Automation In Condition Based Maintenance Using Vibration Analysis

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KEY WORDS
Condition Based Maintenance, Vibration Analysis ,Maintenance Systems.

ABSTRACT

Presently the world has enormous advancement in science and technology the topic considered here is just a drop out of an ocean of knowledge. In the present scenario if we think of life without a computer then it is very difficult for any firm or organization to survive in the market. In this cutthroat competition the emphasis on productivity is simultaneously embodied by safety, environment and ergonomics. Higher product quality, better reliability, better availability of plants, optimization of cost and choosing right maintenance procedure is the chief concern now a days. Generally the production and maintenance task are going simultaneously, nearly 40 to 45% of production cost generally goes to the maintenance work, hence there is a lot of scope to minimize the maintenance cost.

Every physical asset put into service to fulfill specific functions, thus maintenance of this assets is inevitable and is generated from failure of components. Maintenance is generally recognized as a single largest controllable cost and status quo represents a challenge for leading managements to reevaluate their maintenance strategies, thus in this desertion work an attempt is made to understand various maintenance policies, different Signature Analysis, and application Condition Based Maintenance in vibration analysis.

The approach is nearly an intelligent software that uses simple logics of if else rule. It is a decision making software that uses the basic data of the particular plant and suggest the best possible method of maintenance and the time to make the maintenance. The more stress is given to an approach that would provide a platform for future aspirant to append this program by using different monitoring techniques. As only vibration analysis data from one cement factory is taken that is of only two equipment that is most vital in production.

Hence there is enormous field that is remaining for finding the best method of maintenance. As it also an attempt made to use this program user friendly and make this program applicable to laymen also. This program will also store and use various previous history records that may useful for the amateur or the trainees for decision-making purpose without aid of the experienced person.

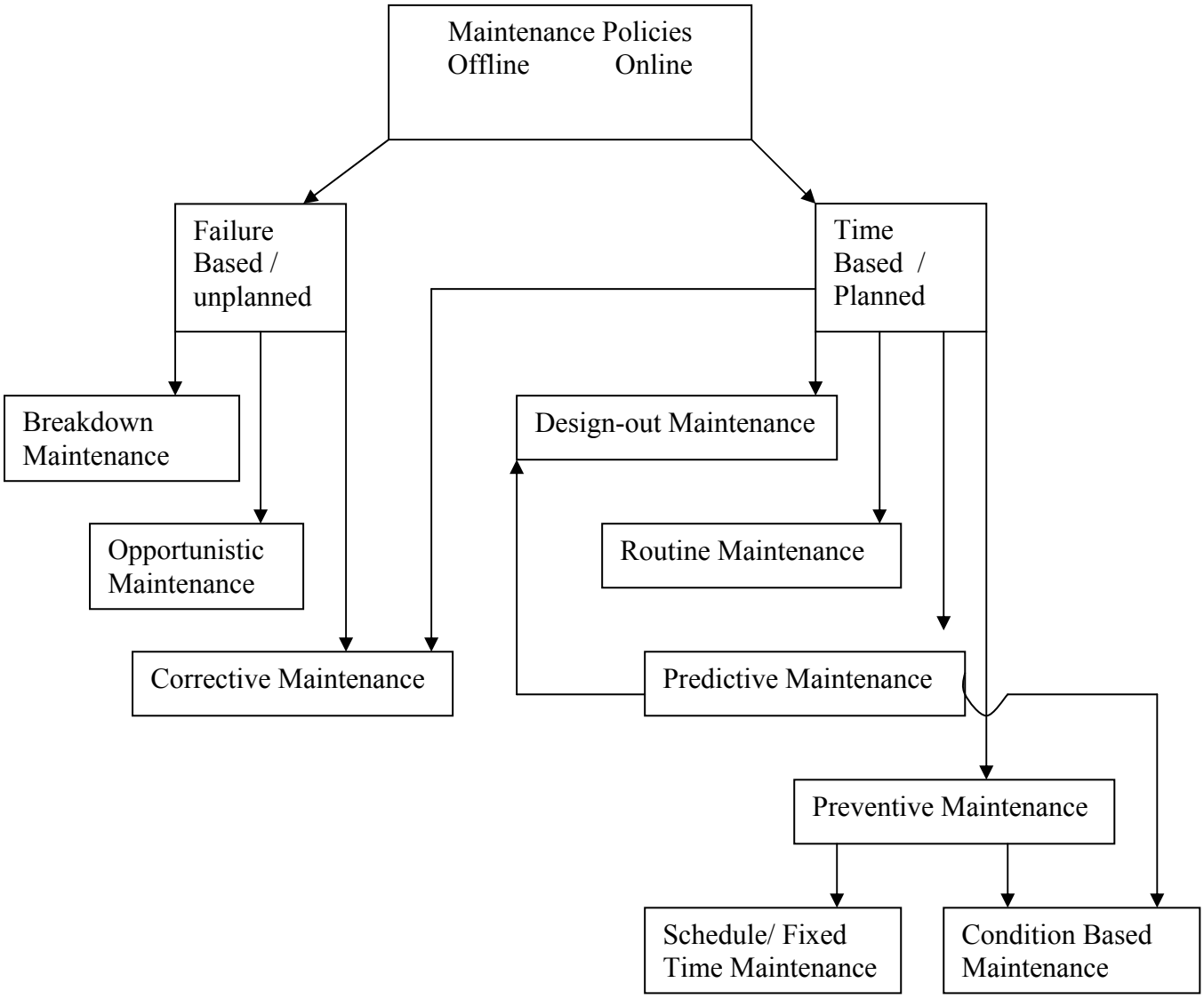
PRACTICAL IMPLICATION

Many types of equipment today are required in service well beyond their intended lifetimes. Dismantling them for inspection is expensive and owners need to consider all relevant information in making the decision. Application of condition monitoring in all the applicable methods is justified, with each showing different degradation modes. Yet many things are discovered regarding vibration analysis but implementing the data in decision process software is never tried. This is very new concept. And it may be possible that by some time all the industrialist replace his or her conventional procedure of monitoring into a decision-making monitoring. Any type of software can be accompanied with it.

INTRODUCTION

There many types maintenance techniques viz. Preventive maintenance, Proactive maintenance, default type, discard type, offline online type. Thus it is always a concern for the decision maker that which type of maintenance should be most appropriate or optimum. Decision makers, therefore, need to take into account the needs of their business, recommendations from the original equipment manufacturer, their own experience and that of other users of similar plant, and information on condition available from the plant offline or online. Condition monitoring using Vibration analysis provides much of this assurance, and has developed such that access to on line vibration data is available to experts who may be located remote from the plant. And the data, which is feed into the program, will suggest the right way to do the maintenance.

Block Diagram For Maintenance Policies



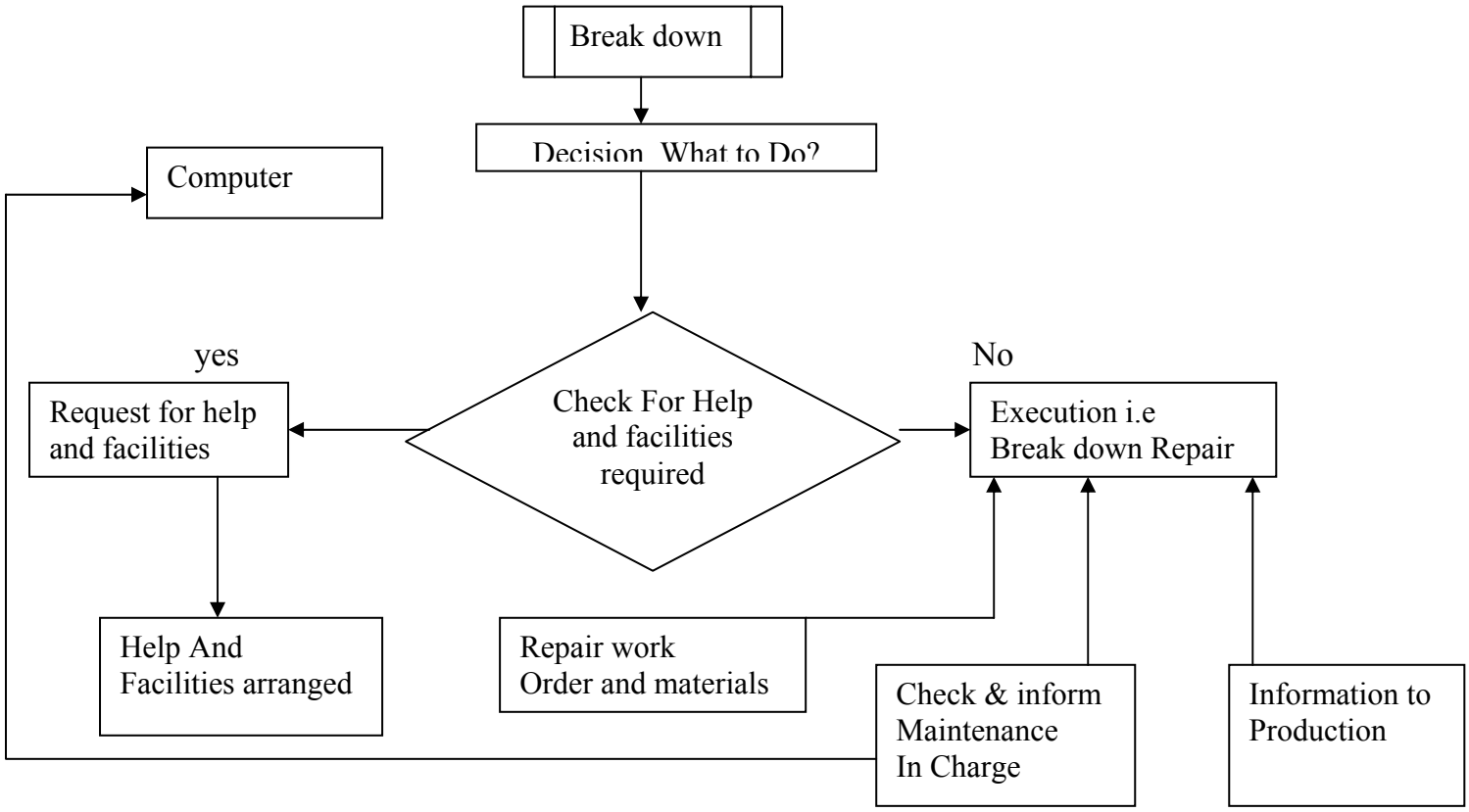
Failure Based Maintenance /Break down Maintenance:

Maintenance is carried out on the basis of the failure. A little lubrication and minor adjustments are done in this system. Applied basically when

- Number of equipments are few
- Equipment are very simple and repair doesn't call for specialist or special tools /tackles.
- Where sudden stoppage /failure of equipments will not cause severe financial loss in terms of delivery commitment or further damage to other equipments /components.
- Where sudden failure will not cause severe safety or environmental hazards.

Big Disadvantage is that it can't be applied to where numbers of equipments are more.

Block Diagram For Breakdown Maintenance

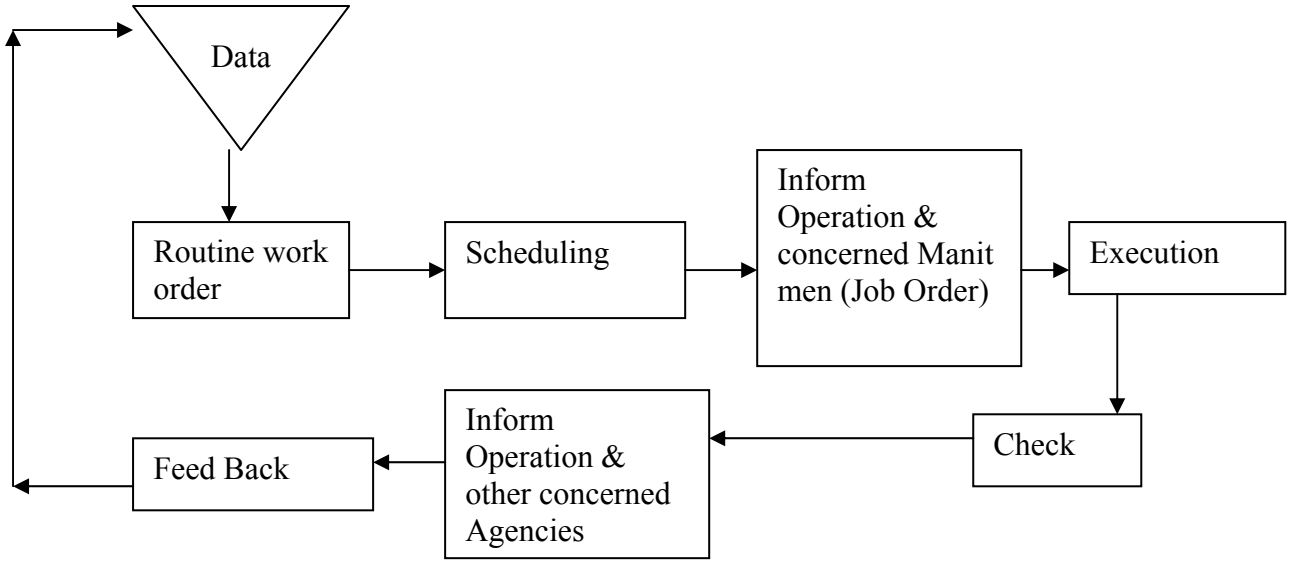


Corrective Maintenance: his Maintenance is carried out for restoring a failed unit. May be little repair to re-design of equipment. It is very fast process. Thus it included in both planned and unplanned **Maintenance**. Work out to eliminate the offline jobs of lower order priority and to eliminate /reduce repetitive breakdown.

Opportunistic Maintenance: In multi component system, with several failing components, often required to follow opportunistic maintenance. Here when an equipment or system is taken down for Maintenance one or two component, the opportunity can be utilized for maintaining other wearing out components. This would be probably economically. Also useful in non-monitored components.

Routine Maintenance: Routine maintenance is the simplest form of planned Maintenance but very essential. As the name, it carried out at regular intervals. It involves minor jobs such as cleaning, lubrication, inspection and minor adjustments of pressure, flow, tightness etc.

Block Diagram For Routine Maintenance:



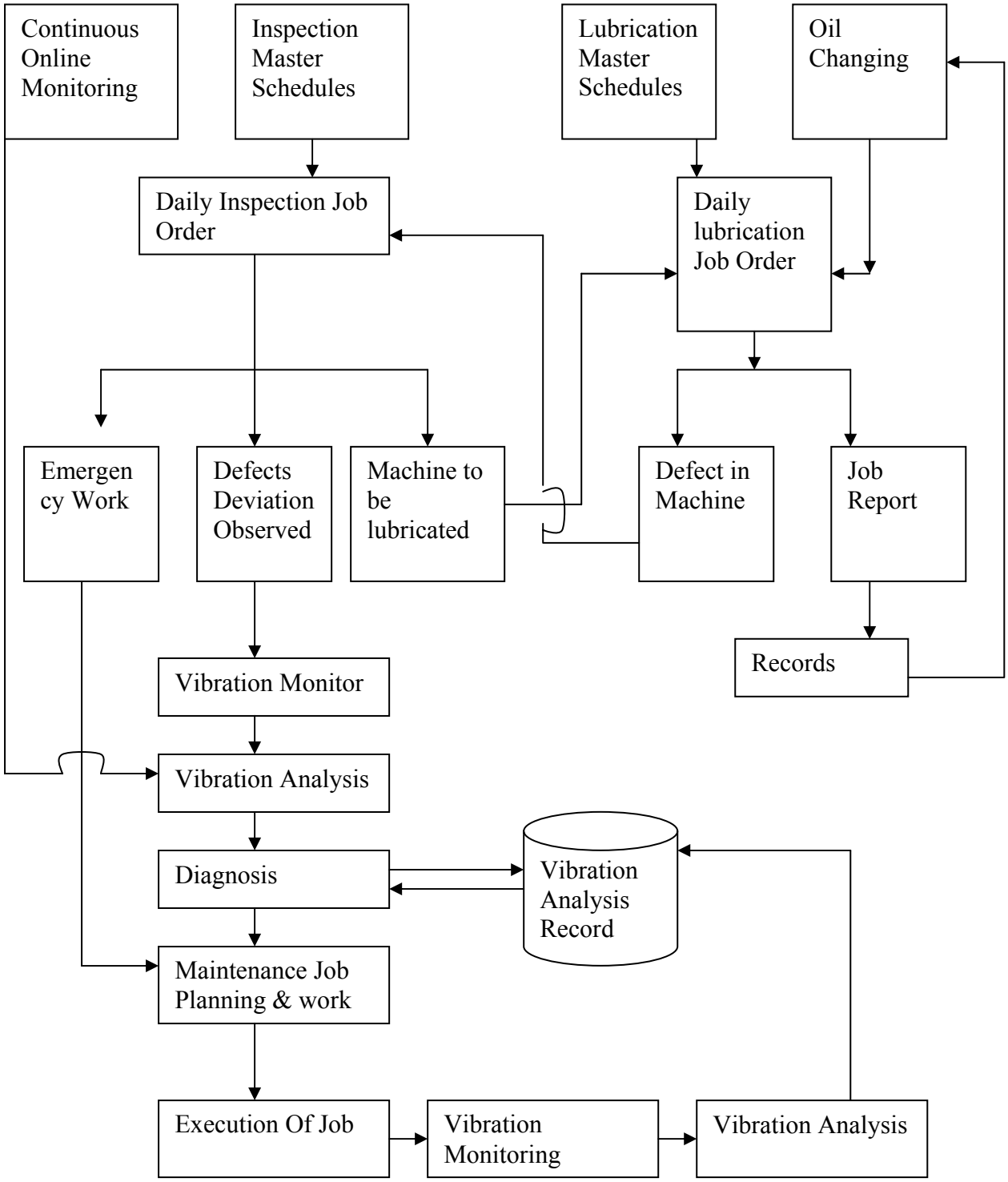
Preventive Maintenance: This is one of the oldest method maintenace. Today also it is used mostly along with corrective main Maintenance and Condition Based Maintenance
(Diagnostic Maintenance) etc. Preventive Maintenance is planned Maintenance of plants resulting from periodic inspection in order to minimize the breakdowns and depreciation rates. Thus detecting health the equipment is restored.

Condition Based Maintenance Systems:
Objectives:

- To intervene before failure occurs
- To do Maintenance only when needed.
- To reduce number of failure and also number failure and also number of shutdowns.
- To reduce Maintenance cost and cost due to production lost.
- Increase life of equipment.
- Reduction in inventory cost / effective inventory control.

Trend Monitoring: Seeing the previous history of the m/c, set standard of its operation limit and compare with recent data take by condition monitoring.

Block Diagram For Condition Based Maintenance:



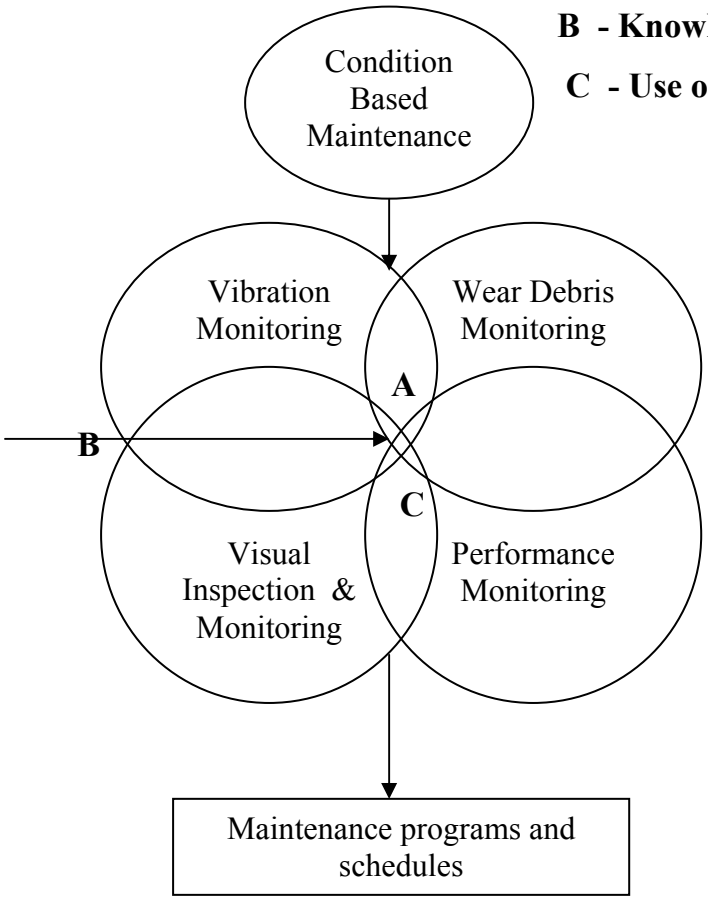
Design –Out Maintenance :It is design oriented curative measure aimed at rectifying a design defects originated from improper method of installation or poor material choice etc. Design –Out Maintenance requires a strong maintenance design interface so that maintenance engineer works in close cooperation with design engineer. Where most of the maintenance concepts aim to minimize number of failure or effects of failures, design out maintenance aims " **to eliminate the cause of maintenance**". It is more suitable for its item/equipments of high maintenance cost. The choice to be made is between the cost of redesign and cost of recurring maintenance.

Block Diagram For Interaction Condition monitoring techniques

A - Use of high Tech Instrument

B - Knowledge Based System

C - Use of sensor



The Decision Making Program Based On the data of Cement Plant Equipment

INTELLIGENT SYSTEM

The maintenance function involves the determination of what needs to be repaired and when it needs to be repaired. This decision is based on a combination of skill and experience. Both of these are needed to determine and interpret the available information and even to determine what information to make available. A skilled manager will use his skill and experience on what failures occur at particular times and what faults show them up often. Actual diagnosis of any particular problem is a critical task, which is particularly difficult in environment of complex machines and process measurements. It may take many years of training to determine how best to use the information available this dependence on skill and maintenance poses a lot of problems. In many companies, the most skilled and experienced people are also the most senior. They are often promoted into other non-maintenance line positions or they may retire.

There is also considerable requirement to teach the particular skills and diagnostic techniques to younger and more junior people. This is particularly difficult when the machine has various quirks of behavior and some problems are fairly rare.

It is difficult to get new staff with the appropriate skills. This is further made difficult by the consistent introduction of new technology, where the skills of the existing staff may suddenly become inadequate or obsolete. There is constant pressure within the industry to do more work with fewer staff. This either means reducing the staff level or increasing the amount of work without changing the staff levels. There is also considerable pressure on each experienced persons time. This can make it difficult to devote adequate time to one are or to a difficult problem. Problems might also creep up unexpectedly when the concerned maintenance personnel are on a holiday.

All these factors imply that something is needed to capture the skill and expertise of the senior people and make it available around the clock, 24 hours a day and through the hands of less skilled personnel.

Knowledge based systems or intelligent systems are a technology designed to precisely achieve this aim. They provide the tools and techniques to preserve the skill and experience of the more senior people in a computer program. This computer program will behave consistently, and its skills would be available 24 hours a day. In general, these computer programs are much quicker in execution. As a result, it reduces the time needed for test and frees other people for other time consuming activities.

Role of intelligent systems in maintenance.

If a maintenance manager has to solve a problem he also needs diagnostics. Many systems are able to detect that there is a problem but not what the precise problem is and what to do about it. Many maintenance systems run through the use of a maintenance management package, which is responsible for the issuing of work orders. Commonly today what that know is that something is wrong with the machine and it has stopped. This is hardly the information available to put on a word order. What is really desired is a more detailed analysis of the particular problem. For example in rotating machinery, the condition monitoring system may detect that the level of vibration on a motor driven fan is too high. Currently it would be necessary to issue a work order to establish the cause. The intelligent system is able to look at the vibration pattern and perform a more detailed diagnosis automatically. It can then determine whether the problem is due to bad bearings, misalignment or blade problems to name a few. The output of the intelligent system can now be inserted on the work order so that the maintenance personnel know precisely the cause before the action is taken. This leads to considerable efficiency. An another example, if a machine tool suddenly stops, it is important that the operator quickly determines whether to call the electrical or the mechanical engineer, or whether they can take simple action to get the machine working again.

As on the spot intelligent system provides the skill needed in a convenient program to lead him through the steps needed to make this conclusion .as machines become more complex, the task of diagnosing and analyzing problems is also becoming more complex. In fact, the problems are getting so difficult that most companies are having severe difficulties. It is vital that intelligent systems techniques are used to capture the diagnosis to make them available on a regular basis

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What is an intelligent system?

The area of intelligent systems has a number of aspects as a result there is a wide variety of meanings and a wide range of interpretations and understandings as to what is involved. Unfortunately it is difficult to simply and precisely define intelligent system. The original foundation for the term "intelligent systems" was from the idea that it was a computer system that captured the expertise of an expert. Intelligent systems cover one application area that of applying knowledge based programs to solve particular problems.

In general intelligent systems are not intelligent, they are just better than traditional computer programs. The term 'intelligent' has misled many people. The idea is to have a computer program, which captures the skill, and the expertise needed a particular problem. The whole idea of intelligent systems is to use more knowledge to solve a problem. Traditionally. Any computer program in any language can achieve the same purpose, but is often too difficult to put in the knowledge of an experienced machinery engineer into a vibration diagnostics program can be very difficult in a low level computer programming language. Fundamentally intelligent systems then provide tools to implement the knowledge needed to solve a particular problem.

In many cases the same problem could be solved with conventional computer technology but it is too difficult to be cost effective. Because of this emphasis on knowledge, most intelligent systems today are referred to as knowledge based systems.

Another common misconception about intelligent systems is that they learn or improve. Intelligent systems do not exhibit learning and do not change their behavior dramatically over time .The main idea behind intelligent systems is to provide a powerful means of representing the knowledge and then manipulating this knowledge at a much higher level. The basic intelligent systems implementation captures the knowledge of the experienced engineer in the form of rules. These rules are intended to be true facts, that is facts that are true in a solution and not dependent on other surrounding computer code. Very often these facts are called 'rules' or ' production rules' or ' if-then rules, and the total system is called a rule based system. The collection of knowledge is most commonly refereed to as the rule base or knowledge base. A basic example is in the form if a number of items are true, then a conclusion must be true. For example;

If the output flow rate is low,
And the pump is on, Then the output filter is clogged.
Or a more complex example;
If the chemical reactor temperature is too high,
And the output flow rate is too low,
And the output flow has stopped and the pump is on,
Then the compound has congealed,
And stop the agitator completely immediately,
And notify the operator.

The intelligent systems application consists of many hundreds of rules of this style. The use of the 'if-then' rule can be contrasted with other programming techniques that use a variety of computer commands and instructions. One of the key ideas of intelligent systems is that only if the rule style is used

Theoretically these rules can be written down in any order and the intelligent system software will automatically bring them together to reach the conclusions. This is one of the potential powers of an intelligent system where the true facts can be specified and the program will work out how to bring them together to reach a result. In actual fact, it never works this simply and care must be taken to determine which rules are needed and how they link together. Another key aspect of intelligent systems is that they represent knowledge symbolically rather than numerically making it easier to read and understand.

A complete intelligent system will consist of two items, the rule base containing the production rules, which describe the knowledge and an inference engine. The inference engine is part of the computer program that manipulates the rule-base. It understands the process by which the rules are used to reach a possible conclusion. Inference engines are standard and independent of a particular applications, it is only the rule based that changes. One could imagine taking a computer application and removing the ruled and the knowledge base. What one is left with is an inference engine and the mechanism for editing and building up the rule- base. This type of computer software is knows as an intelligent systems shell.

It is the shell of a completed application. Shells are used as the standard tools to develop intelligent system applications. They provide the mechanism for entering, testing and debugging rule-bases, as well as the inference engine to manipulate them. There are wide variety of intelligent systems shells available from large main frame systems using their advanced techniques to a very simple low cost PC based systems. Most modern shells also contain extensive tools for browsing and examining the knowledge base and graphically displaying what is happening.

Intelligent System

Advantages

- Intelligent Systems are automated built-in test system which make use of IF-THEN rules to make a decision (based on inputs)-since they are automated, they can replace a human expert's decision-making responsibility.
- Intelligent Systems are able to continuously monitor the condition of a system and make expert decision, whereas human experts may not be available to continuously monitor a system.
- Intelligent Systems are able to give explanations as to how they arrived at a particular solution/decision via an "audit trail" that includes rules the system selected and why these rules were selected.
- Requires less programming (Or "training" time) than Neural Networks.
- In addition to employing hard-and-fast IF-THEN rules, Intelligent Systems can be built using fuzzy logic (uncertain /unclear IF-THEN rules)

Disadvantages

- Since Intelligent Systems are modeled after actual human experts, there may be inherent flaws in knowledge based of the v if the experts' logic is flawed-however, this can easily be fixed by selecting many component experts to verify the rules and the logic of the system
- Since it is relatively simple to make changes to the knowledge based, it is easy to introduce errors into an expert system again this can be remedied with extra diligence in building the Intelligent Systems.
- In order for an Intelligent Systems to be built, the situation must already have been dealt with and encountered by human experts.
- There is certain skill involved in building and effective Intelligent Systems it is important to learn how to question domain experts in order to get better answer for CM situations.
- Intelligent Systems normally do not incorporate economic analysis in their decision (i.e. it is more profitable to replace or to run till failure.)

Trending (Statistical Process control) SPC

Advantages

- Trending is a statistical analysis techniques that is used to measure if actual signals are within reasonable control limits (i.e. if the signals is close to the estimated signal) since it uses only statistical analysis, no knowledge of how the system operates is necessary.
- Trending can be (and most often is) used as input to both Intelligent Systems or neural networks in actual CM software incorporating trend data, specially in the case of neural networks, cuts down on training sets since the trend now replaces a multitude of variables.

Disadvantages

- Trending is essentially a process-monitoring tool rather than control tool .SPC requires that successive observation behaves like independent identically distributed random variables, and thus cannot be considered valid for process where data correlation is significant.
- SPC applies warning and control limits, which are relatively static. That is the control limits do not account fro aging of equipment where the risk of failure in an upcoming interval is partially dependent on its working age.
- Trending normally doesn't incorporate economics analysis in CM.

Neural Networks

Advantages

- Neural networks are processors that have the ability to acquire knowledge through a learning process (i.e. determining) and then store this knowledge by connectors (each connector, or synaptic link has a weight associated with it). Therefore NN are useful in CM because they can learn the system's normal operating condition and determine if incoming signals are significantly different (if use in conjunction with SPC).
- NN useful when there is lots of training data available.
- NN useful when there the CM process has some notable imprecision-they are adaptable and dynamic.
- NN are useful when hard and fast rules (such as those used in Intelligent Systems) cannot easily be applied –in fact, this is specifically with the fuzzy neural networks.

Disadvantages

- There is no method for training NNs that has magically create information that is not contained in the training data.
- Training data must be representative of all the machine condition in order for NN to successfully be used in smart CM.
- Significantly longer training times than those for Intelligent Systems.
- A NN decision engine has the ability to adapt with incoming signal inputs thus, if the incoming signals are drifting, the NN may adapt and view this drift as normal. When in fact, this drift is a sign of an out of control process referred to as "over fitting".
- NN suffer from "spill over", when a drift is introduced into one variable, it impacts the estimate of a different variables this can make it seems as if many signals are drifting. Where as only one signal is drifting.
- NN normally do not incorporate economic analysis in their condition monitoring decision (i.e. is it more prevent replace or to run until failure?)

RESULT AND CONCLUSIONS

Data Interpretation

Thus the data of vibration from cement factory shows that after condition monitoring how the performance of the machine / equipment increased.

The simple program of intelligent system gives abroad idea that how the system can be implemented in different types of monitoring techniques. As due to limitation of time it can't be possible to implement this program to various monitoring techniques. Thus by taking the result of the recent data of the grate cooler fan and bag filter fan the software program suggest the type of maintenance to be done by the user.
Well the program can be append as per the future scope of this topic.
My basic main aim is to thoroughly study different techniques of Maintenance strategies, Condition monitoring techniques and study the vibration monitoring.
Collect the data from one organization that is applying the vibration monitoring for its equipments or machineries. Thus results have been taken from Manikgarh Cement Factory after and before the vibration condition monitoring techniques. and used that data of two key components to make the simple program software. Thus the program is tested and predicted that the program can be used for beginning stage of intelligent system.

FUTURE SCOPE:

There is tremendous scope for future as the neural network can be used. Also the program may be more sophisticated if used with fuzzy logic. This is only the initial stage.
Thus it can also be implied to various industries and with different monitoring techniques. Here to mention a few are Oil analysis, lubrication Analysis, Debris analysis, and shock impact analysis.etc.

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Date 06.07.04 Mechanical Engineering Department MANIT, Bhopal.

Some Special Features About this Topic :

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