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The Cost Effect of Machine Unbalance on Condition-Based Maintenance: (A Case Study of Obajana Cement Plc, Obajana)

[1]Okon Bassey Akpanenang, [2]Ogakwu Paul Andrew, [3]Okpanachi George Echiye
1,3Centre for Satellite Technology Development, Abuja
[2]Department of Mechanical Engineering, Federal Polytechnic Idah, Kogi State
Email: okpanachi1976@gmail.com

ABSTRACT

Machine failures are often rapid on equipment's when unbalance is above severity level. Unbalance above severity level generates other machine defects like bearing deterioration and production lost. Reducing cost is sometimes an overlooked aspect of maintenance. However, a maintenance organization can help a company reduce costs in many ways. For example, a change in maintenance policy may lengthen production run times without damaging the equipment. This change reduces maintenance cost and at the same, increases production capacity. By examining its practices, maintenance can always make adjustments in tools, training, repair procedures, and work planning, all of which can reduce the amount of labor or materials that may be required to perform a specific job. Understanding machine languages help in the determination of equipment health condition through vibration analysis. Vibration analysis is a tool in condition based maintenance use to evaluate the condition of equipment in order to control the sudden failures of equipment in the plant. Vibration analysis is an effective tool in the determination of unbalance using software developed to evaluate the machine defects. This analysis is made using the software to determine the defects before threat starts on the machine and repair can be planned. Unplanned maintenance can be minimized by planning and scheduling of any defect equipment's requiring for repairs during planned maintenance. Therefore, unbalance becomes an important equipment defects to monitor in condition Base Maintenance in other to obtain maximum "equipment's and production" Reliability and optimization. This aspect of condition monitoring does not only solve equipment problems, but makes maintenance less stressful as maintenance can be properly planned or scheduled.

Keywords: vibration, maintenance, reliability, scheduling and balancing

INTRODUCTION

The goal of unbalance in maintenance program is the elimination of machine brake down and maximizing production at lowest cost, highest quality, and within optimum safety standard. The organization gains no advantage from owing equipment or facilities that are not operating or functional. This component is the "keep-it-running" character of maintenance. These activities increase the availability of the equipment and facilities by reducing the number of unexpected breakdown or service interruptions.

Reducing cost is sometimes an overlooked aspect of maintenance. However, a maintenance organization can help a company reduce costs in many ways. For example, a change in maintenance policy may lengthen production run times without damaging the equipment. This change reduces maintenance cost and at the same, increases production capacity. By examining its practices, maintenance can always make adjustments in tools, training, repair procedures, and work planning, all of which can reduce the amount of labor or materials that may be required to perform a specific job. Anytime gained while making repairs translates into reduced downtime or increased availability. Downtime is more costly than maintenance expenditures. Before making adjustment to reduce costs, studies should be conducted to show the before-and-after result.

With the increasing specialization and complexity of equipment and other facilities used in manufacturing, the need for effective maintenance management strategies had become imperative. Various authors have defined maintenance, which could be summarized as the repair and upkeep of existing equipment, buildings and facilities to keep them in a safe, effective as designed condition so that they can meet their intended purpose (Priel 1974; British Standard Institutions, 1974; Makoju, 1988; and Tomlingson, 1993). The effectiveness of maintenance refers to the extent to which the maintenance objectives are met as regards the satisfaction of both internal external and customer requirements (Oluleye and Olajire, 1999).

The United Nations Industrial Development Organizations report (UNIDO, 1971) on maintenance and repairs in developing countries indicated that one of the strongest factors responsible for poor utilization of installed machinery and equipment was the considerable downtime of machinery resulting from breakdowns and stoppages.

Condition based maintenance (aka on-condition maintenance, predictive maintenance, and others) first appeared in the late 1940's in the Rio Grande Railway Company, to detect coolant and fuel leaks in a diesel engine's lubricating oil. They achieved outstanding economic success in reducing engine failure by performing maintenance whenever "any" glycol or fuel was detected in the engine oil. The U.S. army, impressed by the relative ease with which physical asset availability could be improved, adopted those techniques and developed others. During the 50's, 60's, and early 70s CBM grew in popularity and a vibrant CBM technology industry emerged providing training, products, and services which came to be known as "predictive maintenance". The objective of this paper is to look at the cost effect of machine unbalance on condition – Based maintenance.

BALANCING DIAGNOSIS

Before attempting to balance a machine it is important to verify that the fault is imbalance. Since imbalance is believed to be the most common machine fault, balancing is often attempted with little vibration analysis. The vibration due to imbalance will have the same characteristics as the force that caused the vibration. The dominant vibration will occur at the shaft turning speed (1 * RPM). The vibration will be highest in the radial directions. Check the characteristics of the 1 * RPM peak. The peak should not be a double peak. The vibration must be from the shaft under analysis not transmitted from other sources.

Axial vibration should be low except for overhung rotors. Over hung rotors will have high axial vibration at shaft turning speed. This vibration is due to the rocking of the structure in response to the imbalance force, which is outboard to the supporting structure. The vibration amplitude should be steady and repeatable. If harmonics of shaft turning speed are present, they should have low amplitudes. The phase angle of the vibration should be steady and repeatable. The phase shift from horizontal to vertical on a bearing should be approximately 90(+30).

If the phase shift is near 0 or 180, a system resonance should be suspected. If the imbalance condition is static imbalance condition, the phase relationship between horizontal end to end readings should be the same as the vertical end to end readings. For dynamic imbalance, the phase relationship between the end to end horizontal and vertical readings will depend on the relationship of the heavy spots.

If the vibration is steady, balancing can be attempted. However acceptable levels of vibration are rarely achieved. Eccentric machine components generate vibration that is identical to the vibration caused by an imbalance condition. The force and resulting vibration from eccentricity is often directional. If the vibration in one direction, either horizontal or vertical, is greater than two times the vibration in the other direction, test the system for eccentricity or resonance before attempting to balance the machine. When a machine operates near a resonance, high vibration at running speed results from small amount of imbalance. While this vibration appears to be pure imbalance, slight changes in machine speed cause change to the vibration amplitude and phase. These changes make balancing the machine very difficult. Mechanical looseness, electrical faults, and v-belts can also generate vibration near shaft turning speed. It is important to check for these other faults before attempting to balance a machine.

Severity Measures and Chart Applications

Vibration amplitude (displacement, velocity or acceleration) is a measure of the severity of the defect in a machine. A common dilemma for vibration analysts is to determine whether the vibrations are acceptable to allow further operation of the machine in a safe manner. To solve this dilemma, it is important to keep in mind that the objective should be to implement regular vibration checks to detect defects at an early stage. The goal is not to determine how much vibration a machine will withstand before failure. The aim should be to obtain a trend in vibration characteristics that can warn of impending trouble, so it can be reacted upon before failure occurs. Absolute vibration tolerances or limits for any given machine are not possible. That is, it is impossible to fix a vibration velocity can be applied since the lines that divides the severity regions are actually constant velocity lines.

MATERIALS AND METHOD

Balancing Procedure

Typical Machinery Vibration Analyzer Equipment Setup:

From this point on, permits and locknut/ tag outs may need to be suspended temporarily and then reinstated until the field balancing job is complete. Follow the company's procedures applicable to this job. Mount two vibration transducers radially at each bearing. Install reflector tape for photo tach reference on shaft connected to rotor. Mount photo tach, multiplexer, and cabling to machinery analyzer and accelerometers. Set up the job in the machinery analyzer. Ensure that cords, accelerometer, and equipment will not interfere with shaft rotation.

Single Plane Balancing Vector Method

Single plane is used for machines that operate below their critical speed and have an L/D ration lower than 0.5 (L, length of rotor, excluding support length; D, diameter of the rotor). It is recommended to avoid the use of this method for rotors operating at speeds greater than 1000rpm.

For L/D ratio is greater than 0.5 but less than 2, this method should be applied for rotors that do not operate beyond 150rpm. For this method of balancing, the following steps are taken:

During the first run, the original vibration and phase readings are recorded. For example, if the readings obtained are 6mils (or mm, micron, etc.) at a phase angle of 60, a polar plot can be constructed and a vector proportional to 6 mils is drawn at an angle of 60 from the 0 reference. This vector is called 0.

In the next step, a trial weight of 20g is attached to the rotor at any location. During the subsequent measurement, we obtain the vibration and phase readings of 4 mils at 150. It should be noted that the new values are due to the combine effect of the original unbalance and that of the trial weight. Let us call this vector O+T as illustrated below.

The next step is to join the vectors O and O+T. The resultant vector is a result of the trial weight and hence should be designated as vector T below. The vector T is measured and scaled, and found to be 7.2 mils in magnitude. The angle between the vector O and vector T called O is 33.7.

With the above results we are in a position to determine the correction to nullify the original unbalance of the rotor. The question is, if a vector T of 7.2 mils is generated by a trial weight of 20g, what is the weight in grams that caused the original vector O?

$$\text{Correct weight} = \frac{\text{TW vector O}}{\text{Vector T}}$$

$$= \frac{20 * 6}{7.2}$$

$$= 16.7g$$

Mathematically, we need to move the vector T in such a way to cancel the vector O. The movement should be equal in magnitude and opposite in direction. The angle between vector O and vector T is measured as 33.7. Here, the vector T has to be moved clockwise to vector O. The new weight should be 16.7g. It should be moved through 33.7 in the counter clockwise direction (due to fundamental two of balancing) from its original point.

DOWN TIME STATISTICAL DATA

The first-line maintenance is to ensure that all down data collected is entered accurately into the computerize maintenance management system (CMMS). The planner will make changes and adjustments to the schedule and work package after reviewing them with first-line maintenance. The planner maintains a complete and current backlog of work orders. As work is requested, the request is given to the planner. The planner examines the request, plans the job, and reviews the job with the foreman or craft workers. Once the job is planned and approved, it is placed on the schedule.

DOWN TIME COST ANALYSIS

Down time analysis is key factor in condition based maintenance. Downtime increases costs and prevents a company from achieving the financial results desired, whether the goal is to increase profit margins or to be the low-cost supplier. Some organizations refuse to calculate a cost of downtime and some have even said that downtime has no cost. However, they fail to consider the following factors;

Utility costs

Cost of idle production/operations personnel

Cost of late delivery

The true cost of downtime is the lost sales dollars of product that is not made on time. This cost is significantly higher than the base costs mentioned previously, and most companies finance departments use a compromise number. However, a company must understand this cost clearly to make good decisions about its assets and how they are operated.

RESULTS AND DISCUSSION
PLANT RELIABILITY CENTERED MAINTENANCE
PLANT RELIABILITY 1

Reliability is the frequency with which the equipment breakdown. It is often measured by Mean Time between Failures (MTBF).

$$= \frac{\text{Total Hours} - \text{Downtime Hours} - \text{standby Hours}}{\text{Number of Failures}}$$

Reliability centered maintenance is a step by step instructional tool for how to analyze a system's all failure modes and define how to prevent or find how to prevent or find those failures early. These involve the implementation of a strong vibration analysis program on critical equipments. The average vibration level was 8.23mm/sec but today, it has been decreased to 0.11mm/sec. During the first three years (2007) of the reliability improvement program, maintenance costs increased a total of 5%. During the same period, reliability – and, consequently, a production throughput – increased steadily from 83% to 90%. After the initial three years, the reliability continued to increase to 92%, resulting in a reduction of maintenance costs by 40%.

KLIN 1 & 2 Reliability Factor for 2008

RF Line 1	RF Line 2	RF(Original)	Date
0	0	100	Jan
95	93	99	Feb
90	98	100	March
68	68	99	April
54	43	100	May
45	42	100	June
65	54	99	July
70	58	98	August

The figure above is Obajana cement Plc Reliability factor for kiln line 1 and 2 in the year 2008.

The chart above indicates that the maintenance costs increased 5% and then began to fall, ending with a final reduction of 42%. Reliability increased steadily till March to a total of over 98%. However, maintenance costs dropped, Reliability and quality production throughput also went down and continued till June, though the six months basic maintenance processes has not being reinstated.

PLANT RELIABILITY 2

Tough Choices

The figures in this column describes an actual case where the management of Obajana Cement Plc, decided to do whatever it took to cut costs. When the cost saving initiatives started, the maintenance cost was optimal and profitability margin was on the increase but from a short term perspective, preventive maintenance program like planning and scheduling ceased to exist, operation took over maintenance without training them on what to do or how to inspect.

The drop of approximately 15% in reliability, and even in more in quality production output, corresponded to a loss of more than 630,000 tons clinker within six month of production when product could have sold at top prices is attributed to cost saving maintenance initiative. Financial losses, due to low reliability resulting from the cuts in maintenance were conservatively estimated to have exceeded $630, billion during this period.

Short term maintenance savings is not the best maintenance practice, but investing capital on new equipment and restoring worn out equipments and reinstating preventive maintenance inspectors and revising the preventive maintenance program could bring maintenance to world-class.

UTILIZATION FACTOR

Traditionally, mining organizations have focused on the key measures of plant availability and utilization to measure equipment performance. This projects sets out to demonstrate another area to measure equipment utilization factor. The concepts of equipment utilization is, however adjusting planned maintenance start times due to changes in production schedules, taking advantage of maintenance windows as they become available and ensuring equipment is available for maintenance when planned.

Utilization =

The proportion of the time that the equipment is available that is used for its intended purpose

$$= \frac{\text{total hours - downtime hours – standby hours}}{\text{Total hours - downtime hours}} * 100\%$$

PLANT AVAILABILITY

Availability is the fraction of time a plant facility is capable of being used for production during the period it is needed, "availability" could be used instead of "opportunity loss". Depending upon the data available in terms of details, such as, repair times, logistics delay time and administrative delay time, any of the following metric could be used.

Availability: the proportion of time the equipment is able to be used for its intended purpose.

$$= \frac{\text{total hours-downtime hours}}{\text{Total hours}} * 100$$

CONCLUSION

From the foregoing, it is obvious that vibration analysis is the cornerstone of condition Based Maintenance (CBM). This aspect of condition monitoring does not only solve equipment problems, but makes maintenance less stressful as maintenance can be properly planned or scheduled. More importantly, machines are kept running when production is most required thereby satisfying the market requirement. This translates into a lot of money and high Return on investment (ROI) for companies.

It is also important to note that if a company is not interested in taking the bold step of investing vibration analysis equipment and training vibration analysts due to high initial cost, there is a much simpler alternative. A company may just acquire simple vibration pick-ups like the vibration pen for the purpose of capturing vibration readings and maintaining records for trending purposes. A company may just acquire simple vibration pick-ups like the vibration pen for the purpose of capturing vibration readings and maintaining records for trending purposes. Records should be maintained right from when machines are commissioned. This should be compared with the Original Equipment Manufacturers (OEM) vibration limit and if this is not specified ISO 2372 –ISO Guideline for machinery vibration severity is to be used as a guide. When vibration level surpasses the chosen reference, vibration consultant may be called in to analyze and detect the fault responsible for such high vibration levels before catastrophic failure will occur.

Most rotating machine defect can be detected by such a system much before dangerous situation occur. It allows the efficient use of not only stationary online continuous monitoring system but also portable offline systems for condition monitoring and diagnosis as well.

Overall Equipment Effectiveness = Availability * Utilization * Production * Efficiency

Overall Equipment Effectiveness is closely linked to the accounting measure, return on Assets, and provide us with an indication of how well we are using our investment in Plant and Equipment.

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