



Strategies of effective engineering plant maintenance and its implications on industrial and economic growth of a developing Nation

Joseph O Amaechi¹, Chinujinim Godstime Thomas²

Faculty of Vocational and Technical Education, Ignatius Ajuru University of Education Portharcourt River State, Nigeria

Faculty of Science and Technical Education, River State University of Science and Technical, Nigeria

Abstract This article unveiled the causes of engineering plant failure. Re examined preventive, corrective/shutdown and predictive maintenance strategies in light of the prevalent maintenance approaches in a contemporary engineering and developing nation, in a bid to proffer effective maintenance strategies that will provide an acceptable level of plant operation. It found maintenance to be a practice that is carried out following detection of an anomaly and aimed at restoring normal operating conditions. This article also revealed that there is no one plant maintenance strategy for all situations and all organizations. Rather, one requires a blend of maintenance strategies that are right for a given operation and for the age of the equipment. Finally, in consideration of the colossal losses in varieties of ways emanating from ineffective maintenance strategies; concludes that it has become absolute necessary that the resource managers have to strictly consider the implementation of the suggested strategies of effective engineering plant maintenance with acceptable level of risk, in an efficient and cost-effective manner, as were articulated in this paper.

Keywords Plant, maintenance, maintenance strategies, effective maintenance, developing nation, preventive maintenance.

Introduction

Maintenance management in a technologically developing nation like Nigeria should start on the project drawing board. Selecting a maintenance management strategy when the equipment is installed may not give an effective result. Engineering plant maintenance is a management practice that is used to maximize production and minimize loss and waste. Therefore, selecting a successful maintenance strategy requires a good knowledge of equipment failure behavior and maintenance management practices. Once you appreciate why equipment fails, how equipment fails and when equipment fails one can certainly select the right mix of maintenance strategies to extend and maximize its service and performance.

To start with, today's equipment technologies can be broadly grouped as mechanical or electrical. Equipment in both groups has physical presence, you can touch them. Because they are made of solid matter they can break or deteriorate. Equipment fails because its physical substance and structure cannot support the last duty required of it. In other words a final incident destroys it because it is not physically able to withstand that incident. In some cases the end of an equipment's life is instantaneous and without warning. Many times there is a gradual worsening of performance that can be detected. According to Hartford Steam Boiler (2011), businesses, institutions and municipalities are acquiring and increasingly relying on costly equipment and new technologies [1]. Whether it's electrical supply and distribution, environmental controls, refrigeration or computer systems, equipment is vital in today's world. Reliance on new technologies and equipment has actually led to a greater



probability that a business-critical system will fail. Therefore, understanding what can go wrong with any plant equipment is a key to preventing losses and protecting the economic and technological growth of any nation. Similarly, the problem is that Nigerians find it difficult to maintain their own property and see public facilities as government property which does not belong to any body [2]. Many public facilities put in place mainly to give benefits to the people are left to decay without any positive actions from the people to encourage the sustainability of the property. Consequently, public facilities do not live up to its life span due to lack of or rather ineffective maintenance approaches. The lack of maintenance culture from all the economic agents in the country has played great role to keep the country at the level of high deficiency of infrastructure in the midst of insufficiency culminating to colossal waste [3].

Therefore, this article is to provide a framework that can identify or select and apply effective maintenance strategy with the purpose of controlling failure. And thereby takes you through the maintenance practices which affect equipment performance and service life. It also introduces you to the effective maintenance strategies available to you today and how they work in a technologically developing nation.

Causes of plant failure

In a developing nation like Nigeria, already know that anything solid can be broken or will deteriorate. There are usually combinations of causes that can make a piece of equipment fail. These can be categorized into a few simple explanations.

1. **Over-stressed Components:** Physical matter can only survive within a limited range of imposed stresses and environments. Once matter is stressed beyond its endurance it will suddenly fail. Some common examples are overloading, becoming too hot and placing an item under fluctuating forces leading to fatigue situations.
2. **Physical Attack:** This is the case where the environment around the equipment actually damages the equipment. When environmental attack gets too severe the equipment is compromised and fails, as it no longer has the strength or capacity to handle its duty. Common examples are rusting, chemical corrosion, wear, erosion and cavitations.
3. **Error or Mistake:** sometimes, equipment can fail due to the wrong thing being done to it, or a wrong choice being made in ignorance. Failure by error can start on the drawing board at the design stage. It can be due to an operator or maintainer making a mistake. It can be due to incompetent management decision. Some examples include starting equipment when not fully rebuilt, forgetting to put oil in a gearbox, introducing incompatible chemicals and doing the wrong instruction sequence.
4. **Poor Design Choices and-or Poor Manufacturing / Assembly Quality:** this as the heading implies there are times when a part is made incorrectly, built incorrectly or its design was unable to withstand the imposed service duty. Design errors include selecting undersized equipment, wrongly specified components and introducing safety risks. Manufacturing errors like poor welding, poor casting, incorrectly positioned holes and out of tolerance machining are real possibilities. Similarly, assembly errors, such as under-torque on bolts, poorly fitted electrical connections and short-cut assembly quality practices will eventually lead to equipment failure.
5. **Lack of Maintenance and Care:** usually, when equipment is designed the designer makes the assumption that it will be treated with reasonable care and it will undergo a minimum amount of required maintenance. When care and maintenance is withheld from equipment for an extended period of time, accumulated problems develop which eventually cause failure. This can include not changing lubricating oil, leaving electrical equipment open to dust and dirt ingress, starting machines under full load, not checking remaining service life and not cleaning equipment down.
6. **Unimagined Incidents and Knock-on Effects:** Occasionally an unexpected disastrous event occurs that destroys equipment. These include sabotage, acts of God, such as lightning and terrorism. Included in this category are unforeseen preventable events that are a consequence of planned events. An example is where a bolt falls into a machine during a repair and is not noticed. On start-up the bolt is jammed into the working parts and causes a breakdown. Another example is negligent behaviour, such as backing forklifts into operating plant or out-of-control vehicles running into machinery.



The actual time of failure depends on when the cause of the failure coincides with the item's ability to accommodate the failure mechanism. This means that the failure happens at the time the item can no longer operate as required. This point in time can be controlled by the selection of the right maintenance strategies.

The Concept and Trends of Plant Maintenance

The term plant includes permanent and semi permanent structure as well as items such as machines, laboratory equipment, the blackboard or chalkboard, and the learner and teacher tools. Adebayo (2012) defined effective plant maintenance as usually refers to the methods, strategies, and practices used to keep an industrial factory running efficiently [4]. This can include anything from regular checks of equipment to making them function properly, to cleaning garbage bins and toilets. The general aim of plant maintenance is to create productive working environment that is also safe for workers.

To begin with, there is a requirement to improve an understanding of the basic perception of the maintenance role. Here, it is pertinent to note that the maintenance function has undergone serious change in the last three decades. The traditional perception of maintenance's role is to fix broken items. Taking such a narrow view, maintenance activities have been confined to the reactive tasks of repair actions or item replacement. Thus, this approach is identified as reactive maintenance, breakdown maintenance, or corrective maintenance. A more recent view of maintenance is defined by Gits (1992) as "All activities aimed at keeping an item in, or restoring it to, the physical state considered necessary for the fulfillment of its production function [5]." Clearly, the scope of this opinion also contains the proactive tasks such as the following: routine servicing and periodic inspection, preventive replacement, condition monitoring.

In order to maintain equipment, maintenance must carry out some further activities. These activities contain the planning of work, purchasing and control of materials, personnel management, and quality control [6]. This variety of responsibilities and activities convert maintenance from a simple function to a complex function to manage. Maintenance should ensure equipment availability in order to produce products at the compulsory quantity and quality levels [7].

The scope of maintenance management includes every phase in the life cycle of technical systems (plant, machinery, equipment, and facilities), specification, acquisition, planning, operation, performance evaluation, improvement, and disposal [8].

Contemporary Maintenance Practices

There are several maintenance strategies available, they range from pre-emptive methods that remove the need for maintenance and those that cover the ways to maintain well and on to failure analysis methods for removing existing failures. This includes the following:

1. Preventive Maintenance

Preventive Maintenance (PM) strategy was one of the very first and it is still very effective. It comes in two forms – 1) inspection and observation and 2) intervention and replacement.

The first Preventive Maintenance form is the usual response used for equipment and parts that show signs of age and wear-out. It involves inspecting and noting the condition of equipment and its parts and servicing it on a regular basis, such as changing old lubricant. While the servicing is done it is an ideal time to look for evidence of impending failures in critical and working parts. If failure evidence is found, the part is changed for new immediately or at the earliest convenient time before breakage.

A Preventive Maintenance strategy stops failures with the very first use. You can expect a well run and always done-on-time PM strategy to stop failures by up to 90%. You will not greatly reduce the amount of maintenance; only stop most of the breakdown failures. Its benefits will be seen in the first month or two.

2. Shutdown Overhaul Maintenance

Use of Shutdown Overhaul maintenance strategy is aimed at ensuring uninterrupted production for a specific period of time. By renewing equipment regularly you remove the wear-out related stoppages. Once equipment is overhauled to manufacturer's standards you can expect as-new performance. However you are also exposed



to 'infant mortality' risks due to poor quality control, mistakes during assembly, incorrect material selection and introduced damage.

You would do best, if you use a Shutdown Maintenance Strategy, to use a sound and robust Quality Control and Assurance Strategy with very good rebuild and checking procedures.

3. Predictive Maintenance

Predictive Maintenance (PdM) is a very powerful maintenance strategy. This is a conditioned-based maintenance approach which involves monitoring for evidence of changed conditions within the equipment. In order to assess whether an equipment will fail during some future period, and the taking action to avoid the consequences of that failures. The amount of change and the rate of change are tracked and used to predict the time of failure.

Strategies to Enhancing Effective Plant Maintenance in a Developing Nation

Effective maintenance strategies are known to be a contributory factor to the growth and development of a nation. According to UN, a developing country is a country with a relatively low standard of living, undeveloped industrial base, and moderate to low Human Development Index (HDI). This index is a comparative measure of poverty, literacy, education, life expectancy, and other factors for countries worldwide. The index was developed by a Pakistani economist named Mahbub ul Haq in 1990, and has been in use since 1993 by the United Nations Development Programme (UNDP), in its annual Human Development Report. Basically, efficient plants in a nation can help in ameliorating the problems associated with stunted economic growth; efficient plant can be viable only when it is properly or effectively maintained on a regular basis. Here are suggested strategies to enhancing effective engineering plant maintenance in the society.

1. Pre-emptive Detection and Elimination

This is a strategic maintenance planning that should start on the drawing board. Once an item of plant is built you are stuck with this strategy. A piece of equipment requires what maintenance it needs to maintain its performance. There is no reason escaping the fact that the design specifies the maintenance requirements.

Pre-emptive maintenance strategies are the best because they are the least expensive way to reduce maintenance. Their beauty and wonder is that they are an equipment lifetime strategy that brings continual better operation for the equipment's entire operating life.

2. Quality Assurance and Quality Control

This strategy originated in the manufacturing industries and applies equally to maintenance work. It is simply the proper and correct control of manufacture and assembly so that equipment is built precisely as it was designed, with correct and accurate components. It involves substantiating and proving that each equipment item meets its design requirements and that it is assembled into the equipment correctly.

Adopting a Quality Control and Assurance maintenance strategy improves the quality and accuracy of parts and workmanship. This translates into better running equipment with longer mean-times between failures. This strategic maintenance move will produce results immediately though stopping mistakes.

3. Intentional Over-Design Selection

There are times when it is useful to select more robust equipment than superficially appears necessary. This is a strategic maintenance choice that is intended to produce longer periods of equipment operation between failures. It involves specifying equipment with stronger, harder, more resistant parts, using longer lasting components, applying improved protection against ingress of the external environment and the like.

4. Improved Technologies

New inventions and innovative designs usually occur in response to existing problems. It is a wise and valid maintenance strategy to be constantly looking for new technologies that reduce equipment operating problems. When a potentially useful technology is found test it in a controlled and monitored experiment to prove its worth in your situation.



5. Root Cause Elimination and Design-Out

You need a maintenance strategy that solves your problems and continually improves your plant and equipment performance! This is a strategic maintenance step that if not done, results in long-term deterioration in production plant performance. If operating problems are not removed by designing them out, then the problems will accumulate to the point where production falls because equipment continually fails.

6. Proactive Education and Training

People can only change their behaviour and thoughts when they find better ways to behave and think. Once a person knows what is right to do, they will most likely do it. Ignorance is hugely expensive! One of the best maintenance strategies is to teach the engineering design requirements of the equipment to the operators and maintainers who will run and care for it. This is a sound strategic step because it means key knowledge is transferred to the users of the machinery.

7. Engineering plant Maintenance, Planning and Scheduling

This is a key strategic maintenance planning move that is based on the principle that prior planning and preparation will improve the actual performance and execution. This is why elite athletes do not compete unless they have trained for the event. They know that unless they have prepared thoroughly beforehand they will not succeed.

Implications of plant maintenance to the technological and economic growth of developing Nation

Engineering plant equipment is exposed to unique risks that other property is not, such as electrical short circuits and mechanical forces. Unbudgeted losses from a breakdown can be extremely costly and, in many cases, greatly impact the technological and economic growth of a nation. Equipment breakdown coverage is needed to pay for the financial loss incurred as a consequence of a breakdown [1].

The extent of productivity in a country is a function of functional and effective input of production which infrastructure occupies a large position. Oyedele (2012) posits that infrastructure is generally a set of interconnected structural elements that gives rise to the framework supporting an entire structure of development which is a means of attaining set of objectives and considered so much in judging a nation's development status. The importance of proper, timely and adequate maintenance of engineering plant cannot be underestimated, in view of the huge cost of procurement of new materials. Maintenance of engineering plants involves, keeping grounds, buildings and equipment in their original condition of completeness or efficiency [9]. Knezevich (1975) stressed in his view that the time taken for a structure to become obsolete and out-dated is a function of the quality of the original construction and material as well as the quality of housekeeping and maintenance. Equipment fails at the point when the equipment no longer delivers the minimum duty required of it. It may not yet be broken, but it is not able to deliver the needed service [10].

In Nigeria, the established transportation infrastructure has not been given enough attention and maintenance to support the growing population. So, there is high degree of deplorable road network, abandoned railway lines and other infrastructure at the sea ports and air ports. This has in various ways retarded resources mobility, output production and income generation in Nigeria. The much focused in term of public expenditure which is road is in a very bad shape all over the country resulting to incessant road accidents, which have sent a large number of our bright and quality manpower to their graves, denying the country of quality manpower in the midst of scarcity.

The CBN (2003) notes that the annual loss due to bad roads in Nigeria is valued at N80 billion, while additional vehicle operating cost brought about by bad roads is valued at N53.8 billion, hence total loss per annum is N133.8 billion. This value does not include other losses such as man-hour emanating from traffic congestion due to bad roads and emotional and psychological disequilibrium. This situation has impacted adversely on production costs and has raised cost of doing business which does give rise to cost-push inflation in Nigeria. The losses and situation in Nigeria could have been avoided if there have been a sufficient maintenance culture capable of taking needed repairs at the right time [11]. Also in Nigeria, there is a large market for varieties of goods and services, but infrastructure deficiency owing to lack of maintenance have restrained investment. For



instance, power supply gadgets exist, pipe borne water plants are available but improper maintenance, sabotage, selfishness, corruption, among others have made them non functional and supposed provided services are non-available and where available, they function erratically.

According to report by GNA (2012) Mr Kwesi Ahwoi, Ghanaian Minister for Food and Agriculture, while addressing the 82nd Speech and Prize-Giving Day celebration of the St. Augustine's College in Cape Coast under theme "The Culture of Maintenance as an integral part of Infrastructural Development". Mr Kwesi Ahwoi, said that, the lack of a maintenance culture in the country was causing the nation a great deal of money which could have been channeled into development projects. To him the attitude of Ghanaians now is to "build, neglect and rehabilitate" instead of going by the axiom "a stitch in time saves nine". He further stated that "Watching the infrastructure bequeathed by our forefathers to decay before looking for gargantuan funding to rehabilitate them" was unpardonable, he noted, adding that this development has devastating effects on the economy. He said every infrastructure has an economic life span that can only be sustained through proper and regular maintenance, and that lack of strong and universal maintenance in Ghana was due to lack of ethics in effective maintenance. "Lack of commitment from leaders in all spheres of the Ghanaian society" as well as the absence of clear policies and financial resources to effect regular maintenance and the failure of managements across the country was worrying, he indicated [12]. Mr Ahwoi said many analysts and African political leaders relate their poor economic performances to inadequate investment in infrastructure but pointed out that without significant improvement in its maintenance culture, mere addition of more public and private infrastructure cannot result in the anticipated improvement in Africa's economic performance.

Conclusion

This paper unraveled that ineffective maintenance strategies has adversely affected sustainable development of Nigerian economy over the years. Consequent upon which the transport infrastructure put in place in Nigeria, vehicles, buildings, plants and machinery procured for production was left unmaintained and they gradually decay without serving to the fullest of their engineering life span. Infrastructures such as industries, refineries, utility authorities have not been effectively maintained for efficiency in provision of essential services needed to enhance economic activity in Nigeria. Consequently the lack of effective maintenance strategies have contributed to low production which gives rise to low income and poor living standard in Nigeria. Besides, irregular power supply in Nigeria and over dependence on road transport when railway line exists is attributed to lack of effective maintenance strategy. In consideration of the colossal losses in varieties of ways emanating from ineffective maintenance strategies, it becomes absolute necessary that the resource managers have to strictly consider the implementation of the suggested strategies of effective engineering plant maintenance articulated in this paper.

Recommendations

Maintenance is carried out following detection of an anomaly and aimed at restoring normal operating conditions. Although, there is no one plant maintenance strategy for all situations and all organizations. Rather, one requires a blend of maintenance strategies that are right for a given operation and for the age of the equipment. It is here recommended that for effective engineering Plant maintenance strategies to be achieved in a developing nation like Nigeria.

Maintenance culture should be implemented in the organisation of all classes so as to change the mindsets and attitudes of maintenance team, which has the ability and capability to encourage regular knowledge acquisition, skill improvement, and performance advancement in maintenance activities.

Industries and organizations need to adopt plant maintenance strategies with acceptable level of risk, in an efficient and cost-effective manner.

The provision of training and re-training of our technicians in the handling of modern equipment and best engineering plant maintenance strategies in developing nation.

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