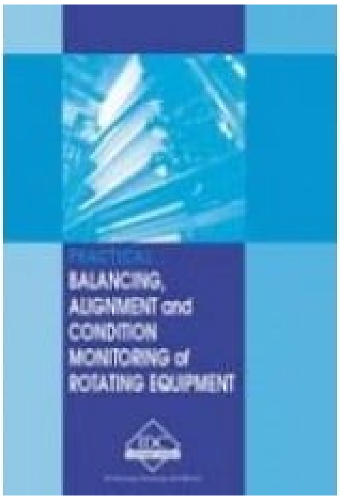
MM-E - Practical Balancing, Alignment and Condition Monitoring of Rotating Equipment



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Short Description

This manual discusses precision maintenance for rotating machinery and associated applications, operations, maintenance and management issues. The focus is on the most up-to-date information and best practice. After an introduction to the application of maintenance and costs of breakdowns, the important issue of vibration and vibration measurement is detailed. The important topic of balancing is then discussed drawing on practical examples.

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Introduction

1.1 The mission of maintenance

In earlier days, different organizations followed different types of maintenance programs. The prime concern was usually the downtime required to put the machine back into service, or the quality and cost of the maintenance, or else safety and environmental security.

Though the above maintenance methods are sound, they lack in one important aspect i.e., the elimination of periodic maintenance services. This is because the older methods stress only how and when to maintain the machine. However, they are not concerned with design changes, which, when implemented, could eliminate the need for further maintenance. Moreover, organizations need to understand that every physical asset is put into service as it is intended to fulfil a specific function. So, it is essential that the machine remain in a condition of satisfactory performance on a continuous basis throughout its expected life.

Hence, the mission of maintenance can be defined as "*to preserve the function of physical assets throughout their life period to the satisfaction of their owners through selecting and applying the most cost-effective techniques for managing failures and their consequences.*"

The new role of maintenance

The above mission statement gives us an insight to into the new role of maintenance. According to this new mission statement, we can conclude that synchronization is required in the functions of design and maintenance teams of the organization. The experience gained by the maintenance team should be continuously incorporated into the design. Regular maintenance activity should be integrated into operations as well.

How to manage the consequences of breakdowns?

When it comes to managing the consequences of breakdowns, we should go far beyond the traditional thinking that “failures are inevitable, and all failures and breakdowns are similar”. We should realize that failures lead to consequential damage to other parts of the machine. Failures incur consequences in terms of repair costs. Failures also affect the safety and environment in which the machine was operating at the time of failure, product quality, customer service and loss of protection, etc. Also, the types of failures that lead to fatal accidents with personnel are not tolerable. We should accept the fact that design flaws of machinery lead to machinery breakdowns and hence, care should be taken at the design level to ensure the machinery functions satisfactorily throughout its intended life period.

Where does PM and predictive maintenance fit into the new roles?

There is a notion that the preventive methodologies (PM) and predictive maintenance methodologies (PdM) involve high cost in terms of men and materials to maintain the machines. This is due to the cost of consequences of failure not being weighed against the cost of maintenance.

PM and PdM methodologies can be implemented in organizations to reduce the risk of fatal breakdowns and consequent damages. These methodologies are also helpful in case the cost of consequential damages is higher than the cost of maintenance.

The PM and PdM methods fit well in the new structure as they can be used in such situations where the organizations do not have time, resources or methodologies to find out the actual cause of the breakdown. Organizations can also use these methods along with other alternative maintenance methods when breakdown and consequential damages are severe.

1.2 Maintenance Philosophies

Organizations follow various maintenance practices and there has been a gradual improvement in these methodologies from time to time. These philosophies are:

1. **Breakdown or Run-to-Failure Maintenance**: This is the earliest type of maintenance where the machine is run until it fails due to a fault. This is an expensive method as it is very difficult to predict the condition of the machine at the time of failure.
2. **Preventive or Time-Based Maintenance**: The preventive maintenance or periodic maintenance method was introduced, with the expectation that machines would not break down in service if overhauled periodically.
3. **Predictive or Condition-Based Maintenance**: According to the predictive philosophy, the machine is repaired only when it is known to have a fault. Machines that are running without any problems are not maintained.
4. **Pro-active or Prevention Maintenance**: The pro-active maintenance philosophy is an innovative methodology, which is being followed by many organizations in recent times. According to this method, the main cause of the machine failure is studied and corrective measures are taken. This method is also known as “root cause failure analysis”.

The above maintenance philosophies are discussed in detail below.

Breakdown or Run-to-Failure Maintenance

Breakdown maintenance or run to failure maintenance is also known as "crisis maintenance" or "hysterical maintenance". Although cost of breakdown maintenance is high, this method has been in practice since a long period. The disadvantage of this approach is the organizations cannot properly plan the time and cost required to put the machine back into service.

The breakdown maintenance method can work in some cases where there are a number of machines available in the organization that are not very expensive to repair; and also when as one machine is being repaired, a similar machine can be put into service as a stopgap arrangement to continue production.

Preventive or Time-Based Maintenance

Preventive maintenance has been popular since the early 1980s when small computers started being used for planning and tracking maintenance. Preventive maintenance is also known as historical maintenance, where the history of the machine is studied and machines are overhauled according to the schedules prepared based on the previous failure analysis of the machines. This schedule is drawn on the basis of calendar time, operating hours of the machine, number of parts produced, etc.

This method is also not the right approach, as in most cases, maintenance schedules cannot be estimated properly. The schedules can indicate necessary maintenance earlier or even later than the actual failure occurs. If it is earlier than the actual failure, then the machines are overhauled unnecessarily, causing production delays. Also, the parts are sometimes replaced before the expiry of their life period, which adds up to the cost of maintenance. Sometimes, overhauled machine fails to function properly due to improper overhauling and also due to replacement of parts with defective parts. It was found that periodic maintenance causes 20% to 25% of start-up failures and 10% of these cases are due to wrong or defective parts fitted during overhauling.

However, preventive maintenance method can be used to maintain machines in which failure due to wear is predominant.

Predictive or Condition-Based Maintenance

Predictive maintenance method involves regular check-ups of the machine. In the case that any part of the machine is found to be functioning abnormally, it is scheduled for maintenance.

The benefits of predictive maintenance are:

1. It increases the reliability of the equipment
2. The overhauling scheduling can be done in a planned manner
3. The productivity of the machines increases by at least 2% to 10%
4. It reduces maintenance cost in terms of spare parts and labour
5. It reduces the need for a large inventory of spare parts, as the parts can be procured as per the planned schedule.
6. It provides increased safety to operators of the machines

However, the predictive maintenance philosophy is not so reliable, as the basis for prediction of failures can be incorrect due to mistaken assessment of the wear and tear of machines. Also, it takes skilled and properly trained professionals to monitor the machines accurately. A proper understanding is required between the maintenance and production teams and they should all work as a team.

Pro-active or Prevention Maintenance

Pro-active maintenance is based on root cause failure analysis. The root cause failure analysis is a study of possible reasons for different mechanisms to fail. Through this approach, the fundamental causes of failures can be corrected gradually over a period of time. Pro-active maintenance techniques involve design modifications of the machinery so that the failures are not repeated.

Pro-active maintenance can be implemented easily where predictive maintenance is already in practice. This is because the pro-active maintenance techniques are basically extensions of the predictive maintenance procedures.

1.3 The role of precision maintenance

In this book we will focus on the role that precision maintenance plays within the general maintenance function of a company. Precision maintenance involves planned maintenance tasks to improve overall plant efficiency and avoid costly breakdowns. It is important to remember that precision maintenance should not be the only focus of a maintenance team, but rather should be used in addition to other maintenance tasks to refine the operations of a plant. Precision maintenance also includes general tasks such as balancing, aligning, lubricating, cleaning, adjusting and replacing parts. The focus of this text is on the alignment and balancing of rotating machinery, with mention of other related precision maintenance tasks, such as vibration monitoring, oil analysis, thermography, performance monitoring and failure analysis. Many of these tasks can also be classified as predictive maintenance tasks. Generally, an overall maintenance program should consist of preventive, predictive and precision tasks. Managing a complete maintenance program should take all of these into account and should have adequate management and shop floor support to succeed. Furthermore, there should be effective communication between the different parties involved in the maintenance program. The most important requirement is that personnel be trained to perform precision maintenance. Vibration analysis plays a major role in precision maintenance and collecting and interpreting vibration data is not always a simple task. In fact, many vibration monitoring programs don't succeed due to a lack of knowledge in how to collect quality data. Other tasks, for instance oil analysis, are contracted to outside parties because it requires specialist instrumentation. Today, most reliability managers are aware of the fact that planned maintenance can save a lot of money and also improve the morale of the floor personnel. In a global economy where companies strive to offer world-class services, precision maintenance is a definite requirement.

We can conclude that organizations need to have a mix of all of the above maintenance philosophies in a balanced and appropriate manner to suit their requirements.