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INTRODUCTION OF CONDITION MONITORING AND CONDITION DIRECTED TECHNIQUES IN MAINTENANCE OF AFAM POWER STATION IN RIVERS STATE NIGERIA

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ABSTRACT

The need for improved performance of the huge investment in industrial plant particularly electrical generating machinery in recent times necessitates the application of condition monitoring techniques in its maintenance. This can provide early warning of potential failure with the opportunity of organizing avoidance strategies to minimize lost in time and unexpected costs. This may greatly improve generation and production efficiency. This paper presents a methodology, which is useful in preventive maintenance (PM) and predictive maintenance (PDM) when applied to Afam Thermal Power Station in the Rivers State of Nigeria. This has lead to some proactive approach to maintenance because the action is triggered by the unscheduled event of equipment failure. With this kind of maintenance policy, the maintenance cost is high due to equipment operating under crises condition, secondary drainages and penalty associated with cost production. It shows a paradigm shift of knowing when things are starting to fail and how to prevent failure. Hence two failure perspectives are in focus-functionally and component failures. The functional perspective expresses what the component does, the component perspective shows how it deteriorates.

KEYWORDS: *Condition Monitoring, Failures, Fault Diagnoses, AFAM Power Station*

Article History

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INTRODUCTION

The continuing drive for improved efficiencies demands that a more educated system analysis of monitored signals provides an indication of or even diagnosis of the cause of a fault. The level of urgency of a condition can then be determined, thus enabling the necessary action to be taken over an appropriate time scale. Maintenance can be scheduled based on plant condition rather than on a time-based regime.

Unscheduled shut down of process plants or equipment will lead to additional costs, usually out of proportion to the costs of the repairs. Many plant managers would welcome a reliability method of anticipating the failure of key components so that downtime could be based on Just-In-Time (JIT) principle rather than on a routine maintenance basis; with attendant reduction in replacement parts holding. Every dynamic system such as electrical, hydraulic, mechanical or thermal – possesses normal characteristic signatures when operating in the desired fashion, may herald the onset of a failure mode. The small difference between normal and abnormal signature has often been hidden by (or even assigned to be) "noise" in the system modern transducers and associated signals-analysis techniques can now discriminate between truly random variations and significant trends which, with knowledge of the system parameters and normal characteristics, can be used to predict time to failure. Such an approach is called condition monitoring. When a component, equipment, systems fail ultimately. It's because a physical part deteriorated. The proximate part degeneration eventually causes a functional failure. A bearing wears until a pump trips on high vibration. When a motor winding resistance fails, the motor shuts and trips the pump off, or when an operator smells smoke and transfer pump shuts down the offending pump. Functions affect work performance. Failure translates as lost functions (August 1999) functions are required while operating plants. When function "break" failures are diagnosed, located at the source and eliminated. While identifying functional problems is one step, tracing it back to its physical source is another matter. Success in managing failure depends on organizational diagnostic skills (Augustine, 1999). Risk accompanies function failures, but it can be managed. Facility instrumentation supports monitoring, and the specific function, measurement requirements, and equipment redundancy determine the instrumentation needed sophisticated microprocessors and sensors can identify and shut down deteriorating equipment, limiting damage. The cost is a loss of the equipment until maintenance is completed.

Although condition monitoring was originally developed to anticipate failure in high-speed gearboxes in the aerospace industry, it is now being applied in an ever-growing range of industries; if process variables such as critical dimension, speed, pressure, potential difference, electrical current etc, can be measured, then it is likely that a process signature can be identified which can lead in turn to the application of condition monitoring techniques.

In the last century, the world of automation has developed and dominated the global scenario in an astronomical manner. The more people become habituated to the mechanical word, the more the equipment for safe and reliable systems and equipment grew. It is obvious that under the regime of scheduled PM some items may be over maintained, that is, replaced, prematurely. However, if the condition of the item can be monitored continuously or intermittently it will be possible to carry out PM action only when failure is judged to be imminent. This is the concept of Condition-Based Maintenance (CBM). Performance-parameter analysis, vibration monitoring, thermography, oil analysis, and ferrography are some of the condition monitoring techniques that support CBM. Each of these methods is designed to detect a specific category of faults. For example, vibration monitoring can be deployed to detect wear, imbalance, misalignment, loosened assemblies or turbulence in a plant with rotational or reciprocating parts.

CBM is an effective way of preventive/predictive maintenance. Especially for all the complex systems, whose component and subsystem require on condition maintenance, condition monitoring-based maintenance can be of significant importance. For example in the case of the modern electric power system, the concept of Reliability Centered Maintenance (RCM) and Total Preventive Maintenance (TPM) which requires on-condition maintenance strategies, continuous monitoring of maintenance of significant items is required.

Integration of condition monitoring strategy into the systems would enable reliability prediction of components/systems, which in turn would realize optimum replacement times. This would not only reduce the number of inspections and premature replacements but also improve the system reliability and availability. Thus, condition monitoring-based maintenance has the potential for huge practical implications, if applied effectively in electric power plants maintenance system. Review of current maintenance policies and condition monitoring strategy in an underlying theme in maintenance. Without appreciating the tactics of maintenance, The need and value for strategy. Tactical value can be missed even with a strategy a tactical value can be lost. Yet with a strategy comes a comprehensive vision for managing short-term, intermediate, and long-term maintenance.

A strategy provides a resources map that uniquely identifies the multiple roles that must be played by various work groups (Augustine 1999). Experts come into play in several ways: developing the strategy and supporting tactics for the existing for the existing plants; identifying the paths for future goals; and managing the emerging maintenance requirements of the plants (Augustine, 1999). Understanding – condition/condition – directed – maintenance would complement tasks in RCM and TPM. Maintenance actions are dependent on many factors such as the failure rate of the plant/equipment, the cost associated with downtime, the repair and the expected life of plants/equipment.

In order to meet these requirements, various maintenance strategies have evolved. Proper maintenance of plant/equipment can significantly reduce the overall operating cost while boosting the productivity of the plant. Although many management personnel often view plant maintenance as an expense, a more positive approach lies in a new perspective of maintenance approach. Thus, maintenance may be divided into correct or failure-based maintenance, Preventive Maintenance (PM) and opportunistic maintenance (Saranga, 2002).

There are four basic approaches to maintenance and design improvement (Tsang, 2002). The four basic types of maintenance are predictive, preventive, corrective and detectives (Moubray, 1995). Over the years, many new strategies which are intended to overcome the problems which are related to equipment breakdown. Some of the common maintenance strategies are as follows: breakdown/corrective maintenance. The approach to maintenance is totally reactive and only act when the equipment breaks down and needs to be fixed. To rectify the problem, corrective maintenance is performed onto the equipment. Thus the activity may consist of repairing, restoration or replacement of components. The strategy is applied as a corrective maintenance, which is required to correct a failure that has occurred or is in the process of occurring.

Hence, it is the main objective of this paper to form a framework which to develop and ensure that power plants in AFAM Thermal Power Stations will start to fulfill their intended functions at a minimum expenditure of resources.

BASIC CONCEPTS AND DEFINITIONS

Preventive Maintenance (PM)

PM usually means overhauling items or replacing components at fixed intervals. Items are replaced or returned to good conditions before failure occurs. The most common forms of this policy are scheduled PM (time-based) and condition-based maintenance (CBM), respectively. In the former approach, PM action is performed on the item at the scheduled time regardless of its actual condition. The schedule can be usage or time driven. Since the schedule is often drawn upon the vendor's recommendations made with limited of any local knowledge of the actual use conditions, or from past experience, it is seldom optimal. PM schedules that minimize resource consumption or maximize availability can be determined through the use of quantitative decision modes such models use factual information such as Time-To-Failure (TTF) distributions. Cost of intervention (inspection, repair or replacement) and the consequence of failure Models for optimizing PM decisions can be obtained in Jardine (1973): Duffouaa et al (1999), Campbell and Jardine (2001).

Condition Based Maintenance (CBM)

In performing time-based PM, some items may be over maintained, that is, replaced prematurely but if the condition could be monitored continuously or intermittently it will be possible to carry out PM action only when failure is judged to be imminent. This is the concept of CBM (Tsang, 2002). Maikis and Jardine (1992) provided an Operation Research (OR) model for optimizing replacement decisions which take into account the information obtained from condition monitoring. Tsang

(1995) gives a survey of recent work on CBM models. Tasks designed to check whether something still works are known as “functional checks” or “failure-finding tasks” (Moubray, 1995). Detective maintenance or failure-finding applies to only hidden failures or unrevealed failures, and hidden failures in turn only affect protective devices (Moubray, 1995).

Design Improvement

The design improvement is modified to achieve one or more of these objectives: improve reliability, enhance maintainability, minimize maintenance resource requirements and eliminating the need for routine servicing.

Reliability Centered Maintenance (RCM)

RCM could be defined as a process used to determine whatever the users of equipment want it to do in its present operating context. Before it is possible to apply a process used in determining what must be done to ensure that any physical asset continues to do whatever its users want it to do in its present operating content, we need to do two things (Moubray, 2004): determine what its users want it to do and ensure that it is capable of doing what its users want to start with. This is why the first step in the RCM process is to define the functions of each asset in its operating context, together with associated desired standards of performance. What the users expect assets to be able to do can be split into two categories (Moubray, 1997).

- Primary functions, which summarize why the asset was acquired in the first-place. This category of functions cover issues such as speed, output, carrying or storage capacity product quality and customer service, and
- Secondary functions, which recognize that every asset are expected to do more than simply fulfill its primary functions. Users also have an expectation in areas such as safety, control, containment, comfort structural integrity, economy protection, the efficiency of operation, and compliance with environmental regulations and even the appearance of the asset.

The maintenance approach best suited to an item can be determined using the RCM methodology. It provides a structure for determining the maintenance requirement of any physical asset in its operating context, with the primary objective of preserving system costs effectively (Moubray, 1997, Smith 1993). Identification of system functions and functional failures as well as failure modes and effect analysis (FMEA) are important elements in RCM it requires the involvement of the operators and the maintainers (Tsang 2002). There are two reasons for such a requirement. First, it draws on the operator’s intimate knowledge about the asset concerned. The involvement motivates the operators and maintainer. Also, the learning outcomes and communications outcomes of RCM studies will enhance the organization’s intellectual asset (Tsang, 2002). RCM is a maintenance perspective in an operational context-understanding plants goals, needs, and equipment (e.g. how equipment serves, ages and fails) and then developing a maintenance strategy to optimize outcomes in the context of the business goal (Augustine 1999).

TPM is a methodology that focuses on people and is an integral part of total quality management (TQM) and just-in-time (JIT) production system. TPM redefines the organization maintenance work by applying the following principles (Tsang, 2003):

- Cultivate a sense of ownership in the operator by introducing autonomous operator maintenance; the operator takes responsibility for the primary care of his plant. The tasks involved include cleaning, routine inspection, and tidiness of the operator’s workspace.

- Optimize operator's skills and knowledge of his plant to maximize operating effectiveness. The operator is thus mobilized to detect early signs of wear, adjustment note oil leaks, errant chips or loosened parts.
- He is involved in making improvement suggestions to eliminate the losses due to breakdown or sub-optional performance of the plant.
- Use cross-functional teams consisting of operators, maintainers, engineers, and managers to improve people and equipment performance, and
- Establish a schedule of clean up and PM to extend the plant's lifespan and maximize its uptime.

Condition Monitoring

Condition monitoring is basically applicable to mechanical components whose condition deteriorates with time (Al-Najja, 1991). This can be done with the help of instrumentation to take regular or continuous measurements of condition parameters, in order to determine the normal operation. A few measurement technologies that are used in condition monitoring are vibration, lubricant analysis, thermography, ultrasonic acoustic emission and high-frequency vibration (Hupton, 1996). Therefore, it has become essential for the electric power industry in Nigeria to invest in the new ideas and techniques to improve and cover all aspect of the maintenance requirements. Thus the concept of condition monitoring becomes an important part of condition-based maintenance (Saranga, 2002). According to the B3 3811 (1984), condition monitoring is defined as continuous or periodic measurement and interpretation of an item to determine the need for maintenance.

In the mid-1970s when condition monitoring just started developing, it was treated widely as an instrument for technological measurements of the parameters which described the condition of items. But since 1980, information technology has undergone radical change, which made a great impact on condition monitoring by eroding the boundaries between the personal computer (PC) and instrument collection and processing of data has become very simple as the network of PCs has replaced mainframe computers, enabling the information to be shared around the company. Now the focus is placed on the results obtained from the processed data, rather than the data obtained from measurements, making condition monitoring into result-oriented technology that helps designers and operating personnel by giving intelligent information (Rac, 1996). Also, different measurement technologies within condition monitoring, which have been competing with each other, are being integrated into a multi-discipline in order to complement each other. This facilitates the decision maker to choose the best combination of monitoring techniques, which are both economically and technically sound and serve the main purpose of condition monitoring (Saranga 2002).

This transformation of condition monitoring techniques brought about a new pace to already condition-based maintenance. There has been a great need for new maintenance. There has been a great need for new maintenance strategies, which combine these important disciplines to improve the system reliability and availability. Knezevic (1987) proposed relevant condition predictors (RCPs) based maintenance. This method incorporates the direct condition of items into the calculation of reliability characteristics and adopts the required level of system reliability as the optimization criterion to implement the maintenance procedures. Saranga (2002) defined RCP based maintenance as maintenance carried out in demand to a significant deterioration in the condition of a system through its constituent items, which are indicated by a change in the corresponding relevant condition predictors.

This change is monitored with the help of condition monitoring techniques and hence RCP-based maintenance is applicable to only those items that under-go degradation occurs due to gradual deterioration, which is experienced in most mechanical systems due to wear, corrosion, fatigue, crack growth etc. in RCP based maintenance significant items, where their condition is described by a relevant condition predictor taking into account cost-effectiveness of condition monitoring techniques and their availability Saranga (2002) enumerates the benefits of RCP-based maintenance as

- Deduction in downtime, since defective components can be predetermined, repair parts of can be ordered and manpower scheduled for the maintenance accordingly. Moreover, sensors that monitor the relevant condition predictors eliminate the time for fault diagnosis; and
- Defective parts need to be repaired or replace and the components in good working order are left as they are, thus minimizing repair cost and downtime.

Condition monitoring-based maintenance is carried out in two parts. A first part is a systematic approach, with each step addressing a sequenced set of questions for each individual item of the system. The answers to these questions lead to the type of maintenance strategy that is more suitable to the corresponding item. The second part is a mathematical model which is the implementation of condition monitoring-based approach to maintenance planning. There are four steps involved in the first part (Saranga, 2002):

- Identification of the maintenance-significant items (MSIs).
- Determination of all condition parameters;
- Identification of relevant condition predictors (RCPs), and
- Selection of condition monitoring technique.

METHODOLOGY

The responsive maintenance process starts with an identification of the problem (fig. 1). CDM in a proactive organization is structured around monitoring. The task provides earlier warning of failure and allows more planning time.

Identification of the Maintenance-Significant Item

An asset is judged to be significant if it could differ from any failure mode on its own, could threaten the safety or breach any known environmental standard and would have significant economic consequences (Moubray, 1997). Items are also judged to be significant if they contain hidden functions whose failures would expose the organization to a multiple failure with significant safety, environmental or operational consequences. In order to identify the MSIs of the system under consideration, a comprehensive survey of all consisting items of the system is carried out, which is often done by failure modes, effects and critically analysis (FMECA) and failure modes effects (FMEA), FMEA and FMECA are methodologies designed to identify potential failure modes for a product or process before the problems occur, to assess the risk associated with those failure modes and to identify and carry out measures to address the most serious concerns (Relia Soft, 2002). Even though there are many different types and standards, mostly FMEA’s/FMECA’s consist of a common set of procedures. In general, FMEA analysis is conducted by a cross-functional team at various stages of the plant/equipment design, development, and manufacturing process and typically consists of prioritized uses, based on RPN and criticality analysis (Reliasoft, 2002).

The RPN system is a relatively rating system that assigns a numerical value to the issue in each of three different categories: severity (S), Occurrence (O) and detection (D) the three ratings are multiplied together to determine the overall RPN for the issue 5 or 1 to 10 and the criteria used in each rating scale will be determined based on the particular circumstances for the product/process that is being analyzed.

$$RPN = (S)\ (0)\ (D) \ldots \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where

S is a rating of the severity or seriousness of each potential failure cause.

D is a rating of the likelihood of detecting the failure cause.

The criticality analysis method is similar to the RPN rating system except that it calculates the ranking in a different way. Criticality analysis takes into account the probability of failure for the item and the portion of the failure likelihood that can be attributed to a particular failure mode. The critically for each failure mode is calculated as in Eqn (2)

$$\text{Criticality} = (Q)\ (FMFR)\ (P) \ldots \ldots\ldots\ldots\ldots \quad (2)$$

Where

Q is item unreality i.e. the probability of failure for the item at the time of interest for the analysis.

FMFR is failure mode ratio of unreliability i.e. the ratio of the item unreliability that can be attributed to the particular failure mode, e.g. if an item has four modes, then one mode may account for 40% of the failures, a second mode may account for 30% and the two remaining modes may account for 15% each.

P_L, a probability of loss i.e. the probability that failure mode will cause a system failure (or will cause a significant loss). This is an indication of the severity of failure effect and may be set according to the following scale; actual loss = 100%; probable loss 50% possible loss 10% and no loss 10%.

A typical FMECA of the (gas turbine 17) GT17 system in Afam Power Station based on the RPN is shown in table 1 while table 2 shows the risk ranking of first four prevailing failure modes of the subsystem.

Applications and Related Analysis

In recent years, there has been a tremendous improvement in the way PM and condition monitoring (CNM) are treated and implemented organizing standards around major classes of equipment has the added benefit of focusing plant at their plant, its varying needs, and the options and strategies necessary to maintain it. Standards focus us on what time-based and condition based PM wants us to perform and steer us away from performing low-value maintenance.

Functional classification structures can be very effective at monitoring large grouping of equipment through the use of performance tests. The cost-effective simplifies monitoring, ultimately components must fail components must be further grouped throughout of codes.

Equipment analysis can be developed by hand, spreadsheet, or a variety of software products software provides the ability to create and document on a programme basis, which can be carried over time to support a “living” maintenance, programme. The software can provide essential standardization and grouping tools and also be used as a training tool

(Augustine, 1999). System failures are ultimately caused by discrete component failure but can be identified much more easily at the system level than at a discrete complement level. Component failures ultimately cause function failures. In a broader context, component failures can in turn, have root causes. Failure and root causes are addressed by FMECA. Normally, the focus of failure analysis is to get to root cause. This will prevent reoccurrence RCM will show when components fail, the failure mode describes how they do so. Mode and cause together define a failure mechanism. A failure mode can be managed if the failure mechanism is understood. The goal of FMEA analysis is to identify-concisely-the failure modes and mechanism of interest. Successful plant operation depends upon achieving design failure modes and full component life.

A complete RCM begins with an FMECA, RCM for an existing facility is posterior assessment experience limits scope of the review and focuses on value. New facilities can be reviewed using a priori RCm, utilize a variety of formal reliability engineering tools including FMECA. Projections of likely problems, availability and maintenance costs can be generated based solidly on analysis (Augustine, 1999).

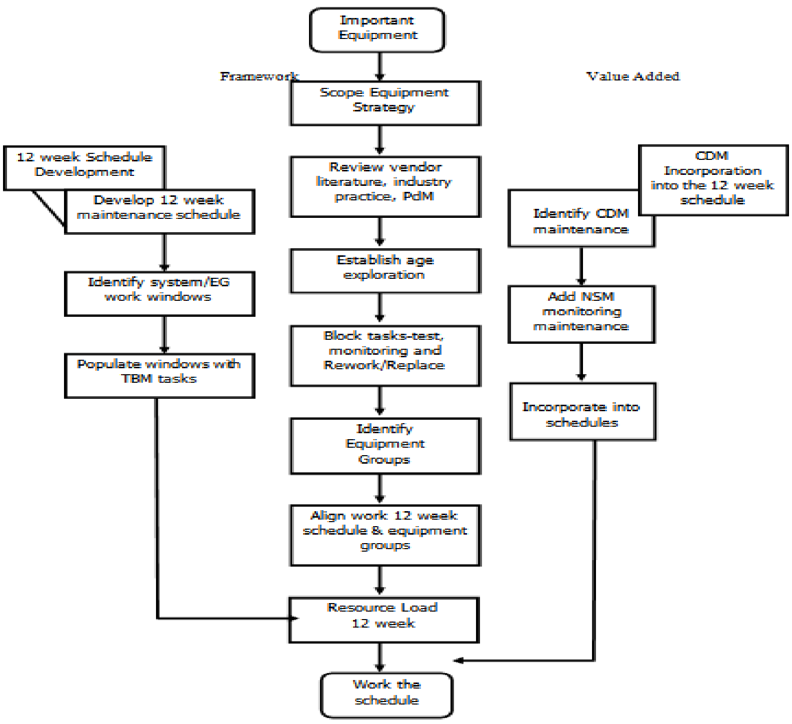

Figure 1: Responsive Maintenance

Table 1: The FMECA of the GT 17 Major Subsystem

Function	Functional Failure	Failure Mode	0	Failure Effect	S	D	RPN
To extent technical energy from hot gases chemical energy	Unable to deliver mechanical energy at all unable to deliver adequate mechanical energy.	No hot gases from the combustion chamber (i.e. no combustion)	1	No combustion at all at the comber and hence there is no shaft work at the turbine	8	2	16
Emanating from the combusting system and deliver same mechanical energy smoothly to the generator.		Stator and rotor blades "thermal shock" due to an excessive rapid acceleration of engine at the start-up stage.	2	This can result in turbine blade life reduction and also turbine efficiency reduction can initiate tripping of the system.	8	6	144

Table 1: Contd.,

			3	This can result/cause a violent vibration from the turbine blade which may affect the journal bearing and cause blasé damage.	8	6	144
		Stator and Rotor blade thermal shock die to excessive rapid loading at synchronous speeds.	1	Turbine Blade life can be reduced and turbine efficiency reduced drastically also.	8	7	56
		Warped turbine shaft due to improper cooling of the system during shut	2	Cause violent vibration in the system which will adversity affect many components (wobbling operation)	9	7	126
		Stator and Rotor blades pitting (colliding)	1	Can reduce the life efficiency of the blade.	7	7	49
	Unable to operate smoothly (noisy/rough operation)	Metal or material build -up on the Rotor blades	2	This cause wobbling of the Rotor due to out of balance effect can result to violent vibration and blade/bearing damages.	9	3	54
		Cooling system blockage (cooling system failure)	1	This can cause a very high-temperature rise at the turbine inlet area which can lead to blades burnt it can also cause the system to trip off. This will also lead to thermal shock on the blades.	8	3	96
		Frequency surge from the national grid.	5	Can cause frequency surge and lead to back pressure build up which can reverse the turbine motion. It will accompany violent vibration with it's attendant damages tot eh blades the bearing and the entire system.	10	2	100
Acts as a passage for the true gases to exit through the exhaust system.	Flue gas exit restricted	Gas (fumes outlet system partially	1	Can cause back pressure build-up that can trip the system	9	5	45

Table 2: Risk Ranking of First Four prevailing Modes of the Subsystem

Subsystem	S/No	Failure Mode	RPN
Air	1	Blocking of filtering	48
	2.	Improper design of manifold	42
	3	Filter not dense and mesh too large	36
	4	Manifold construction (blockage)	36
Air compressor	1	Blades failure due to fatigue	140
	2	Blades failure due to surges and Eddies	126
	3	Blades failure due to cracks	120
	4	Rotor stocked due to lack of lube oil	75
Gas Scrubber	1	Excessive wet gas supply from NGC	160
	2	Condensate drain valve and line blockade	140

Table 2: Contd.,

	3	Filter meshing too large and wide	112
	4	Low quality and gasket deterioration	96
Combustion Chamber	1	Combustion chamber wall tiles damage	96
	2	Cooling system faulty	72
	3	Ignition failure	72
	4	Outlet nozzle blocking	62
Turbine	1	Blades failure due to thermal shock	144
	2	Blades crack due to fatigue	144
	3	Warped shaft	126
	4	Frequency surge from the national grid	100

Analytical FMECAs have been used for years in aerospace applications to zero in on risk contributors and manage overall risk on a budget. Two primary operations tasks are condition monitoring and sensors and instrumentation to identify equipment failure and failure functional testing for hidden failure functions-alarms, trips, and other protective or standby devices-assure function is preserved.

An effective PM programme identifies degrading, not failed equipment, to provide maintenance planning with a heaps-up' about equipment that needs work. For outage work, it helps define the next ''window" (fig 2).

To estimate a scheduled window, there is the need to understand the failure identified and the deterioration window before final failure. On condition maintenance (OCM) identifies a work window in which equipment can be maintained prior to final failure, but does not guarantee work input to the CDM process on the right schedule.

Conditional Overhaul

This was an initial strong case against traditional overhauls' made by Nolan and heap. Though focused on commercial aircraft jet turbine engine could be used in the electric power industry. Conditional overhauls correct primary and secondary failures but do not exhaustively replace a non-ageing part and competent. They are used more in traditional utility maintenance to manage costs. For turbines and other large rotating machines, there is still a case for "overhaul", based on grouping many multiple independent failure mode PM: tasks and the extensive disassembly required for large machines.

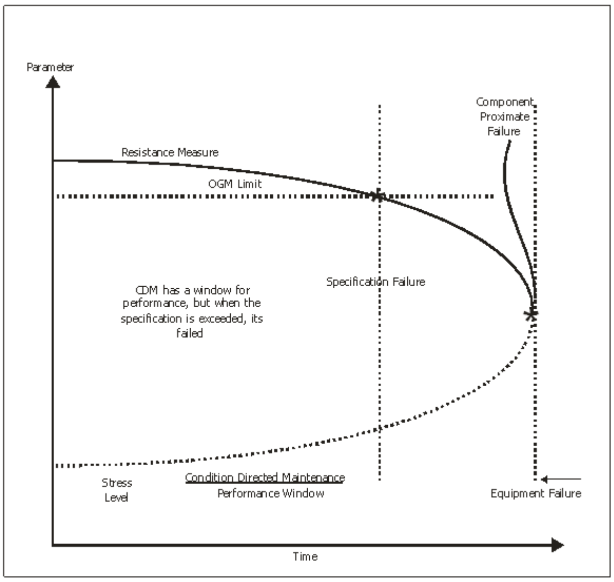

Figure 2: Condition Maintenance Timing

For a turbine, many inspection tasks need to be performed based on time and risk. They include those on instruments and stages. Instrument inspection tasks encompass penetration weldment inspection, failed thermocouple replacement, calibrations and control connector inspection. Stages inspection include blade deposits removal, LP stage tie wrap inspections, blade root tip crack inspection, bearing dimensional checks, steam cut back, across gaskets, along the split casings, at penetrations, bolt creak inspections, and rotor creak inspection.

Overhaul activity requires turbine stage disassembly/re-assembly for a large 500MW plant alone is 4,000-work-hour task. Even with a three-shift coverage working six days per week, it takes a 20-man/shift crew several weeks to complete (Augustine 1999). Effective overhauls require using both time-based and on-condition maintenance risk management

Manufactures recommend performing inspections on every overhaul, but experience also has shown that doubling those intervals was suitable. This adjustment provides risk management, but also substantially reduces overhaul costs. A decision such as this can only be made unit by unit based on specific inspection results. This requires maintaining a history.

Overhaul task can be time-based or on condition. For example, performing efficiency, load behavior, and main bearing vibration level trends are on-condition indicators. Time-based age mechanisms include blade root tip cracks, tie wrap cracks and control valve deposits. Instrumentation can convert time-based tasks to on-condition tasks. Blade deposits can be monitored by careful stage efficiency tests. That necessitates instrumentation maintenance such as calibration.

Feed water chemistry influences the rate of metal transport as well as blade deposits. Feedwater heater leakage or boiler operation can influence oxygen levels in transient periods, as well as the need to perform an overhaul. Condenser leaks influence feedwater chemistry especially facilities that lack full flow demineralizers. These secondary factors can be improved using a combination of known aging performance, history since last overhauled and condition monitoring as an ongoing risk control practice. The on-condition (condition-directed) tasks include bearing temperatures (thermocouple replacement), bearing vibration (bearing inspection and rework) and performance especially stage performance, load capability and response. Other areas for improving overhaul timing include control valve position trends (value stem and seat rework), value stroke test (valve packing and operators) and turbine protection tests.

A turbine in base-load service to operate smoothly at a steady load. A load-following plant, on the other hand, must “ramp” (move to a new load level) smoothly. Failure to perform either well could indicate control valve set erosion or stem bending. Owners are extending turbine overhaul intervals five-year nominal overhaul intervals are being pushed upwards of 12 years, based on condition monitoring (August, 1999).

The overhaul should be extended using combined information. As generation gets more competitive, achieving maximum production with no schedule interruption is more important than ever. The use of condition monitoring, age exploration, and other hedges can reduce the tendency to incrementally extend equipment inspection intervals. A database of equipment components and their failure modes is also helpful, as are benchmark intervals.

A characteristic of modern equipment is the combination of one or several dominant age-based failure modes and an underlying complexity. The composite exhibits mixed characteristics. A strategy of managing the known aging failures with a condition or time-based maintenance, as appropriate based on the certainty of aging and organizational capability, combined with condition monitoring, maintains this equipment very well. The challenge for the Nigeria Electric Power Industry is to develop the simple standard application of this strategy.

Maintenance Problem in Nigeria Electric Power Industry

The culture of time-based maintenance/overhaul has actually made things worse in case studies of Nigeria electric power industry. Objectives review uncovered the no-so-obvious problems that maintenance did not always improve equipment performance. The problem was not mainly on the maintenance performers; rather, it could be best explained in fundamental statistics – an intrusive overhaul of plants and equipment on time-based resulting in higher failure rates. The power stations have not focused reliability on operating periods and capacity utilization. These could be period between scheduled outages, calendar periods; budget periods and peak production periods. There are varying scheduled outages with reliability engineering in-play. A major scheduled outage ought to occur on the interval of 12 months (or longer), a general benchmark is 18 months. Special outages run on longer intervals-turbine 5-12 year's interval, for instance. In today's economic climate, operators push design envelopes to extend to outages periods.

Maintenance practice in Afam Electric power plant is crisis-oriented on the day-to-day. Hence, lack of preparation for predictable events is what provides a crisis orientation. While work will always be in a dynamic environment, proactive maintenance as can be derived from a failure management based strategy can manage or remove a great deal of stress for everyone. Operation and maintenance are harder to perform under adverse circumstances – especially when some plant managers wear crisis purple hearts and some corporate cultures reward those who promote and manage crises rather than stable productive workplaces.

The AFAM electric power industry needs stable, predictive operations so as to get the job done and minimize crisis responses. In the Afam electric power generating industry workers don't understand the maintenance needs of the equipment. Problems are persistently maintenance issues; since root cause analysis are never initiated before taking up design changes in maintenance. Also, the organization has failed to the recognized the true cost of maintenance. Usually, low quality is associated with product unpredictability. High-quality components have longer mean time between failures (MTBF), a more predictable "lifetime". Random failures require more efforts to mitigate the failure (e.g.) introduce intendancy and to detect and correct the failures that ultimately will occur.

The uncertainty of random failures inherently raises costs. This increases initial operating cost, product costs, or both ultimately life-cycle costs are higher. Predictable failure mechanism adds value. Corporate cost information is often unavailable or inaccurate in the Afam electric power industry. There is still no effort to learn the cost and crisis management. Predicable costs are a challenge to achieve. Spontaneous, undocumented problems are common, and standards absent. Predictability does not happen by chance. Random approaches lead to high costs. Developing consistent information processes that support cost management requires practical experience and time.

CONCLUSIONS AND RECOMMENDATIONS

Preventive maintenance plays a major role in today's competitive world, where almost everything depends on the successful operation of plants and equipment such as electric power station. People are becoming aware of the fact that it is essential to maintain the condition of the plant and equipment in order to achieve greater reliability and availability of the system. Maintenance strategies like CDM with the help of the improved and integrated condition monitoring techniques have given a great opportunity for understanding, monitor and maintain the condition of an item ever before. This paper has shown that gradual deterioration in mechanical and electrical systems can be predicted through continuous monitoring and determining the FMEA and FMECA as well as the RPN using data collected from the life tests of (gas turbine 17) GT17 in

Afam thermal power station. The failures can be prevented and the required reliability level of the condition system can be maintained by the integral use of condition monitoring techniques and by efficient implementation CDM. CDM enables the maintenance engineer to decide an optimum maintenance strategy for each critical component of the system by giving substantive and corroborated diagnostic information. With the advent of advanced computer technology. It is possible to integrate all the information into a single system in order to get a complete figure of the plant at any instant of operation.

In AFAM thermal power station, the informality the lack of a maintenance strategy that is understood and applied introduces random factors into work performance. This dilutes planned maintenance effectiveness and increases the frequency and dispersion of failure. A maintenance plan which ought to address equipment control failures has been difficult to do in this organization. Statistics tell that around 85 percent of the tasks in a typical large generating facility is condition monitoring and CDM, a large fraction of which should (or needs to) be implemented by operators (Augustine, 1999). Consistent, integrated measurement processes provide the necessary feedback information that enables staffs to tune the maintenance plan. Available generation-oriented computer management maintenance system (CMMS) software and user-friendly feedback mechanisms, accessible to any employee, provide effective feedback. Maintenance organization in the Nigeria electric power industry need to deliver operating equipment most of the time at lower cost, higher reliability, and availability. They should replace traditional maintenance staff and annual-unit outages with flexibility scheduled overhauls at the lower cost. Workers should literally wear all hats-operator, mechanic and technician to develop "utility worker" with the modern emphasis on process and the competitive pressure in the utility industry – the maintenance process of the Afam Thermal Power station industry should be too ripe an improvement opportunity not to change. This challenges the corporate culture of the organization. Emphasis on new innovative work practice means that more work performance needs to see other methods. Maintenance improvement throughout the industrialized nations includes RCM and TPM. While each represents a good start at defining and advancing the maintenance profession, each has the intangible aspect that brings proactive maintenance to mind. While proactive maintenance has its place tangible techniques will have greater success in the Nigeria Electric Power Industry.

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