International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 6 June 2022, pp: 1225-1234 www.ijaem.net ISSN: 2395-5252

Small Scale Production Industries and L0w Cost E- Maintenance System

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Submitted: 01-06-2022 Revised: 10-06-2022 Accepted: 15-06-2022

ABSTRACT
This paper discusses the design and use of low cost e-maintenance systems for the promotion of small-scale industries in Nigeria. Maintenance is crucial to manufacturing operations. In many organisations, the production equipment represents the majority of invested capital, and deterioration of these facilities and equipment increases production costs, reduces product quality. Over recent years the importance of maintenance, and therefore

maintenance management, within manufacturing organisations has grown. The maintenance function has become an increasingly important and complex activity, particularly as automation increases. The opportunity exists for many organisations to benefit substantially through improvements to their competitiveness and profitability by adopting a new approach to maintenance management. Several tools and technologies including Condition Based Maintenance (CBM), Reliability Centred Maintenance (RCM) and more recently e-maintenance have developed under the heading of Advanced Maintenance Strategies. However, the adoption of advanced maintenance strategies and their potential benefits are usually demonstrated in large organisations. Unfortunately, the majority of small and medium scale industries are constrained by the lack of knowledge and understanding on the requirements, which need to be in place before adopting an e-maintenance system.

Keywords: E-maintenance system, small scale, industries, low cost

I. INTRODUCTION

Maintenance is one of the major activities in manufacturing as it influences production quality and quantity and directly affects production cost and customer satisfaction. Any machine downtime can lead to a delay in the production cycle and create a significant bottleneck in the entire production flow, resulting in heavy costs. (Pallath, 2015) Maintenance has always been a severe cost driver in the production industry. Studies show that, depending on the industry, between 15 and 70 percent of total production costs originate from maintenance activities (Christian et al., 2020). Maintenance is crucial to manufacturing operations. In many organizations, the production equipment represents the majority of invested capital, and deterioration of these facilities and equipment increases production costs, reduces product quality (David et al., 2018).

The performance and competitiveness of a production enterprise is dependent on the reliability and availability of their production facilities. The life cycle of any component in a production system is a function of its effective maintenance program. All equipment required for production is expected to operate at 100% efficiency at all times. Maintenance of plant and equipment use in production results to high production quality products, the speed of production increases and improve the overall performance of plant. The maintenance resources maximum utilization, improve cost reduction and controls the total operating budget for the plant as well as reductions in total labour costs through increased speed and efficiency of production.

One other important reason for performing maintenance is that the plant and equipment that are not maintained properly become worn too early. This early deterioration has cost implications that are associated with the replacement of the equipment. The introduction of careful maintenance program can lead to the increase of the equipment lifespan which will minimize the cost of repair. Effective maintenance activities allow equipment to be repaired before its failure hence avoid the cost of uncontrollable failures and possible revenue loss. (Dowler, 2015)

Maintenance strategy is a planned way to upkeep devices, which contains actions such as “identification, researching and execution of many repairs, replace and inspect decisions”.

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Implementation of the strategy requires executable, tactical plans (Velmurugan & Dhingra, 2015, Shafiee & Sørensen, 2017). Therefore, maintenance can be contemplated as an organizational purpose that functions in accordance with production. In this way, it can be concluded that maintenance disturb production by increasing the capacity of production at the same time also controlling the quality of the output and quantity

Maintenance costs have now become investments that yield good results. There is a cost associated with diagnostic actions. An increased inspection frequency results in higher incurred cost for industries. Therefore, optimization of diagnostics schedule is an issue that needs careful attention. Deciding optimal condition monitoring intervals is another issue needed to be addressed. The condition based maintenance of large assets of an industry should be carried out with seamless integration of data and information with other activities (such as production/inventory planning) that are influenced by maintenance actions so that optimum utilization of plant assets is effected with minimum overall cost.

MAINTENANCE OPERATIONS :TRADITIONAL VERSUS MODERN TREND;

Maintenance is broadly classified into two: (a) Unplanned maintenance ;Corrective or reactive maintenance (reacting only when malfunctions or breakdown occur) This requires a component to fail before replacing it (known as run-to-failure), this may well lead to the entire production line going down. And that downtime is always expensive.

(b) Planned maintenance; preventive and predictive maintenance are involved. Preventive maintenance activities require performance of maintenance activities at fixed intervals based on previous experience or legal requirements while predictive maintenance monitors the condition of critical equipment machine to determines when to replace a component by looking at its level of wear and tear., Once it exceeded a pre-defined level, the system issues a warning.

Unplanned downtime is costly, whether in terms of lost production, disruption to consumers or safety issues in the case of a major incident. Reputational damage is a further factor to consider. If the number of unscheduled outages production network is experiencing is on the up, it's likely that current maintenance practices are falling also. While preventive maintenance is certainly a step up from a reactive approach, it has its own pitfalls. A scheduled monitoring program through predictive maintenance will help us keep on top of repairs, leading to efficient use of maintenance time and resources (Daily et al., 2019).

Predictive maintenance uses condition monitoring process to determines when to replace a component by looking at its level of wear and tear. Once this has exceeded a pre-defined level, the system issues a warning. The component affected is, however, still intact and could be reused. This can help minimize drastic losses and even prevent them altogether. Predictive maintenance assist companies in getting more out of their machines and production lines. It reduces both planned and unplanned downtime with more efficient maintenance and upgrades (Rolf, 2022). Predictive maintenance allows industry to identify and rectify problems in a planned and timely manner, minimizing the risk of power cuts and catastrophic failure (David, 2022). Predictive maintenance is a maintenance policy leading to improved efficiency since it allows an estimation of the remaining useful life of the machinery. This approach is based on condition monitoring ideally conducted by sensors, which allows a continuous monitoring process of relevant machine parameters such as vibration and temperature (Christian et al., 2020)

The highest level of maintenance is **e-maintenance** (advance predictive maintenance)**.** This employs analytics and machine learning on machine and environmental data. E maintenance can be described as the area of maintenance where technology is used to provide decision support for operations and maintenance, through the application of advanced information technology (Niklas et al., 2019). E maintenance is a proactive maintenance using technology like the internet of things (IOT), machine learning, cloud computing and big data analytics, to predicts when a component is likely to fail, and send alerts to replace it before it causes problems.

E maintenance enables more efficient and better maintenance work, as it can reduce remedial maintenance, which in turn leads to reduced costs, as unexpected errors can result in increased downtime (Niklas et al., 2019). In addition, Niklas et al. (2019) believed that , with e maintenance, the correct type of maintenance can be utilized and the frequency for device maintenance can be reduced through real-time diagnosis. This leads to reduced costs for companies that implement e maintenance as well as environmental benefits through improved resource utilization

The advancement of information and communications technology (ICT) has enabled maintenance functions to be more closely integrated with external parties; for example, joint information sharing and collaboration between the plant maintenance function and equipment (e.g. remote monitoring) (Muller et al., 2008; Aboelmaged, 2015), (Baines et al., 2017; Huang et al., 2019).

. This makes it possible to recognize when a component is likely to fail, and to react accordingly. This data-driven maintenance takes a different approach. It targets and continually checks equipment, components and environmental factors. In fact, it systematically employs the application of artificial intelligent (AI) in our maintenance strategy to do the following

- reduce downtime
- lower costs and follow-up costs
- minimise unplanned downtime
- increase the lifespans of machines and equipment
- optimise the performance of your machines
- use previous data to detect abnormalities in how your equipment is running
- recognise the best time to perform maintenance
- prevent unnecessary scheduled maintenance
- home in on error sources
- recommend appropriate remedies
- schedule your service and maintenance team better
- reduce the workload of your field engineers
- manage spare parts more effectively

Artificial intelligence (AI) is then able to draw on pattern recognition and algorithms to identify information, such as the time at which a component may fail. The system is constantly learning and its predictions become very accurate. This will assist to prevent downtime before they occur (Rixk and Bergallan, 2018)

. This new technology drives companies to undergo comprehensive digital transformation . Digital transformation can be defined as processes in which digital technology is used to create new approaches to do business by replacing traditional approaches. Therefore, digital maintenance or e maintenance has received increasing attention over the recent years. Digital maintenance or e maintenance can be described as the area of maintenance where technology is used to provide decision support for operations and maintenance, through the application of advanced information technology. Niklas et al. (2019) and David (2021) identified six signs that an industry need this e maintenance ; when (a) number of unscheduled outages is escalating (b) there is need to reduce maintenance costs (c) asset reliability needs to be improved (d) we want to improve safety for maintenance personnel (e) we want to reduce operating cost

This advanced predictive maintenance has been pointed out to be an important element in digitalizing maintenance with different application within remote maintenance . It has also been estimated that this advanced predictive maintenance can reduce the machine downtime by 30–50% and extend the lifetime of the machine by 20– 40% (Harald et al., 2020).

The use of this advanced predictive maintenance offers great advantages in minimizing system downtime, leading to a reduction in production loss. In contrast to regularly performed maintenance activities, customer experience is enhanced, and customer loyalty is strengthened (Spenda et al., 2017). In recent years, many companies ,especially big organizations, have chosen to follow digital trends and use more smart and connected devices to find new ways to create and deliver value, which is referred to as digitization, Internet of things (IoT), or Industry 4.0

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SMALL SCALE PRODUCTION INDUSTRY CHALLENGES IN ADOPTING E MAINTENANCE

The small scale Industrial sector plays a vital role in the industrial development of any country. The importance of the small scale industrial sector is well recognized throughout the world over for its significant contribution in gratifying various socioeconomic objectives, such as higher growth of employment, output, promotion of exports and fostering entrepreneurship. Small and medium enterprises (SMEs) are considered as the backbone of economic growth in all countries because they account for more than 75 percent of global economic growth. Small and medium enterprises (SMEs) are contributing in providing job opportunities and also act as a supplier of goods and services to large organizations (Amtita, 2015).

Small and medium enterprises (SMEs) played the above important roles in modern economies because of their flexibility and ability to innovate The growth and prosperity of every society is guaranteed by small and medium-sized enterprises (SMEs) . They act as the driving force of many manufacturing economies (Mittal et al., 2018) and are widely known as capable innovators due to their “flat organizational structure” and are more “flexible” in comparison with multi-national enterprises (MNEs). Thus, small and medium-sized enterprises (SMEs must be developed in terms of technology to optimize their performance by integrating and applying the concept of Industry 4.0 to be able to compete nationally and internationally. To better understand the technology requirements for small and medium-sized enterprises (SMEs) to become Industry 4.0 recognized; the nine pillars of Industry 4.0 must be employed to highlight the areas in which small and medium-sized enterprises (SMEs) can implement new technologies; thereby becoming integrated, autonomous, and optimized (Vaidyah et al., 2018).

E maintenance is a revolutionary paradigm that aims to improve maintenance systems’ performance in terms of quality, time, cost, and flexibility, as well as human and machine decision-making capabilities. Most large enterprises have already taken first steps towards adopting e maintenance. Small and medium-sized enterprises (SMEs) on the other hand, are struggling with developing an e maintenance adoption roadmap. Application of e maintenance by small and medium scale industry will allow them to focus on developing a sustainable methodology .

Adoption of e-Maintenance in small scale production industries will ultimately be to exploit the available technology and tools to make the case for more cost-efficient, resource-optimized, integrated and effective maintenance management. Thereby, the practicability and profitability of solutions must be focused. Small and medium-sized enterprises (SME) could benefit from e maintenance potentials by establishing new processes, products business and maintenance models. However, small and medium-sized enterprises (SMEs) often have limited resources for research & development, investments, consulting or qualification of personnel. Thus, active support for small and medium-sized enterprises (SMEs) by public funding is required (Egon et al., 2017)

However, small and medium-sized enterprises (SMEs) in comparison with multinational enterprises face various challenges in transforming to Industry 4.0 due to limitations on internal resources, specialist workforce, and the lack of knowledge and experience when defining the appropriate strategy which elevates Industry 4.0 from theory to practice . Moreover, small and medium-sized enterprises (SME) do not have right perspective about “the financial effort” required for the acquisition of such new technology nor on the overall impact on their business model (Schumacher et al., 2016). Although many, small and medium-sized enterprises (SMEs) have recognized the opportunities offered by Industry 4.0, many of them are still reluctant to introduce solutions (Schumacher et al., 2016)

The great importance of small and medium-sized enterprises (SMEs) means that beyond economic rationales, the successful integration of, small and medium-sized enterprises (SMEs) into Industry 4.0 is also a relevant social challenge and thus, specific policies and programs should be designed accordingly (Müller & Voigt, 2018 (Bär et al., 2018; Müller et al., 2018). While it is true that general challenges of Industry 4.0 in small and medium-sized enterprises (SMEs) are comparably better understood, the implementation stages of Industry 4.0 for small and medium-sized enterprises (SMEs) and which resources are required to achieve the next stage has scarcely been investigated to date (Arcidiacono et al., 2019; Ghobakhloo, 2018; Mittal et al., 2018, 2019). In response, this paper takes a cost-based view (CBV) to address this research gap, aiming to contribute to a better understanding of the implementation stages (Miren et al., 2021).

In most small scale production industries maintenance strategies are still based on a” FAIL” and” FIX” approach instead of ‘ PREDICT ‘and ‘PREVENT’ approach. The major expenses associated with this type of maintenance management are: (i) high spare parts inventory cost, (ii) high overtime labor costs, (iii) high machine downtime, and (iv) low production availability

The net result of this reactive type of maintenance management is higher maintenance cost and lower availability of process machinery. Analysis of maintenance costs indicates that a repair performed in the reactive or run-to-failure mode will, on the average, be about three times higher than the same repair made within a scheduled or preventive mode

Summarily, some of the problems that hindered the choice of appropriate maintenance strategy in small scale production industries are : financial problems; inability to determine facility life cycle; poor spare parts management; underutilization and non-utilization of available resources; incompetent maintenance staff; irregularity in power supply (in developing countries) insufficient basic repair and maintenance equipment; ineffective work methods; poor organization, poor monitoring and control. Most factory downtime are caused by these above situations. There is no alert provided that looks at normal wear over time. If it were possible to monitor the normal wear, then it would be possible to forecast upcoming situations and perform maintenance tasks before breakdown occurs.

Today, with industry so focused on the bottom line, the cost of downtime has a big impact on profitability. If equipment starts to wear, it is possible to start producing parts with unacceptable quality and not know it for a long time. Eventually, machine wear will seriously affect not only productivity but also product quality

E MAINTENANCE STRATEGY

E-maintenance is an emerging concept generally defined as “a maintenance management concept whereby assets are monitored and managed over the Internet”. Further, “e-maintenance is defined as the part of maintenance support that ensures that the maintenance process is aligned with the operation and modification processes to obtain business objectives, through proper information logistics by information and communication technology (ICT) utilization .

The key constituent elements of e-Maintenance are the introduction of web-based and semantic maintenance technologies and tools, use of micro-electromechanical and wireless sensors, as well as asset self-identification technologies, E Maintenance) is a maintenance strategy that manages equipment to, reduce constant breakdown and improve machine uptime for maximum productivity. This involves monitoring of equipment status via a simple and secure connection, for excellent functionality .

Diagnostics can be performed remotely to monitor the status, workload and usage pattern for each device. This allows authorized partners to gather the necessary information for planning and servicing the equipment when required. This type of maintenance detects when a critical technical fault occurs, or when any devices is not performing up to standard, so timely support can be swiftly arranged. Resulting in the equipment being kept in tip-top condition to maximise up time. The widespread concept of e-maintenance refers to the integration of information and communication technologies to meet needs for supporting maintenance strategies and plans. With the aid of wireless and Internet technologies, any manager, operator, or expert is capable of remotely linking to a company's equipment for data collection diagnosis and, perform adequate monitoring of such equipment . Consequently, the lack of manpower problem can be solved**.** This process has almost unlimited potential to reduce the complexity of traditional maintenance guidance through online guidance based on the results of decision making and analysis of product condition give main capabilities for implementing e maintenance and its relationship within the noted industries. The required capabilities are, namely, digital technology development, organizational development, change of work routines, compliance with regulations, and assuring information security (Niklas et al., 2019).

The key benefit brought in by e-Maintenance is that maintenance information and access to related services can become ubiquitous and transparently available across the maintenance operations chain. This in turn enables stakeholders to take critical decisions related to maintenance in the light of the most relevant knowledge, information and evidence, which are transparently shared across them. E-Maintenance enables the development of self-aware and self-serving assets equipped with sensing and condition monitoring capabilities. Thus assets become aware of their condition and actively influence maintenance decision making and planning (Emmanouilidis and Pistofidi, 2010).

Even re-distribution of the number of sensor modules among the wireless network’s subgroups (each dedicated to one monitored equipment), offers self-calibration potential for the network deployment and topology. The flexibility and versatility offered by wireless technologies enable an increased level of self-awareness about the state of individual machines to be attained. In doing so, they pave the way to a more widespread implementation of condition-based maintenance (CBM) practices.

DIGITALIZATION OF SMALL SCALE PRODUCTION THROUGH E MAINTENANCE

While there is much hype, little research has been conducted that informs companies about how to profitably integrate the internet of things (IoT) with strategic or operational processes. This paper views the internet of things (IoT) through the lens of predictive maintenance -- the use of real-time data and predictive analytics algorithms to dynamically manage preventive maintenance policies. These are being used by numerous manufacturing organizations to transition from product-oriented to service-oriented business models. In particular, we analyze optimal preventive maintenance policies in an environment where equipment is subject to a deterioration, which shifts it from its initial, fully-productive state, having a specified, age-dependent failure rate to a less-productive or deteriorated state.

. On the other hand, the systems are also part in the digital world – described by data and information (“cyber”). These systems are further characterized by intelligent control, information and communication devices which are used to

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 6 June 2022, pp: 1225-1234 www.ijaem.net ISSN: 2395-5252

recognize and influence the system's environment. Thus, they are able to communicate and cooperate autonomously with other systems and humans.

Physical things (e.g., devices, containers or tools) are directly connected to the internet as well as other things and humans by using information and communication technologies (e.g., embedded systems). The humans become part of th.is information network with the help of mobile devices (e.g. as smartphone or smart watch). Building on that, new services for users or customers can be applied (e.g., online order by touch of a button).'

Interdisciplinary competencies are required to understand how new approaches and technologies can be used efficiently for the own processes. Therefore, the three dimensions human, technology and organization have to be considered in a holistic way for the successful digital transformation. e-maintenance integrates existing tele-maintenance principles, with Web services and modern e-collaboration principles

Moreover, condition based maintenance (CBM) was discussed as a relevant aspect of e-maintenance and intelligent maintenance, and the evidence that predictive maintenance and its application in machine health prognosis are becoming very popular. Several tools and technologies including Condition Based Maintenance (CBM),) and recently e-maintenance have developed .. However, the adoption of those modern maintenance strategies and their potential benefits are mostly applied in large organizations. Unfortunately, the majority of small scale production industries are constrained by the lack of knowledge and understanding on the requirements, which need to be in place before adopting any other maintenance strategy.

E maintenance enables more efficient and better maintenance work, as it can reduce remedial maintenance, which in turn leads to reduced costs, as unexpected errors can result in increased downtime. Preventive maintenance, in which parts are changed per time intervals and thus creating risks when changing functional units, can be reduced by the preventive maintenance being developed toward state-based maintenance, which enables e maintenance (Niklas et al., 2019).

In addition, Niklas Johansson et al. (2015) believed that, with e maintenance, the correct type of maintenance can be utilized and the frequency for device maintenance can be reduced through real-time diagnosis. This leads to reduced costs for companies that implement e maintenance as well as environmental benefits through improved resource utilization

THE DESIGNED LOW COST E-MAINTENANCE SYSTEM FOR SMALL SCALE PRODUCTION INDUSTIES

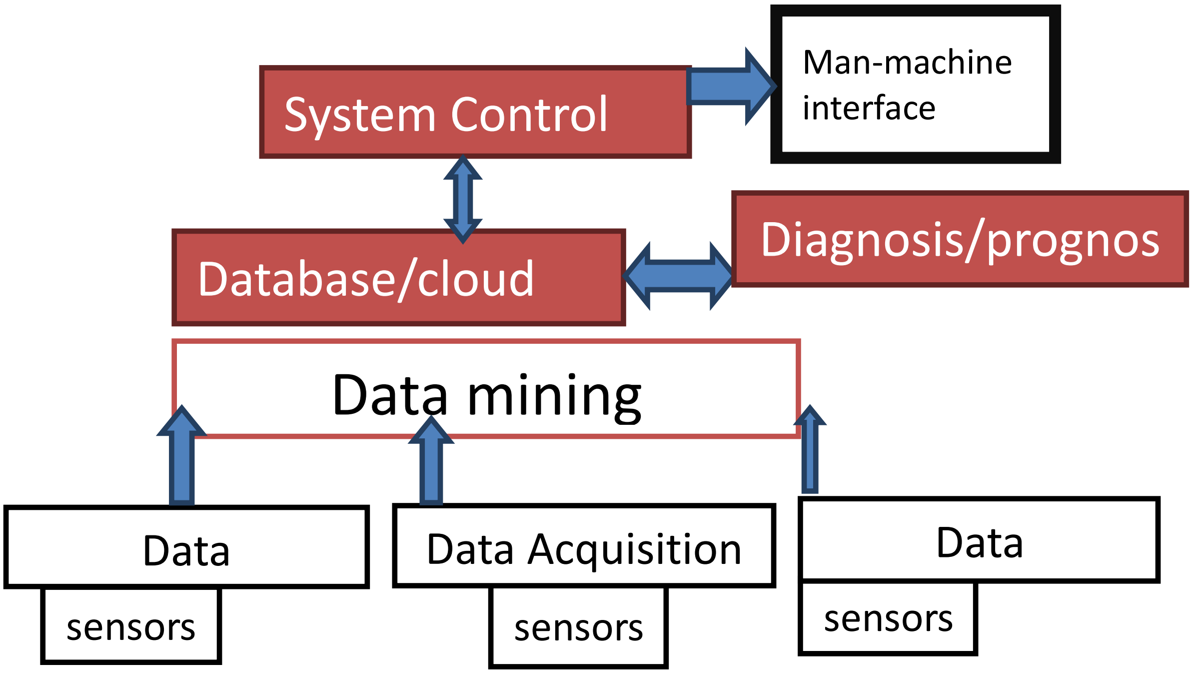
Small scale industries do not have time or resources and qualified staff, to develop complex ICT structures or to think about a digitalization strategy for the company. There is also skepticism about the word "Industry 4.0" and the benefits of it. Majority of the production industries still rely on outdated maintenance policies and focuses on an inefficient run to failure approach or statistical trend driven maintenance intervals

However, this paper reports the basic concepts, materials and methods used to develop Industry 4.0 architecture focused on e maintenance, while relying on low-cost principles to be affordable by small production industry. The focus of this work, therefore, is a low-cost, easy-to-develop cyber-physical system architecture that measures the temperature, the acoustic and vibration variables of a machining. This low cost e maintenance utilizes mobile devices coupled with software applications as tools to perform maintenance work in a more efficient, streamlined manner; in a paperless, cloud environment; and with statewide data reporting capabilities.

This system focuses on monitoring of critical parameters of small scale industrial machines to determine its current health level and predict future problems to be avoided beforehand. The low cost e maintenance uses direct monitoring of the mechanical condition, system efficiency, and other indicators to determine the actual loss of efficiency for each machine-train and system in the plant. This requires the use of wireless sensors of appropriate parametric needs of the machine to be measured. The sensors are to be embedded on specific part of the machine in the machine shop or work station. Type of wireless sensors technologies available includes, but is not limited to, the following nondestructive technique vibration analysis, infrared thermography; oil analysis and tribology; ultrasonic; motor current analysis; performance monitoring acoustic analysis and visual inspection. In order to obtain reliable information about the production object, sensors are installed in different parts of the machine to monitor its operation in real time. The data that these sensors send must then be consequently structured and properly labeled (Mercedes et al., 2021).

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 6 June 2022, pp: 1225-1234 www.ijaem.net ISSN: 2395-5252

LOW COST E MAINTENANCE: MODEL DESCRIPTION



The low cost e-maintenance system is based on automated data collection, supportability analysis, concurrent engineering, electronic data interchange and interactive electronic technical manual. For this low cost e maintenance system, three nondestructive techniques will be used: (1) vibration monitoring, (2) thermography, (3) acoustic level of each machine .

Each technique has a unique data set that will assist in determining the actual need for maintenance. Wireless sensor networks shall be deployed as flexible alternatives to wired instrumentation systems. Their ease of installation & operation, scalability and topological flexibility are their main advantages over wired solutions. All wireless sensors will connect to a transceiver module which has capacity for diagnosis analysis, prognosis analysis and predictive capability .The transceiver will be made to connect to an app on smart phone or computer wirelessly with the principle of internet of things. Appropriate data for ideal temperature ,vibration,and acoustic level of each machine will be taken . With the aid of machine learning (artificial intelligent) ,the mobile system will learn the ideal situation of those machines and process it .The result will be further processed to provide diagnosis and prognosis analysis of those machines to be monitored.

All the processes will be done remotely and in real-time if the system is implemented in a cloud service. The users can access the information from any device with an internet connection, making the system very versatile. Any of the following cloud services can be used; Microsoft Azure, Google Cloud or Oracle The information is analysed using big data technologies, and compared to information on earlier breakdowns. .Artificial intelligence (AI) is then able to draw on pattern recognition and algorithms to identify information, such as the time at which a component may fail. The system is constantly learning and its predictions become very accurate. This will assist in preventing downtime before they occur. Then, machines and humans are connected. This means, for example, that messages of failures are directly reported to the mobile devices of the personnel and actions are derived automatically.

Regular monitoring of the mechanical condition of the above machine-trains will ensure the maximum interval between repairs and minimize the number and cost of unscheduled outages created by machine-train failures. It is a means of improving productivity, product quality,

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and overall effectiveness of small scale production plants (feed mill). The system enables production operations to achieve near-zero-downtime performance on a sharable, quick and convenient platform. The integration of wireless and mobile technologies with web-based programming will enabled low cost e-maintenance system to support small scale production industries efficient operation, consequently reducing unnecessary maintenance and related costs.

SPECIAL TRANSCIEVER MODULE FOR E-MAINTENANCE SYSTEM

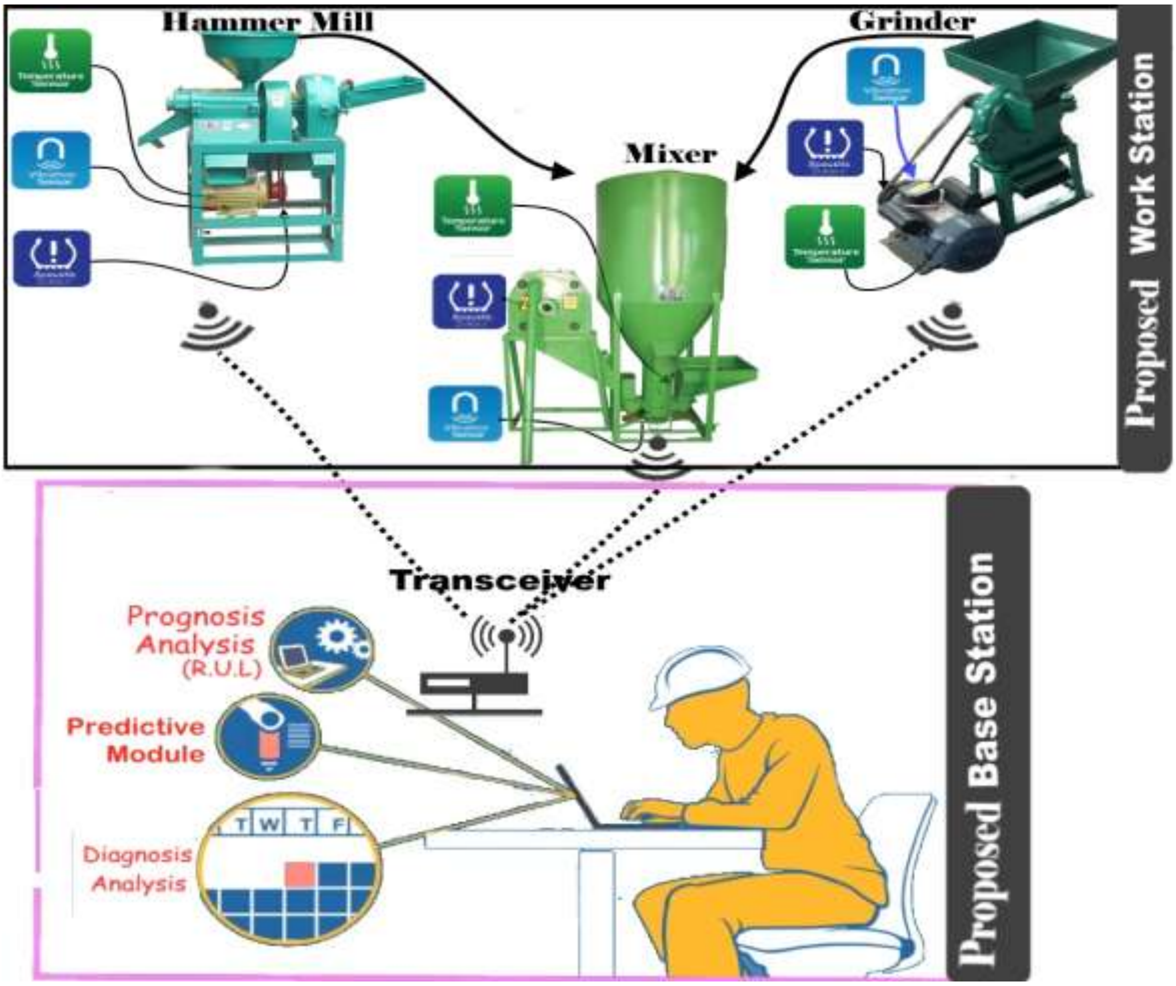
Transceiver module in this low cost e maintenance system serves as an intermediary equipment between wireless sensors and mobile devices (laptop, smart phones, I pad, or tablet) with the ability to receive and transmit signals. This transceiver will receive real time data from wireless sensors for processing, analysis and interpretation of related data .This will further transmit the result to mobile devices via internet or intranet.

WIRELESS SENSORS INTEGRATION

Sensors provide automated data collection, and are also the best source of reliable data. Data collection is the foundation of a good predictive maintenance strategy, which is another undeniable trend. Wireless sensor technology has been recognized as one of the emerging technologies of this century widely used for intelligent data sensing. A wireless sensor network is composed of several sensor nodes, where the main objective of a sensor node is to collect information from its surrounding environment and transmit it to appropriate equipment.

.The low cost e maintenance system will use wireless sensor networks that have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionalities. In wired systems, the installation of enough sensors is often limited by the cost of wiring**.**

APPLICATION OFTHE LOW COST E -MAINTENANCE SYSTEM FOR A SMALL SCALE FEED MILL



ADVANTAGES OF LOW COST E MAINTENANCE SYSTEM

With this low cost e maintenance, the correct type of maintenance can be available and the frequency for device maintenance can be reduced through real-time diagnosis. This will leads to reduced costs for companies that implement e maintenance as well as environmental benefits through improved resource utilization (Niklas et al., 2019). Low cost e maintenance service provision, are not limited to static solutions of wired infrastructures controlled by complex software. With the increasing penetration of wireless and smart phone technologies, data relevant to condition monitoring and equipment maintenance can become ubiquitously available to personnel, via mobile and handheld devices, or remotely via the internet by simply coupling to relevant maintenance services, offered by remote servers or by the asset monitoring infrastructure. . In this setting, it is possible to employ handheld devices, (smart phone,) as well as miniaturized sensor solutions within a more flexible and decentralized condition monitoring and maintenance management integrated environment. Small scale production industries will work with a simple device offering a limited but clear set of interaction interfaces to retrieve or enter maintenance data. Thus, the user is empowered to become a dynamic mobile actor, operating in a dynamic environment, carrying the capacity to perform maintenance tasks with the support of available supporting IT tools (Campos et al. 2009).
The main advantages brought by wireless sensors include:
(i) ease of installation:
sensor positioning is freed from the constraints of cabled installations and accessibility without worries about complex or even dangerous cabling, especially on moving parts;
(ii) simplified network design: dynamic topologies for fault tolerant networks allow redeployment, traffic rerouting and network robustness to deal with possible interference;
(iii) Scalable, large and yet maintainable infrastructures, as new nodes can easily be added to the network.

The mobile e maintenance provides services that can be delivered anywhere, any time and to anyone authorized to have access to, maintenance documentation, predictive health monitoring and maintenance planning services, Part of the processing will be undertaken by smart sensor solutions, delegating some of the condition monitoring tasks to the lowest possible processing level, the machine level. The developed solution will strike the right balance between local processing and information exchange between devices, implying trade-offs between energy efficiency, processing capacity and the quality of the maintenance decision support process
Smartphones, tablets and computers have become integral parts of this world. Home appliances like washing machines or coffee makers, which are connected to the internet and can be remotely controlled by a smartphone, are also well known. In the figurative sense, this kind of machines can be seen as so-called “cyber-physical systems” Egon M and Hendrik H (2017)

II. CONCLUSION AND RECOMMENDATIONS

Nigeria population is fast growing and technological advancement must also be growing in like manner, for this reason, production engineers and manufacturers are working round the clock seeking for technical ideas of maintenance to meet up with ever increasing demand of the populace. The maintenance of production machinery and equipment and assurance of availability of spare parts are becoming increasingly important. Maintenance management is a data-intensive activity. Maintenance forms an important aspect of human and non-human resources development as it is considered one of the major catalysts of the continuous existence of all forms of resources in the universe. With the increasing specialization and complexity of equipment and other facilities used in manufacturing, the need to develop effective e-maintenance systems in the industries had become imperative. E-maintenance is primarily carried out to sustain equipment and facilities as designed, in a safe, effective operating condition, ensure production targets are met economically and on time; prevent unexpected breakdown of machinery and equipment extend the useful like of equipment; and to ensure the safety of personnel using the system. The poor maintenance of these physical facilities accelerated deterioration and shortened their useful life. It is therefore recommended that e-maintenance culture should be the way of life small scale industries in developing nations as one of most important and effective methods of stimulating industrial development.

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