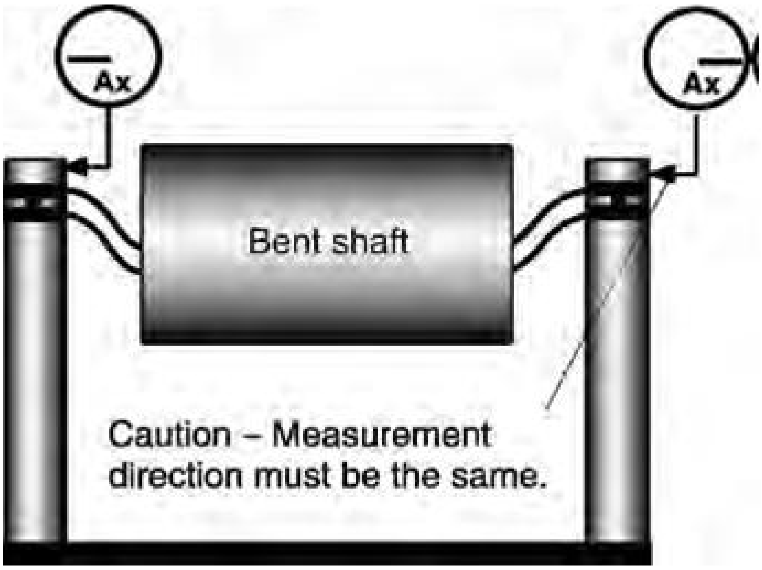

Figure 2.7: Note the 180° phase difference in the axial direction

Source: Cournelius, 2004

2.4.3 Misalignment

Misalignment, just like unbalance, is a major cause of machinery vibration. Some machines have been incorporated with self-aligning bearings and flexible couplings that can take quite a bit of misalignment (Taylor, 1980). However, despite these, it is not uncommon to come across high vibrations due to misalignment. There are two types of misalignment that is angular misalignment and parallel misalignment.

From Figure 2.8, angular misalignment primarily subjects the driver and driven machine shafts to axial vibrations at the 1x rpm frequency (Mitchell, 1981). The figure is an exaggerated and simplistic single-pin representation, but a pure angular misalignment on a machine is rare. Thus, misalignment is rarely seen just as 1x rpm peak. Typically, there will be high axial vibration with both 1x and 2x rpm. However, it is not unusual for 1x, 2x or 3x to dominate.

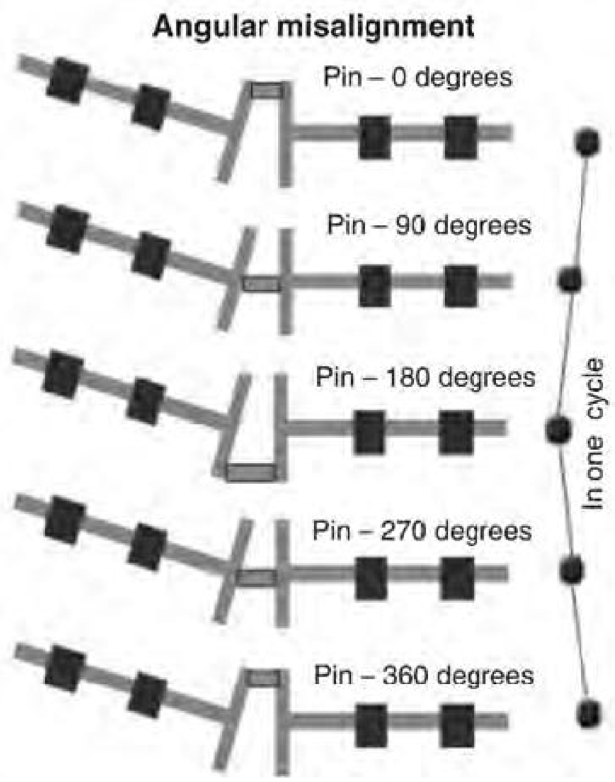

Figure 2.8: *Angular misalignment*

A 180° phase difference will be observed when measuring the axial phase on the bearings of the two machines across the coupling as shown in Figure 2.9.

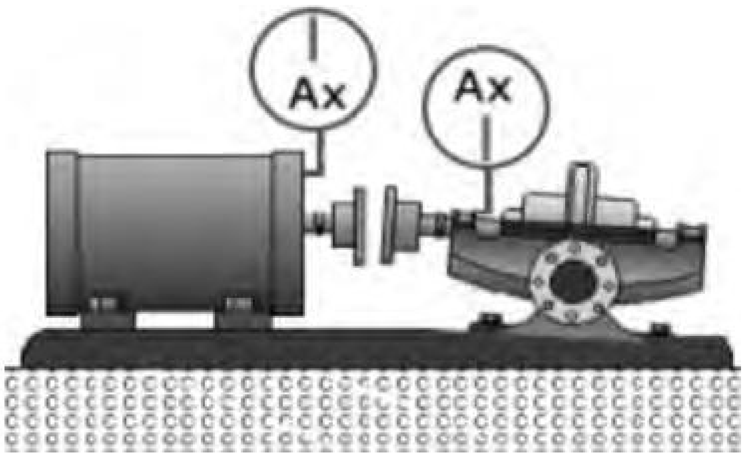

Figure 2.9: Angular misalignment confirmed by phase analysis

Source: Cournelius, 2004

Parallel misalignment has similar vibration symptoms compared to angular misalignment, but shows high radial vibration that approaches a 180° phase difference across the coupling (Downham, 1980). As stated earlier, pure parallel misalignment is rare and is commonly observed to be in conjunction with angular misalignment. Thus, we will see both the 1x and 2x peaks.

When the parallel misalignment is predominant, 2x is often larger than 1x but its amplitude relative to 1x may often be dictated by the coupling type and its construction. When either angular or parallel misalignment becomes severe, it can generate high amplitude peaks at much higher harmonics from 3x rpm to 8x rpm as in Figure 2.10 or even a whole series of high-frequency harmonics. Coupling construction will often significantly influence the shape of the spectrum if misalignment is severe as in Figure 2.11.

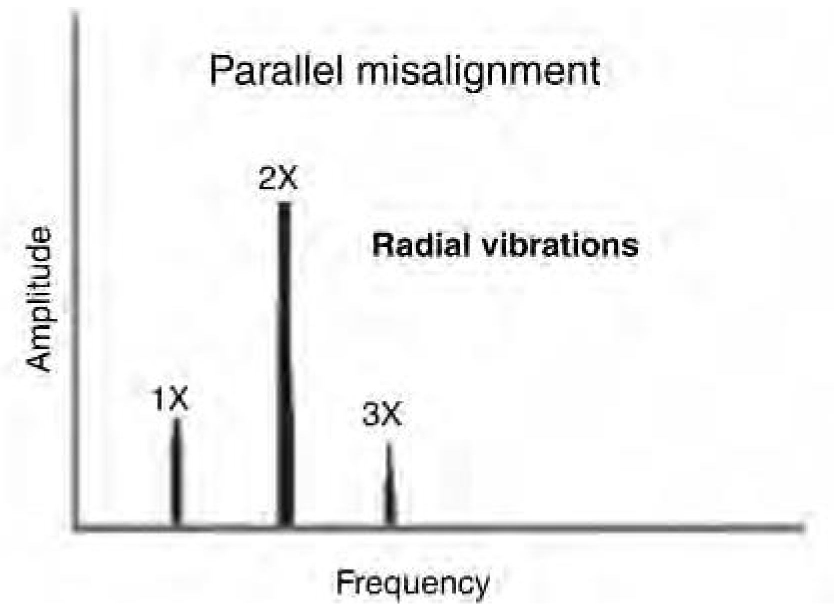

Figure 2.10: FFT of parallel misalignment