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Mechanical & Mechanics Engineering

Hydraulic Manner and Laws

Behavior of Industry Workers

Highlights

An Empirical Study Proposal

Home Automation using Raspberry PI

Discovering Thoughts, Inventing Future

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Mechanical and Mechanics Engineering

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An Empirical Study Proposal for Testing Operating Equipment Effectiveness with Reliability Indicators

By Carl D. Hays III

Abstract- In this empirical study we are proposing to conduct a longitudinal, quantitative research design on a population of machines to test Hays' (2022) theory that the Operating Equipment Effectiveness (OpEE®) score with a quality status indicator will increase productivity and reduce the associated cost of maintenance (CoM) through improving reliability (see Figure 1). In addition to this test, this paper will pursue answers to the research question whether firms using status indicator(s) will achieve more consistent and timely maintenance than firms using standard maintenance practices as measured by the established performance indicator OpEE®. The expected results will show that using a quality status indicator will significantly improve maintenance timeliness and consistency, which will improve overall productivity, and reduce the cost of maintenance. This study will provide a significant contribution to machine maintenance and productivity research by demonstrating a method to adopt quality status indicator(s) using sensors, the Internet of Things (IoT), and provide proactive maintenance strategies to optimize machine productivity in a variety of use cases and industries.

Keywords: *OpEE®, OEE, IoT, quality sensors, equipment maintenance, productivity.*

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I. Introduction

Machines with wheels and tracks operate in the field as (opposed to factories) and perform various types of jobs. The street sweeper's job for example, is to clear streets of debris using a spinning broom (see Figure 2). The street sweeper is considered productive when it is in operating in two modes. In the first mode, it is available to sweep streets, and sweeping streets. In the second mode it is available to sweep and traveling to a job site. OpEE® is an established productivity indicator that measures the performance of machines like this street sweeper when it is in the two example modes. These modes are measured by three variables, availability, work time, and non-idle time.

Availability indicates when and how often a machine can perform work over a period of time. Work time is a measure of what percent of time a machine was performing its job function. In the street sweeper example, this would be the percent of time the sweeper was clearing debris off streets. Non-idle time reflects the percentage of time the street sweeper was traveling to a job site to perform work. The street sweeper is considered unproductive when it is not available (due to service or being underutilized) and referred to as downtime or unscheduled downtime and often related to an issue with reliability (Chicheney et. al, 2022).

Chicheney et. al (2022) goes so far as to say, "insufficient reliability of machines…result not only in significant downtime of equipment but also increase their operational cost" (p. 866). To minimize downtime, machines, such as the street sweeper, require regular maintenance to perform the job that they were designed to do. Reliability, as Hays (2022) suggested, is a measure of how well we maintain our machines. The maintenance function is designed to optimize reliability and the associated cost of maintenance (CoM). The CoM refers to the operational cost of maintaining equipment. This expense includes replacing parts and fluids. This cost may be increased or decreased depending on how well machines are serviced and maintained including the frequency of maintenance.

While the maintenance function is critical to overall productivity, it is not typically managed with status and performance indicators to optimize it. A status indicator informs us when to service the machine. A performance indicator informs us how well we are managing the service and productivity of the machine. This lack of performance and status indicators, make it difficult to optimize decisions on increasing productivity and reliability. The research on the topic is likewise scant or focused on specific use cases without a theory and methodology that may be universalized. Furthermore, a measure for both productivity, and reliability is needed to compare how these machines perform over the course of their useful life. The research study in this paper suggests a method and design to test Hays' (2022) theory of using OpEE®, a measure of overall productivity, with quality status indicator(s), a measure of reliability, on a population of machines.

This paper is intended to provide a research design and methodology to test Hays' (2022) theory and is structured as follows: a literature review will be presented to provide a background for the research proposals, define the research problem and address relevant studies related to this maintenance and productivity issue. Furthermore, this review will present a research gap this study intends to bridge. The next

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section will present the study proposal, the hypotheses and their rationale. From the hypothesis a proposed methodology and research design will be presented. Next will be a discussion of the expected results, implications from the results, and recommendations for future research. The empirical study will end with a conclusion tying the elements of this paper together in a coherent narrative.

II. Literature Review

a) Background

Overall Equipment Effectiveness (OEE) has been one of the more important performance indicators in factories since its invention. OEE provided a useful measure of productivity and quality for plant managers to judge overall performance. Wegner (2022) presented a ranked list of the top 15 smart factory Key Performance Indicators that firms are focused on increasing and OEE was number one on this list. Because of the success of OEE as performance indicator in factories, several derivatives were developed to solve various problems in different industries. A possible way to view machine performance would be to consider them as mobile factories performing the job functions, they were designed for. In this light, OEE was a performance indicator that could be modified to fit machine applications in several industries.

OEE "was modified to solve gaps in various issues, such as sustainability, human factor, transport, manufacturing system, mining, cost, port and resources" (Lisbeth, 2020, p.1). One such derivative was Operating Equipment Effectiveness (OpEE®) developed and tested by Hays (2021) to measure overall productivity for lift trucks. OpEE® was not a perfect translation from OEE because the Quality indicator was removed, however OpEE® provided a better measure for productivity than the industry standard, which was utilization. To transfer OEE to machines, Hays (2021) had to sacrifice the quality indicator form OEE which measured the total number of good widgets produced per batch of 100. This was also referred to as a quality defect rate.

To address this gap with the OpEE® score Hays (2022) added a quality indicator focused on reliability. To implement Hays' (2021) conversion of OEE to the OpEE® score a Proof of Concept (PoC) was developed by Faehn (2022). Faehn, an application engineer at Applied Fluid Power, who provided the sensors, status logic, and used the Internet of Things (IoT) platform elevat-iot.com to develop the OpEE® status indicator. In addition to the OpEE® score, Faehn (2022) developed another quality indicator referred to as brush life indicator (BLI), (see Figure 3). The original theory presented by Hays (2022) suggested the quality indicator be a hydraulic fluid contamination sensor (HCI) made by Tan Delta, (see Figure 4). The Tan Delta sensor monitors the condition of hydraulic fluid and was the primary quality status indicator proposed by Hays (2022).

Faehn did not use the Tan Delta sensor, but rather applied the OpEE® score with a different quality indicator on a machine designed to sweep debris off streets, (see Figure 1). This proof of concept (PoC) made some key changes to the OpEE® formula, which provided both leading and lagging indicators, (see Figure 3). As a leading indicator, the OpEE® score would provide performance productivity up to the last operating event, allowing managers to determine how well each machine had performed over time because the score was cumulative. Faehn (2022) modified the score to allow for a rolling 24-hour update. This modification provided day-to-day data, or a lagging indicator, to determine how the machine was trending over time.

In addition to modifying the OpEE® formula, Faehn added a quality indicator, which provided the remaining useful life of the broom, referred to as the 'core,' used to sweep the streets. The quality score, ranging from 0-100%, provides a status indicator, much like the fluid condition indicator, for when each core needs to be serviced, (see Figure 5). The sweeper must maintain a specific amount of pressure on the core to move material. This pressure causes the core container to move closer to the pavement as the whisker length changes.

When the machine reaches the caution status, this indicates to the service manager that the core needs to be scheduled for replacement. Having this service indicator would allow managers to schedule core changes during downtime rather than when the machine is sweeping streets. Timely core maintenance would eliminate the use of cores that were past their maintenance due date and when they are least effective at sweeping streets due to poor whisker length, and or could cause damage to the street sweeper. For both hydraulic fluid and cores, changing them too early costs more money because a higher quantity of both must be replaced. Changing them too late, may reduce the overall replacement expense, but it can lead to carrier damage in the case of the core, and component wear and tear in the case of hydraulic fluid. The key to enhancing productivity and reducing the cost of maintenance, is optimizing the maintenance function.

b) Research Problem

Standard methods for monitoring the reliability of machines are inadequate for predicting and preventing failure. Failure leads to reactive maintenance strategies requiring costly unplanned downtime to replace and repair parts and fluids. Downtime effects the overall productivity of machines because the machine is not available to perform work. How does the research suggest that we address this problem?

Because OpEE® is a relatively new concept, the focus of this review will be on how OEE because addresses the downtime problem as it is a well-established metric. Hays (2021) provided the research and analysis transferring OEE to OpEE® establishing that insights from research on OEE will translate to OpEE®.

In an empirical study of material handling systems using OEE as a measure of efficiency, Yazdi et. al (2018) found that to improve the performance of a system it is important to identify the problems that limit overall efficiency. To evaluate the systems' performance, Yazdi et. al (2018) suggested that focusing on the "sources of productivity," resources can be applied to improve performance (p. 1). The Yazdi (2018) study recommended testing the manufacturing system utilizing sensors and algorithms to identify areas of improvement and evaluate performance over a time series. The sensors would provide the specific data to evaluate performance, and the time series provided a period to evaluate the effects of the research proposal. The benefits of improving OEE are increasing productivity, reducing cost, providing awareness, and extending the useful life of equipment (Yazdi et. al, 2018). These benefits were similarly expected from applying the Hays (2022) theory to mobile factories.

Garza-Reyes' review provided a survey of OEE studies, summarizing OEE as a measurement of performance used in industries to monitor productivity and drive improvements to process and performance (2015). Garza-Reyes identified limitations to OEE, noticing that it does not do an adequate job of "sub-optimization" for each machine or provide an approach to defining performance targets and does not incorporate strategies for a more balanced review of these systems (p. 507). This limitation could be that the quality variable in OEE is focused on the defect rate of the parts being produced but not necessarily on components that could lead to the failure of equipment. This issue, identified by Garza-Reyes, with OEE creates a gap between *what* OEE is used for, a measure of overall productivity, and *how* to improve the system using the OEE score. Hays (2022) theory seeks to close this gap with mobile factories by focusing on the quality indicator as a measure of equipment reliability and not just an indicator of performance quality. This is accomplished through using sensors to monitor key and individual components or the "sources of productivity" as identified by Yazdi (2018) in addition to incorporating reliability sensors that are applicable to each individual machine as suggested by Garza-Reyes (2015).

c) Machine Maintenance

The function of maintenance is to optimize the reliability of machines and equipment to meet the needs of the business and companies that own and operate them (Smith & Mobley, 2022). Smith and Mobley (2022) discuss two maintenance approaches to servicing machines and equipment - reactive and proactive maintenance both of which require some form of predictive process to determine machine status. "The common premise of predictive maintenance is that regular monitoring of the actual crafts condition, operating efficiency, and other indicators of operating condition of machine trains and process systems provides the data required to ensure the maximum interval between repairs and minimize the number and cost of unscheduled outages created by machine train failures" (Smith & Mobley, 2022, p. 47).

The reactive maintenance approach responds to the situation where a part requires service. The measure of success is based on the response time to meeting this request. Proactive maintenance on the other hand, responds to predictive data gathered by procedures (Smith & Mobley, 2022). Predictive procedures are most commonly visual inspections where a person checks on the status of equipment following maintenance procedures outlined in the operator's manual. When an issue is identified, maintenance reacts to a request for service.

The goal of both predictive and reactive maintenance is to minimize downtime; however, this begs the question as to what the best path is to provide regular monitoring of the "actual crafts condition" (Smith & Mobley, 2022, p. 47).

d) Performance Indicators

The concept of performance indicators has been applied to innumerable use cases from sports to finance, from business to factories, from machines to people, and even to animals. The basis for using a performance indicator is to understand and quantify how systems operate. There are two types of performance indicators- leading and lagging indicators. Leading indicators indicate trends and *lead* to results. Lagging indicators are a measure of performance. "We use leading indicators to manage a part of the business, while lagging indicators measure how well we have managed" (Smith & Mobley, 2022, p. 89).

With this knowledge, new and interesting options are available to determine *what* to do with this information, which often leads to the innovation of *how* to do it. Hays (2021) determined that a new performance indicator was needed to measure the productivity of machines with wheels and tracks. Hays (2021) determined that Overall Equipment Effectiveness had been successfully used and established in manufacturing. In order to transfer OEE to machines technological advances were required.

While Hays (2021) had determined *what* would be a useful invention, the *how* involved new technology including but not limited to: an IoT application, which connected a population of machines to a time series database; a hardware and software application that collected the necessary data and transformed it using

mathematical equations into the variables Hays (2021) used to derive the OpEE® score; the right sensors to interpret and collect the data from the machines that would be used in the formula. With these ingredients, it was possible for Hays (2021) to develop and transfer the OEE score to machines operating anywhere in the world.

After developing the OpEE® score, new sensor cost effective sensor technologies were incorporated to provide a more complete theory for the OpEE® score (Hays, 2022). This theory provided both a productivity indicator in the OpEE® score, and a reliability indicator measuring hydraulic oil contaminations levels which directly correlate to equipment reliability (Hays, 2022). The sensor used for this theory was made by Tan Delta and designed to detect contamination levels in hydraulic oil. The Tan Delta sensor was unique in that it was incorporated into the hydraulic oil system on the machine referred to as an *inline* sensor. Typically, hydraulic oil contamination is determined by connecting a machine to the hydraulic system, or an oil sample is sent to a lab, to determine particulate levels of contaminants within the scope of analysis. Adding this inline sensor to the machine allowed for a real-time, dashboard view of both productivity and reliability. This research proposal relies on the engineers developing new technology to manage and measure using sensors.

e) Digital Sensors

Sensors detect and transmit information that they are designed to monitor and measure. Digital sensors can do this through data, and when connected to an IoT platform. Iansiti and Lakhani (2014) wrote that digital sensors are increasingly replacing analog tasks typically performed by people. Michalski (2018) indicates that sensors have reached a level of industrial maturity that their primary focus must be on the "expectations" of end customers (p.2) or, in the context of this paper, to maximize productivity and reliability of machines. Sensors perform very important roles in monitoring performance because they provide access to the data used to produce OEE and OpEE® scores. For mobile factories, this data is gathered by sensors. These sensors are critical to capturing the data that can be transformed into meaningful data for use by managers.

Pararach et. al (2021) claims that IoT allows manufacturers' access to critical data produced by sensors. This data provides real-time values used to understand the working efficiencies measured by the OEE score. The empirical study performed by Pararach et al. provides a framework for how to develop a sensor-based IoT-connected solution to extract data from printing machines and connect them to the cloud. These time series data are then used to develop the OEE score. The OEE score is a performance benchmark "used at regular meetings to monitor and improve set up time (where) root cause analysis can be used to find out the actual cause of breakdown (p. 8). Both studies (Michalski, 2008; Pararach, 2021) discuss using IoT with key sensors to extract data and develop OEE scores that can be monitored and managed to improve performance. This empirical study proposes a very similar approach using IoT, sensors, and status indicators on mobile factories to monitor and manage the OpEE® score to improve productivity, reliability, and overall equipment performance.

f) Summary

There has been a lack of research on applying performance indicators to machines with wheels and tracks. Because of this, Hays (2021; 2022) transferred OEE to OpEE® in an empirical study and then proposed a new theory to add a quality status indicator to OpEE® to provide a better measure of both productivity and reliability. Current research on OEE suggests that the quality indicator lacks information as to *why* the value increases or decreases which is likely due to a source that affects production. This gap in the research literature may be covered by this empirical study seeking to test Hays' (2022) theory and what other status indicators could be used. For this study, the first status indicator will be the Hydraulic Fluid Indicator (HCI), the second is the Brush Life Indicator (BLI), and the third will be Visual Inspections (VI) of equipment using a tape measure.

III. Study Proposal

This study intends to determine how status indicators could be used with the OpEE® score to increase productivity and its associated costs related to the maintenance function. The purpose of this quantitative study will be to determine what relationships are found within the time series data from the front broom sweepers using the Operating Equipment Effectiveness (OpEE®) score and status indicators measuring the brush life of the sweeper core, and the fluid condition of the hydraulic oil. The results may show that the population of machines using the OpEE® score and following the status indicator predictive maintenance recommendations will have a significant impact on machine availability and work time. Machine data will also be analyzed to determine whether the status indicators provide for a more consistent replacement with the treatment population versus the control population without the status indicators.

A concept map of the hypotheses to be tested versus the control is provided (see Figure 6). In an ideal world, a part is repaired or replaced at the right time, in the right place, and at the best cost. Adding a quality status indicator to the OpEE® score would optimize the time to replace the component. When a part fails without advanced notice, this could occur in the middle of performing its work function, which would require the machine to be taken out of service and delivered to a

service location for repair. This service event impacts both the availability and work time of each machine. When a machine is taken out of service, it is not available to work for the time it is being repaired.

When a machine is not available to work, there is a reduction in both its availability score and its work time score. Availability is the percentage of time in a calendar year the machine is capable of performing work. The work time score is the percentage of time that a machine is performing its actual function such as sweeping streets. This is also referred to as productive time. These two variables can be difficult to optimize without advanced notice on when a part is going to need repair. Predictive data leading to proactive maintenance would provide the advanced notice required to optimize maintenance, which in turn affects availability and work time.

Adding a status indicator that provides advance notice of when a core part needs to be serviced would allow for better scheduling of the machine for service, or proactive rather than reactive. The machine could then be scheduled for maintenance on planned downtime rather than to take out of service when performing work. This proactive maintenance would optimize both the availability and work time variables in the OpEE® score. The anticipated results are that the following hypotheses will be supported by data collected and analyzed.

The information that this study intends to provide is the actual fleet availability of the equipment to perform work, the utilization of the equipment during operation, and the remaining life of the core over time. By having this information available to them, a fleet manager will be able to optimize operational decisions. This study does not aim to provide a qualitative analysis of the scaled solution, but rather to configure and deploy the application so that a future study may be conducted to determine its value to fleet managers.

Operational decisions will be enhanced through the availability indicator by informing fleet managers how often the machine is being used during a calendar year. The utilization indicator will inform fleet managers as to the rate of productivity the machine is performing when it is being used. The BLI will provide information on when a machine needs to be scheduled for service when the core bristle length reaches the minimum acceptable length for service. The objective of this study is to scale the PoC and present it on an IoT platform so that a further qualitative study can be done with fleet managers. The research questions that this paper intends to explore is whether firms (or managers) by adding status indicator(s) will increase timely and consistent maintenance over firms using a standard maintenance approach as measured by the OpEE® score. The status indicators proposed to be tested are the brush life indicator (BLI), Hydraulic Condition Indicator (HCI), Dashboard Indicator (tachometer), and Visual Inspection. The following is an analysis of each hypothesis and what results are expected form the study.

IV. Hypotheses

a) Brush Life Indicator versus Visual Inspection

The first proposed hypothesis is to determine what relationship there is between the BLI status indicator and core maintenance. The optimum whisker length for a core change is 10.25". If the core is too late (when the whiskers are shorter than 10.25") or too early (when the whiskers are longer than 10.25") this could impact overall productivity, and the CoM. This study will likely show that adding the BLI indicator to the maintenance function will significantly improve the consistency of the core change at the 10.25" marker, and result in a more timely and proactive maintenance function to replace the core. This real-time status indicator will allow fleet managers to optimize maintenance scheduling to improve operations. Standard practice for core replacement requires visual inspection and typically a physical measurement of the whisker length. This practice can be unreliable, inconsistent, and imprecise when distributed through a population of machines.

The standard maintenance practice could result in replacing the core too early or too late. Replacing the core too early results in more cores being used during a calendar year resulting in higher CoM. Replacing the core too late could result in damage to the machine system operating the core due to its distance from the pavement during operations, which is based on whisker length. The closer the core is to the ground the greater the risk for damage. Monitoring whisker length using the BLI indicator may significantly improve overall cost of core replacement and limit unnecessary damage to the machine while also improving the quality of the work being performed.

Furthermore, when a machine is damaged it is taken out of operation for repair. This repair requires unplanned downtime and results in lost productivity. Lost productivity would be accounted for with the OpEE® score which measures machine availability. When a machine is being serviced it is not available to work. To optimize CoM, the best case would be to change the core at the right time, and in the right place. The right time is when the whisker length reaches 10.25". The right place is a planned service event at the maintenance shop rather than in the field. If machines are being serviced based on inconsistent visual inspections, or damaged because the whisker length is too short, or the core is replaced to early, this will be more costly to the firm. Additionally, unplanned downtime will result in lost productivity.

Hypothesis 1: Firms (or managers) using the BLI will result in more consistent and timely core maintenance which will increase overall productivity and reduce CoM versus companies that do not.

b) *Hydraulic Fluid Condition Indicator versus Visual Inspection*

The anticipated results from this study will likely indicate that there is a significant difference in timeliness for hydraulic fluid changes. Machine using the HCI indicator will provide more consistent and timely maintenance than machines not using the HCI indicator. The standard process for servicing equipment is based on visually inspecting the engine hour tachometer of each machine to determine where it is in its service journey and whether to replace the fluid. Some businesses may do this inspection daily weekly or monthly depending on overall seasonal or contract demand for services.

This approach will likely result in inconsistent maintenance functionality under best case. Under worst case, the approach could result in machines operating with significantly contaminated hydraulic fluid, causing additional and preventable wear and tear to components, requiring lubrication. Monitoring and managing the hydraulic oil service function using a real-time, fluid condition indicator will likely, and significantly, outperform standard maintenance practices.

As with the BLI, timeliness of maintenance matters to the overall CoM. Changing hydraulic fluid too early results in an increase to the CoM because more fluid is being used to lubricate parts in a calendar year than necessary. Changing too late, as mentioned, can result in premature failure of parts due to wear and tear. Premature failure may also result in unplanned downtime requiring service to repair or replace components. This service event will impact productivity because the machine will not be available to work and thus reflected in the OpEE® Score.

Hypothesis 2: Firms (or managers) using the HCI will result in more consistent and timely hydraulic fluid maintenance which will increase overall productivity and reduce CoM versus companies that do not.

c) *BLI and HCI versus Visual Inspection*

Because the HCI indicator monitors hydraulic fluid condition, and the BLI indicator monitors core status, having both status indicators on the same machine will improve productivity and reduce CoM more than either one is on its own. Managing fluid health in a more timely and consistent maintenance function preserves the life of components in the hydraulic system that requires lubrication and could result in a longer, more productive life.

We would expect to see issues with hydraulic fluid contamination increase wear and tear on parts and components. This wear and tear over time will express as component failure. Component failure leads to both preventable and unplanned downtime for maintenance. This downtime is preventable because the proper maintenance of hydraulic fluid based on contamination will result in more timely replacement. This downtime is more costly because it results in replacing parts earlier than necessary due to increased wear and tear. On the alternative, if the hydraulic fluid is replaced too early, this results in unnecessary increases in the CoM. Replacing hydraulic fluid before it is required may result in better maintained hydraulic system, however it increases the CoM because due to an increased frequency of service. This is also true for the core and brush life indicator.

Monitoring the whisker length of the core results in more timely replacement of each core resulting in either less costly overall use of the machine by preventing premature core replacement, or less quality work and potential machine damage by preventing late core replacement. Using both together may significantly improve the useful life of the machine so that it will work more hours with the optimization of the hours worked being affected by the BLI.

Hypothesis 3: Firms (or managers) using the BLI and the HCI, will result in more consistent and timely hydraulic fluid maintenance which will increase overall productivity and reduce CoM versus companies that do not.

V. Methodology

The focus of this research will be on using a quantitative experiment to explore and validate the hypotheses. This empirical study proposes to use longitudinal, time series study. These data will be acquired from a cellular-enabled device connected to the machines that can be transmitted to the elevat-iot cloud. The population of machines will be spread out in regions, providing diversity for field testing. When the data has been collected by the cloud platform it will be exported to Microsoft Excel for analysis. The focus of the interpretation and analysis will be to determine how close to the target replacement status machines were serviced, referred to as the delta and expressed as a percentage. In addition to the maintenance delta, OpEE® score, and CoM comparisons will be made between the treatment and control group.

VI. Research Design

a) *Quantitative Method*

Yazdi et. al (2018) provided an excellent approach to studying the relationship between a performance indicator as a measure for a system over time period. Their study proposed to measure OEE using a time study on manufacturing production line. A time study monitors and measures the instruments to determine how they are individually performing with OEE being the measure for overall quality and productivity (Yazdi et al, 2018). With this understanding of

performance, an evaluation of the overall system can be made (Yazdi, et. al, 2018). Measuring a complex system requires a software application to record events and provide a report of the events and activities. These reports can then be analyzed using mathematical or statistical models to determine productive versus wasted time (Yazdi et. al, 2018). Yazdi's study incorporated devices that were used to collect performance data, and then the effect on time was studied to determine overall performance as measured by OEE. Using this methodology, a similar approach is recommended for this study.

This research will evaluate the OpEE® score on a population of machines with the appropriate status indicator(s) measuring and monitoring event data over a time series. Each machine will a hardware and software kit installed on each machine to collect the data and connect to the elevat-iot platform. The elevat-iot platform will record the detailed event data required to analyze performance. Each kit will have an elevat-iot approved IoT Gateway with Cellular SIM card. The elevat-iot gateway will connects to the and transmit data through the AT&T cellular network. Each machine will have a computer controller which contains the software programming and logic required collect the sensor data and calculate the OpEE® score and BLI and HCI indicator logic. The BLI status indicator connects to an arm angle and pressure sensor. HFI indicator connects to a Tan Delta fluid condition sensor. These sensors transmit data to the elevat platform through the IoT gateway.

Once the machines are set up correctly and are connected to the elevat-iot platform the data will be collected over a 6 month period. The elevat platform has two different views that will be used by maintenance personnel. Each organization has dashboard indicators, (see figure 3 and figure 4), that provides an individual machine view in addition to a fleet view indicator, (see figure 7) providing an overview for all of the machines. The combination of these dashboard views provides maintenance personnel with status indicators to schedule maintenance for each machine. At the end of the 6 month collection period a time series data set will be exported for statistical analysis to determine the OpEE® score and the maintenance delta for each service event. This statistical analysis will present the differences between productivity and the CoM as defined in the experiment.

b) Productivity and Cost of Maintenance Measures

For this study, OpEE® will provide the productivity measure and CoM will be the measure for maintenance costs. For this research proposal, the OpEE® score has been modified from its original version in Hays (2021, 2022). Availability will be a standalone percentage rather than multiplied to work time and non-idle time. This will allow for a direct comparison of machines on unscheduled and unscheduled downtime as discussed in the hypothesis sections. The OpEE® score will be based on the last 24 hours rather than an accumulating score over the 6 month period. This design will allow for a comparison of changes to the score every 24 hours rathe than the final score at the end of the period.

The first version of the OpEE® score, was designed as an accumulating score. This did not provide a very good lagging indicator. This version of the OpEE® score will provide a more useful measure for changes to availability, work time, and non-idle time which are the elements to measure productivity. These changes will not sacrifice the integrity of the original score as the performance objectives of measuring productivity over a times series will remain intact with this experiment. The overall score may be calculated from each daily interval, in addition to averages which were not possible with the original version of the OpEE® score.

The CoM will be calculated based on the number of changes for hydraulic fluid and core between treatment and control with respect to the target time to replace. When a machine is serviced too early, this results in an increase of service intervals. There is a cost associated with each service interval, to replace components, therefore increasing the frequency and increasing the CoM. On the alternative, servicing a machine after its due date can result in component damage and downtime.

For the BLI, the target time will be when the core has reached 10.25" where the IoT status indicator will indicate "replace" in the elevat platform. In the case of the HFI, the fluid will be replaced when the status reaches roughly 35% contamination and the IoT indicator status will be "replace." The method for analysis will be comparing the time stamp of when both the core and the hydraulic fluid return to a value of 100%. The time stamp will be expressed as a Universal Time Coordinated (UTC). At a value of 100% on the status indicator will mean the core and the hydraulic fluid have been replaced. This replacement UTC time will be compared to the UTC time and value of when the status indicated to replace them.

This comparison will result in a delta Δ score between the replacement UTC and the replaced UTC and expressed as a percentage. For example, if the status indicator for the core is at 63% and the core was replaced at 63%, the delta would be 63% - 63% or zero percent difference. If, on the other hand, the core reads 60%, and the core was changed at 60%, the delta would be 63% - 60% or a 3 percent delta. The greater the delta, the greater the difference between when the core status was "replace" and when the core was actually replaced. In the above example, the core was changed too late. If the core were changed too early, the delta would be

expressed as a negative number, for example, 63% - 70%. This would result in a delta of -7%.

Additionally, a count of total replacements can be made by analyzing how many replacement events occurred. A replacement event is when the core or hydraulic fluid drops below 100% and then returns to 100%. This drop and return indicate the core and fluid have been replaced. Counting and comparing these events between the control and treatment group will provide a difference in service events. Each service event will be assigned a cost for labor and materials. The cost of total events in labor and materials will be compared as the CoM for the treatment and control groups.

c) Treatment and Control

The research design will compare the % delta score of the treatment group to the control group, (see Figure 6). The treatment group will be comprised of Superior Broom machines and maintenance personnel. The maintenance personnel will be the mediating variable who are responsible for replacing the core and the hydraulic fluid, (see Table 1). The control group will use standard inspection practices of Ocular (Visual) and an Analog Sensor (Tape Measure). The control group of machines will be monitored with the same software and hardware devices as the treatment group e.g. they will have the BLI, HCI indicators and the OpEE® score logic. Maintenance personnel in the control group, however, will be instructed to follow standard practices for the core and hydraulic fluid maintenance. By having both the treatment and control group measured in the same way, this will allow for comparison of the maintenance practices on the population of machines.

The control group was chosen from a population of machines rather than comparing organizations to other organizations because the maintenance standards for each machine does not change based on the organization. The manufacturer sets the recommended maintenance interval, the recommended form of inspection, and the recommended course of action. What is important in this case is to determine whether any organization may benefit from using status indicators like the BLI or HCI to maintain their machines.

The treatment group will be required to use the BLI or the HCI status to change the core and/or hydraulic fluid. The treatment group will rely on the quality status indicator(s) which will result in timelier, consistent core and hydraulic fluid changes. Additionally, both the treatment and control group will have the OpEE® score to review changes in productivity. The expectation is this the control group will rely on VI to change the core which will result in inconsistent and potentially less timely core changes which will increase downtime. By reducing maintenance downtime overall productivity will be increased. The population of machines is to be determined including the research locations and control/treatment population.

VII. Expected Results

The expected results of this empirical study will inform us about the maintenance practices of the organizations studied. Through incorporating new status indicators that are accessible remotely, we anticipate that this will be used to improve maintenance scheduling, timeliness, and reduce overall downtime. Reducing overall downtime will increase productivity through making machines more available to work. We expect that the maintenance operation will be more proactive in determining when and where to schedule machines for maintenance. We expect the OpEE® score to show a difference between machines using the BLI and HCI indicators in both productivity and CoM. With the evidence that the HCI and BLI indicators provide for more optimized maintenance, increased productivity, and reduced CoM, we expect rapid adoption of this approach within the organizations participating in the study, and an increased willingness to attempt using the technology in organizations that are maintaining machines based on standard practices.

In addition to accelerated adoption, we expect firms to invent new status indicators based on sensors that can monitor the useful life of key components like hydraulic fluid and cores. We anticipate that this approach could be used in forestry where saw blades need to be replaced based on cutting effectiveness. We expect industries using conveyer belts to incorporate status indicators for ball bearings that are used to run the conveyer. We anticipate that new ways of thinking will be invented to determine how to measure the useful life of key components based on a 0-100% scale.

What are possible alternate outcomes? In an ideal world the maintenance function will follow the treatment recommendations and use the status indicators to plan and schedule maintenance. While this is the design intention, it is possible that maintenance does not adequately utilize the new indicators to perform its function. In this case, we would be able to determine if a population of machines in the treatment group behaved more like the control group, e.g. inconsistently in terms of maintenance timeliness. Another possible outcome could be that the status indicator is utilized but the scheduling and maintenance performance are not as efficient as necessary to perform the maintenance function. Because of the possibility of a poor effect, we will be seeking a statistically significant population of machines to account for non-performance in the treatment group.

VIII. Implications

a) Overall Impact and Significance

The implication of this study would be to suggest that a variety of quality sensors across industries could be used to increase reliability and overall machine productivity at an economical cost (because manufacturers cannot afford to put sensors on everything). Demonstrating the utility of this technology could greatly influence the adoption of cost-effective sensors and IoT to significantly improve fleet performance and profitability. Demonstrating that more than one type of quality indicator can be used with the OpEE® score could have tremendous impact on industries using machines and equipment.

This study could provide the roadmap for identifying a quality indicator such as a sensor and identify the conditions from 0-100% for the status indicator. These indicators will form the basis for component needs to be repaired or replaced allowing maintenance managers to use more consistent, timely, and proactive rather than reactive maintenance. Furthermore, this paper will suggest that the research conducted in this proposal will lay the foundation for applying machine learning to automate proactive maintenance and scheduling based on the scores to enable better scheduling, optimized performance, reducing operational cost and maximizing the return on assets.

b) Potential Impact on Business

Businesses seek to maximize return on investment (ROI). There are significant expenditures on the machines used to perform the work that businesses are either contracted or directly own the machines performing the work. To maintain these machines so that can perform the work they are designed for, businesses employ service and maintenance personnel. Measuring the work time of these machines translates to the overall productivity and ROI. Maintenance personnel are responsible for servicing the machines so they can perform the work they were designed for during their useful life. This begs the question, what is the best method to optimize this business operation?

Through adding sensors that monitor the key components required to perform work that indicate when a machine needs to be serviced, businesses will optimize the health, performance, and useful life of these machines and therefore maximize their ROI. On the contrary, not measuring the productivity or reliability of equipment performing work leaves maintenance at a disadvantage, with cumbersome, manual processes like visual inspections, to determine whether a machine requires maintenance. This lack of convenient data results in less timely maintenance and often disrupts the normal workflows while service reacts to a failure. It is in the business' best interest to enable maintenance to proactively service machines to maximize ROI through extending the useful life of the equipment and improving overall work time and reliability.

c) Potential Impact on Teaching and Instruction

This study will have significant implications for academic institutions and instructions. This study proposes that there are multiple sources for status indicators and provides the framework to evaluate those sources and construct a status indicator to significantly improve the maintenance function. With a logical methodology and clear roadmap to implement Hays' (2021; 2022) theories, educators may focus on *how* to design and implement this empirical proposal rather than determining both *what* needs to be done and *how* it could be performed. If the theories presented by Hays are adopted, it could provide new industry standards for academia to implement best practices in machine performance with a key performance indicator, OpEE®, to enable the overall measure of success.

As an industry standard, OpEE® with a status indicator could drive course materials to focus on sensors that could be used to develop additional status indicators. Numerous institutions could join and produce significant research efforts in applying Hays' theory to various applications including, but not limited to, forestry, construction, municipalities, oil and gas, agriculture, and even manufacturing. In this respect, this empirical study is simply a seed that can be planted in numerous institutions, researchers, students, and practitioners to produce significant forests all over the world.

IX. Future Research

This study proposes implementing Hays' (2022) theory, connecting it to an IoT platform to acquire, maintain, and analyze the sensor data. This effort may require a significant amount of labor to determine the results and whether the quality status indicators have a significant impact on the maintenance delta between when the core or hydraulic fluid should be replaced and when it is replaced. The results could be automated using machine learning to supervise and transform this data into descriptive views, removing the data analytics portion of the exercise (e.g. extract, transform, and evaluate).

Furthermore, machine learning could be designed to automate the maintenance scheduling function to improve overall response times. This study proposes to replace the current dashboard status indicator on the machine with a remote status indicator connected to an IoT platform. Both require monitoring and scheduling to be successful because people are still involved within the service chain. The serviced chain is an analogy of linking workflow steps together where step one is the machine requires service all the way to

the last step where the machine is serviced. Each step is a link in the chain. The less links in the chain the more efficient the service will be. One step is scheduling the maintenance. This step usually requires a person to do multiple actions that could be automated.

For example, this could be changing hydraulic fluid, or replacing the core. When the machine is ready for service e.g. they are near the "replace" status automation would be able to assess when a machine needs service. After assessing service status, the machine learning algorithm could access the maintenance calendar and select an open date, time, and location for service. The algorithm could then submit the appropriate work order to obtain the parts, and the facilities required to perform maintenance. This automation could have significant operational impacts related to scheduling machines and people, parts procurement, and inventory management, optimizing facility use, and reducing overall costs associated with the maintenance function.

X. Conclusion

This empirical study proposal sought to develop the method and justification for testing Hays' (2022) theory that Operating Equipment Effectiveness would be a more effective measure for productivity with a reliability indicator. Because OpEE® is a new theory there is very little research on its use, hence why this paper focused on the large body of work on OEE. Even the research on OEE from which the OpEE® score was transferred suggested OEE did not do an adequate job of monitoring sources that effect the overall score. Other research studies on OEE suggested adding sensors and software to monitor the system to make improvements. To address this, this study proposed the research questions focusing on what other kinds of sensors could be used to develop status indicators.

The implications of this study may impact businesses in maximizing their ROI, and academia by providing a reproduceable theory for new quality status indicator innovations, research, and studies to determine its effectiveness. To achieve the maximum return on this theory and technology, this paper proposed to automate the discovery of critical components that may be used as quality status indicators through the adoption of Artificial Intelligence referred to here as a Machine Learning algorithm. Using AI could enhance the research efforts. In addition to AI usefulness in research, the automation of the maintenance function could enhance service scheduling and mitigate the human impact on overall results because a service manager is still required to monitor the IoT platform and schedule machine maintenance. With this in mind, we conclude the future is bright for the adoption and implementation of OpEE® with a reliability indicator.

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Tables

Table 1: Hays (2022) theory vs. standard maintenance practice

Indicators	Theory HCI and BLI	Standard Maintenance Hydraulic Fluid	Standard Maintenance Brush Core
Sensor	Condition Measure	Engine Hours	Visual Inspection
Sensor Value	65%	1500	10.25”
Status Logic	Change	Change Fluid	Change Core
Status Indicator	IoT Gauge	Tachometer	Measuring Tape
Maintenance Response	Check IoT Gauge Change	Check Machine Tachometer Change Fluid	Check Measuring Tape Change Core

Note: HCI is the hydraulic condition indicator. BLI is the brush life indicator. A tachometer is the equivalent of an odometer however it tracks engine hours versus engine miles. Standard maintenance practice is based on the operator’s manual for the equipment. The value of 1500 engine hours is an example and could be an interval of every 500 hours.

Figures

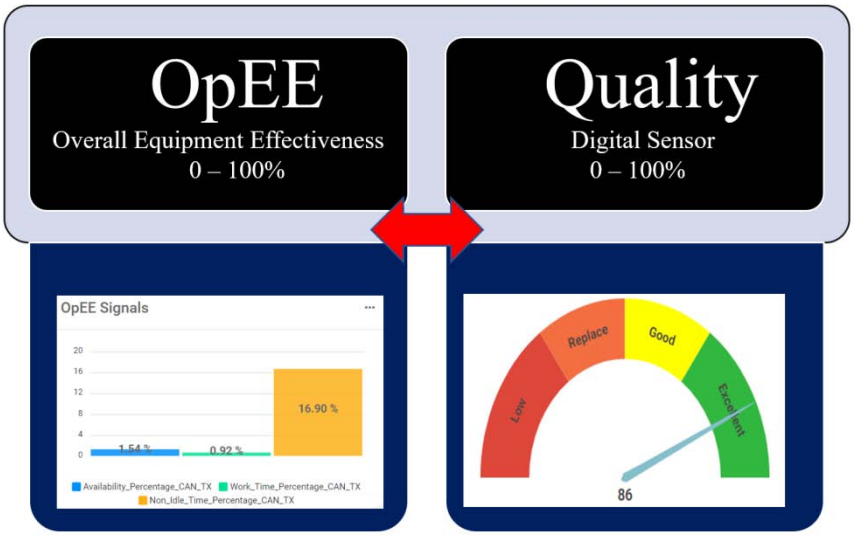

Figure 1: Hays (2022) theory OpEE® and a quality indicator

Figure 2: Front Broom Sweeper

Note: This broom sweeper's primary function is to sweep streets, performing this work when the broom is spinning. The blue broom is called the core. Core life is determined by the remaining length of the blue whiskers in the broom.

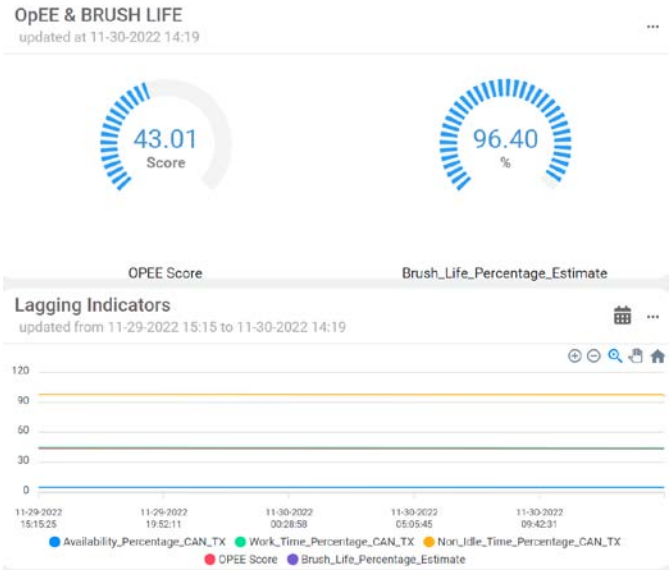

Figure 3: Application dashboard with the BLI, leading and lagging indicators

Note: This is a dashboard view on elevat-iot. The Brush_Life_Percentage_Estimate is referred to as the Brush Life Indicator (BLI) in this paper.

Figure 4: Tan Delta Hydraulic Condition Sensor

Note: This sensor is IoT-enabled, which allows for time series data and a status indicator gauge to inform maintenance when hydraulic fluid is out of specification due to condition deterioration.

Figure 5: New Core Whisker Length

Note: The new core whisker length is 16.25" radius. When the whisker length reduces to a 10.25" whisker length the core should be replaced.

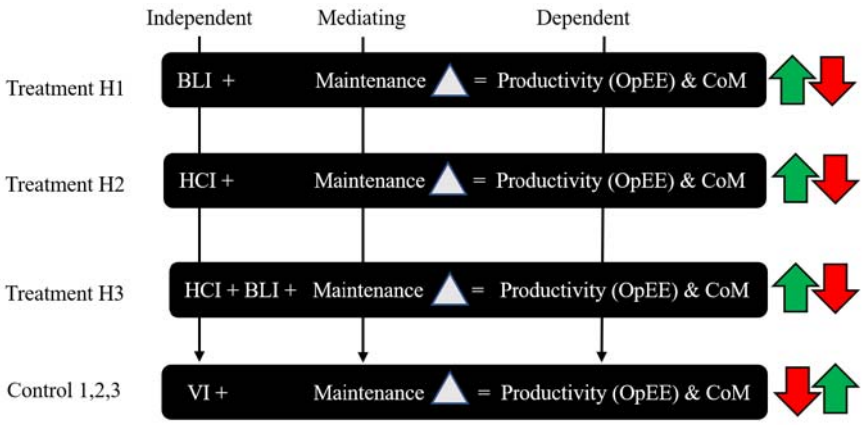

Figure 6: Research Concept Map

Note: BLI is the brush life indicator. HCI is the hydraulic condition indicator. Maintenance Δ is the time difference between when the part or fluid should be changed and when it was actually changed. Productivity is measured by the Operating Equipment Effectiveness score. CoM refers to the cost of maintenance, e.g. when a core or fluid is changed too early, on time, or too late.

Asset	OpEE	Availability	Work_Time	Non_Idle_Time	Indicator
920663	43.01	4.71%	44.10%	97.53%	96.40%
920664	18.96	5.15%	25.10%	75.53%	60.40%

Figure 7: OpEE® and Status Indicator Fleet View

Note: This spreadsheet view provides a comparison of equipment performance and remaining brush life.

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Evaluate the Behavior of Industry Workers Toward Safety and their Impacts in Environment

By Mustafa Eldoma Hassan, M. I. Shukri & Khalil. B. Ahmed. A
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Abstract- In this paper, evaluated the behavior of the workers in the industry toward safety, conducted among workers in workshops and factories in the Omdurman industrial area to identify and highlight the behaviors of workers toward occupational health and safety and their impacts on the environment. Data were collected through a questionnaire given to 58 workers, to explain the attitudes and practices of workers and tanker drivers were observed. Interviews were conducted with number of decision-makers in several departments concerned with the environmental impacts of industry. The workshops studied included welding, carpentry, car repairing, and disposal and restoring batteries. Related, hazards were identified and classified. The caught in or between things had the highest incidence, the machines were the primary cause of fractures, amputation, and wounds (17.2%, 15.5%, 24.2%, respectively). Equipment was leading the main cause of burn and contusive from the heat source (8.6%, 12.1%, respectively). Hazardous materials was the fundamental cause of poisonous from a chemical birth sources, coma, and death (13.8%, 6.9%, respectively).

Keywords: *safety, occupational health, worker, industry, unsafe acts, accident.*

GJRE-A Classification: *FOR Code: 091399*

Strictly as per the compliance and regulations of:

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I. Introduction

Sudan has witnessed industrialization since the mid-fifties, such as Soap and Oil, Printing, Soft Drink and sweet, cottage industries, and some utilities such as Railways, Water, and Electricity, etc. Spread in several geographical areas. Workers enrolled at that time were in the order of a few thousand. Legislation concerning worker's safety was first passed as envisaged in the workshops and factories ordinance 1949. Although occupational health (OCH) has been practiced since 1967, its functions were only stipulated after the Public Health Act passed in 1975. These stated establishment a section of OCH [1]. Small workplaces were not considered in safety policies. When a person walks through, he will immediately notice the lack of security, protection is a culture that must be built in all working in these workplaces [2]. The typical, standard physical hazard in most industries is heat, noise, ionizing radiation, and vibration [3]. Mechanical vibration produces a level of danger that affect the nerves, and noise exceeds the permissible level, leads to loss of hearing [4], and ergonomics are related to the space within the workshop building and layout the machine. The size of the workshop does not allow workers to assign separate places for raw materials and products. The passage between devices is so tiny to endanger the workers [5]. With rapid industrial development other minerals like asbestos, radioactive ore, oil and diesel which are also source of occupational disease [6]. The study conducted that the research is still in its infancy in Sudan, various researchers have examined the nature, source, and impacts of accident, injuries, and illnesses that severely comprises workers Health and safety [7].

a) Sample Data Manipulation

The data in this study was collected from the following personal information of the targeted people. As shown in figure 1, the sample was randomly selected from most of the education levels present in the study area, to compare the education level to knowledge. Clear successes indicator were given that confirmed the correct sample selection.

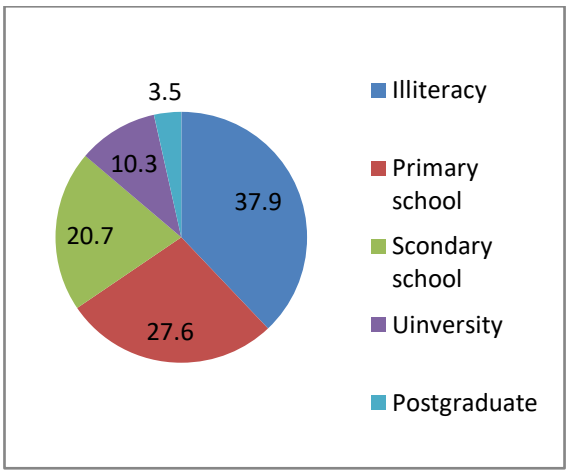

Figure 1: Education level

The type of job affects the safety behaviors of many workers. So the main occupations concerned with the conduct of workers towards occupational safety and health and their impact on the environment were chosen, as shown in figure 2.

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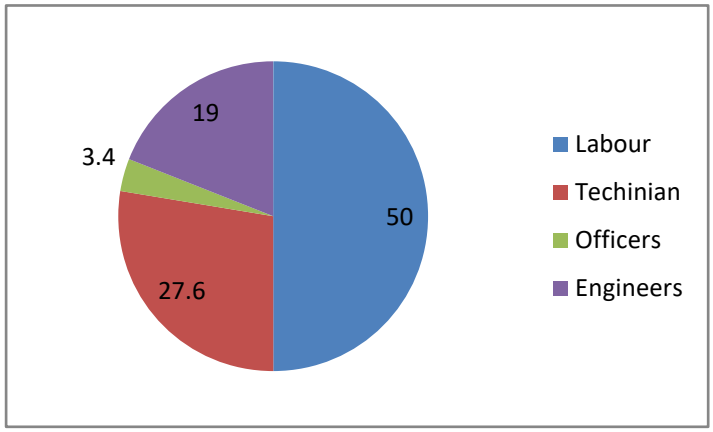

Figure 2: Respondents by job

The study area is characterized by age diversity. It has been observed that age has a direct impact on safety procedures, as in figure 3. Also, practical experiences affect occupational safety and health decisions, so multiple occasions were selected in this study, as shown in figure 4.

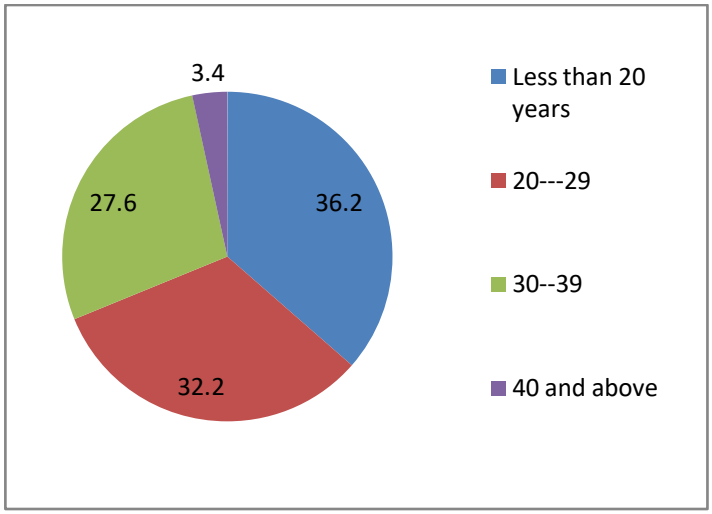

Figure 3: Respondents by age

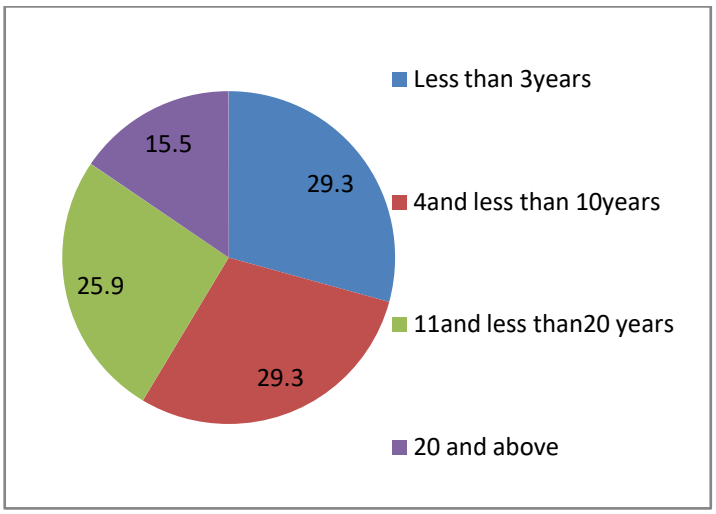

Figure 4: Respondents by experience

There are many industrial activities in the study area. Two types of activities were selected that have a hazardous on health in the surrounding residential areas, as in figures (5 and 6).

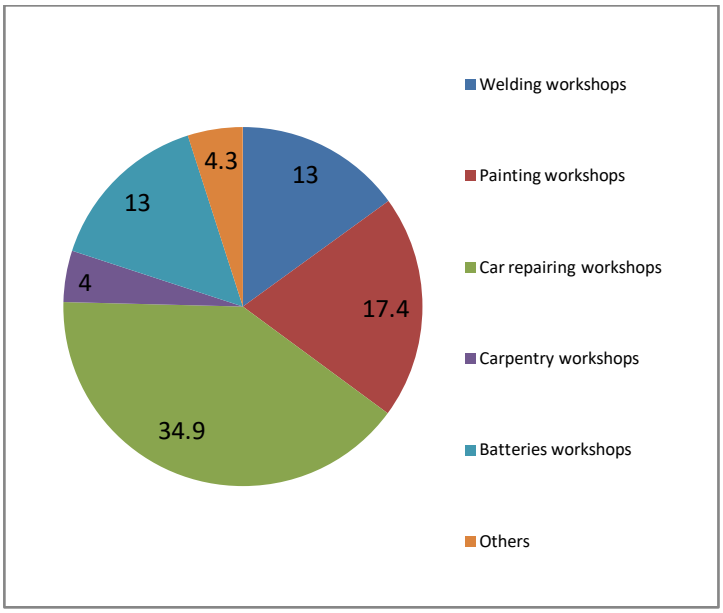

Figure 5: Types of workshops

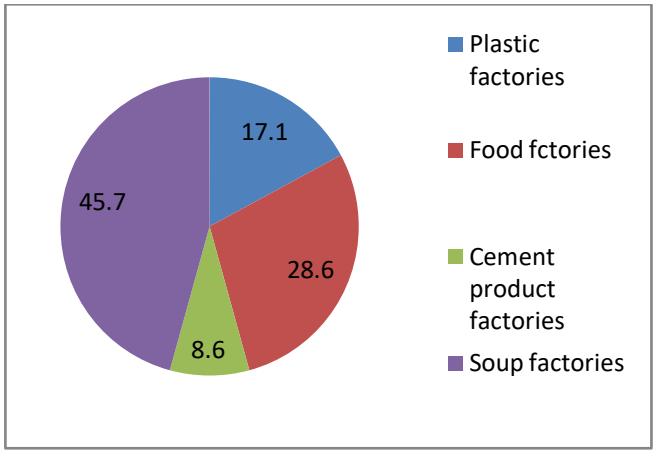

Figure 6: Types of factories

The leading causes of accidents in the study area were identified. The following figure determines the percentage of the causes of the accidents. So the most frequent causes of accidents, 48.3% of workers said unsafe behavior, and 27.6% said unsafe work and, 24.1% said personal reasons. This figure represents the accident analysis according to the hazardous workplace condition, dangerous acts, and unsafe individual factors, respectively. The dangerous workplace conditions included inadequate guard, unguarded hazards, defective safety devices, faulty or lack of tools or equipment, hazardous workstation layout, unsafe ventilation or lighting, lack of personal protective equipment (PPE), and flimsy clothing, and lack of or insufficient training in the engineering, industry.

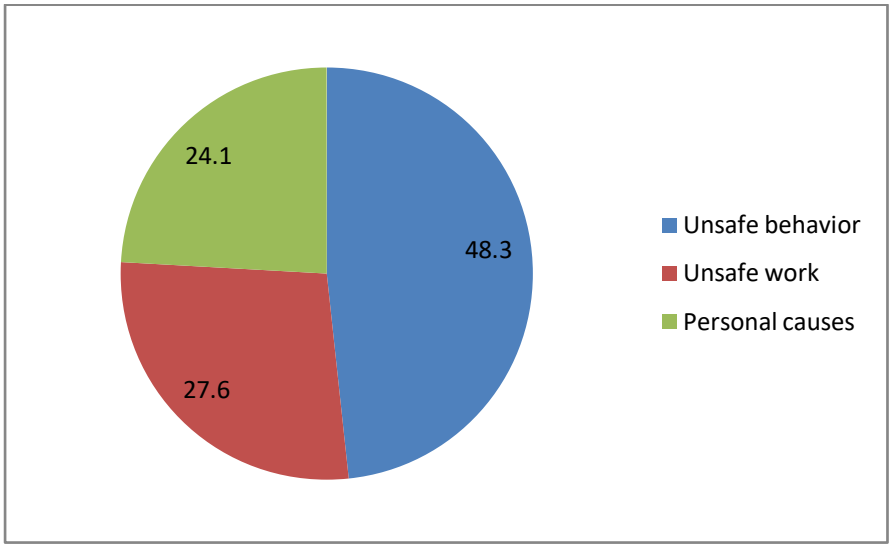

Figure 7: Causes of Accidents

II. Results

By analyzing the manipulated data, the leading causes of injuries were identified, as shown in the following tables.

Table 1: Personal causes

Personal causes	Number of people	Percentage %
Deliberate causes	0	0%
Polemical	17	29.3%
Fatigue	16	27.6%
Carelessness	20	30.5%
Other	5	8.6%
Total	58	100%

As show in table 1 the personal causes of work accidents, no deliberate causes, but 29.3% of personal reasons were polemical, 27.6% of the ground from fatigue, 30.5% carelessness, and 8.6% from other reasons.

Table 2: Technical cause

Technical causes	Number of people	Percentage %
Arrangement of machines	14	24.1%
Type of machine	15	25.9%
Tools	13	22.4%
Lack of maintenance	13	22.4%
Other	3	5.2%
Total	58	100%

Table 2 shows the technical causes that cause accidents 24.1% from the arrangement of the machine, 25.9% from the type of machines, 22.4% from tool, 22.4% from lack of maintenance, and 5.2% from other.

Table 3: Medical causes

Number of people	Percentage %	Medical cause
22	37.9%	Intensity of light
4	6.9%	Ventilation
5	8.6%	Noise
19	32.8%	Poisonous material
8	13.8%	Others
58	100%	Total

As shown in table 3, the accidents from medical causes were 37.9% from the poor levels of light, 6.9% from ventilation, 8.6% from noise, 32.8% from poisonous material, and 13.8% from other materials.

Table 4: Administrative causes

Administrative causes	Number of people	Percentage %
Lack of training	15	25.9%
Lack of follows	20	34.5%
Lack of awareness	8	13.8%
Lack of PPE	9	15.5%
Others	6	10.3%
Total	58	100%

Table 4 shows the accidents from the administrative causes 25.9% of casualties from lack of training, 34.5% of accidents from a lack of awareness but 15.5% from lack of PPE, and 10.3% from others.

Table 5: Most common injuries

Common injuries	Number of people	Percentage %
Fractures	10	17.2%
Amputation	9	15.5%
Death	1	1.7%
Poisonous	8	13.8%
Wounds	14	24.2%
Coma	4	6.9%
Burns	5	8.6%
Contusive	7	12.1%
Others	0	0%
Total	58	100%

Table 5 show the accident incidence rate of the different types of accident. The caught in or between things had the highest incidence. The table shows the distribution of accidence according to their causes; it, is clear from the table that machines were the primary cause of fractures, amputation, and wounds (17.2%, 15.5% and 24.2%, respectively). Equipment was the leading cause of burn and contusive from the heat source (8.6%, 12.1% respectively). Hazardous materials were the fundamental cause of poisonous from a chemical sources birth, coma, and death (13.8%, 6.9%, respectively).

III. Discussion

As indicated by the result, the majority of workers early, young in age and have low levels of education not reached primary school. When investigating their knowledge about hazards exposed from the jobs, the finding revealed that their perception towards such hazards was negatively associated with the magnitude of actual the real situations. This indicates that knowledge about the dangers, risk need high levels of education by which individuals can get, the difference between what kinds of risky work. On the other hand, the findings of the interview showed that although the decision-makers in safety are fully aware of the risk of hazards, they complained about the absence of collaborative work for managing these hazards due to neglecting this issue by the specialized authorities. The most frequent unsafe acts by workers were using defective equipment and failure to use perfect equipment, tools, especially in oil and soap. engineering and food industries. This might be due to the lack of regulation of occupational health and safety in Sudan. As regards unsafe personal factors, attitude had the highest percentage in all industrial this might be due to the bad psychological conditions, including, poor wages, critical incident and accidents were caused by combination of equipment and unsafe personal factors. Most researchers believed that unsafe personal factors were key agent for more than 70% of occupational accidents.

IV. Conclusions

The study reviewed health and safety. Results showed there is no system for safety and health management in Omdurman-Locality. There are no control or safety measures. There are some gaps in the knowledge of workers in safety and health. However, there is generally a positive attitude to improving industrial safety and health among those surveyed and interviewed. A national program for industrial safety management is essential in Sudan.

This work can be further extended by studying the impact of environmental pollution, and the effectiveness of safety procedures on productivity.

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Home Automation using Raspberry PI

By Syeda Jamala Fatima

Abstract- The home automation system based on the Raspberry Pi and Node MCU leverages house hold appliances and allows users to control them vi the internet from anywhere in the globe. It enables control and operation of appliances and gadgets in a house through communication between hardware and software. Home automation might lead to more effective and intelligent energy saving strategies. The main goal of this project is to build a home automation system using a Raspberry Pi and a Node MCU board, with the internet controlled by the Telegram application. With the Io idea, all household appliances and electrical equipment may be regulated automatically as well as manually via relay circuits.

GJRE-A Classification: DDC Code: 004.678 LCC Code: QA76.9.B45

Strictly as per the compliance and regulations of:

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I. Introduction

The internet-based functioning of physical devices (also known as "connected devices" and "smart gadgets"), buildings, and other items integrated with electronics, software, sensors, actuators, and network connectivity, allowing these objects to gather and share data, is referred to as the Internet of Things (IoT). Home automation is defined as the interconnection of physical things via sensors and software. Network connections are used to acquire and share data. Home automation refers to the automated and electronic control of household features, activities, and appliances. Home automation systems are becoming more popular as a way to control objects around the house. All forms of home equipment, including doors, lights, fans, electric heaters, surveillance systems, and consumer electronics, are included in the household automation system.

The goal of the home automation system is to automate the control of equipment and systems in the house by utilising existing technologies. This project shows a prototype of an intelligent home automation system that uses the Telegram application to operate household appliances, electrical equipment, and other devices from smart phones, computers, tablets, and other devices with an active internet connection. It will use relay circuits, Raspberry Pi, and Node MCU with the concept of IoT to turn on or off and operate household appliances and electrical equipment remotely as well as manually. Home automation offers a lot of promise for exchanging data among family members or trusted persons for personal security, and it might lead to energy-saving measures in the future. When one of these automated systems is used in a residential installation, it is referred to as a home automation system. All electrical and electronic equipment and devices are monitored and controlled via the Telegram application. The rest of the paper is laid out as follows: Section II examines some key aspects of related works, section IV elucidates the proposed methodology, section V presents experimental results, and section VI concludes with a discussion of future work.

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II. Literature Survey

In [1] The project development includes an Internet of Things-based secure home access solution. Using the Raspberry Pi controller, camera, and numerous other connected sensors, this presents a smart, creative, and secure access. The system is a synthesis of all previous work, for which an IR sensor is used to identify objects, which then triggers a camera for facial recognition. The technology is intended for secure remote access and control of household equipment.

In [2] A Smart Home Application with Wi-Fi module prototype and implementation are shown. As a Wi-Fi module, the ESP8266 is utilised. A hardware interface and a software interface make up the system. The integration of ESP8266 Wi-Fi technology for managing home appliances and sensors is represented in the hardware interface, and a software interface is given for controlling numerous users of the house. The output of this system is reached by utilising the blynk app for smart home automation. The temperature and humidity is depicted, along with a Wi-Fi connection. GSM and GPS modules are used to send messages on a mobile phone.

In [3] The system provides smart wireless home security by sending an email with a photo to the house owner if intruders enter the residence and also by sounding an alert if a fire occurs. From anywhere in the world, the system can regulate and monitor the house temperature, humidity, flame status, and other home equipment. The technology updates data every three seconds, allowing speedy decisions to be made. The Pi-camera immediately sends an email with an intruder photo or a fire mishap to a concerned person, improving the safety of the property and the home owner. The system is also capable of controlling household appliances.

In [4] The goal of the study is to create an IoT-based system that allows users to operate electrical appliances remotely using an Android mobile application. The mobile application was put to the test, and the reaction in terms of turning on/off appliances

and locking/unlocking doors was noticed. Thing Speak cloud provides a web access for monitoring data logs and signal transmission. The technology performed as intended in terms of lowering energy use.

In [5] The appliances are managed by the Raspberry pi server, which runs according to the user command received from the phone through an android app. Smart home automation is suggested for the elderly, based on python, OpenCV, raspberry pi, and android applications. Face identification and recognition from a camera positioned outside the main door, which can be accessed from the phone, is used to create a unique door monitoring system. The hardware for regulating the intensity of light using the Raspberry Pi's PWM output is presented. For home security, an automatic door monitoring system based on an Android mobile is presented.

In [6] Smart home automation particularly for old age people is proposed based on python, OpenCV, raspberry pi and android application, the appliances are controlled by the Raspberry pi server, which operates according to the user command received from the mobile phone. A unique door monitoring system is designed based on face detection and recognition from a camera installed outside the main door, which can be accessed from the phone using android application. The hardware implantation for controlling intensity of light using PWM output from Raspberry Pi is depicted. An automatic door monitoring system using USB camera, python, OpenCV, raspberry pi, and android device is proposed for monitoring and security purpose. IoT provides more flexible and low-cost solutions for daily life problems which ultimately improve the user's life. Although many previous researchers proposed many home automation systems by using different concepts, there are some reasons for the motivation to design an efficient home automation system. Previously proposed home automation systems are expensive and complex, Bluetooth based home automation systems required intrusive installation [6] and some of the senior citizens does not use G-mail, Twitter or web server as it requires the account creation as well as additional wi-fi module [2,3,5] and find it difficult to operate as it requires additional learning [4].

III. Problem Statement

The high cost of ownership, inadequate administration, and difficulty in attaining security are the four primary issues that home automation systems confront. The main goal is to create and construct a low-cost, open-source home automation system that can manage and automate most household appliances using a simple interface. Our suggested system has a lot of versatility since it connects its modules to the Telegram Application utilizing wi-fi technology. Secure wireless communication protocols between user and telegram server, will be used in the system.

IV. Methodology

The System Architecture includes a set of hardware components such as the Raspberry Pi, Node MCU esp8266, MLX Sensor, and relays. As well as a set of software components like Raspbian operating system, Arduino IDE and Tele-gram application as shown in the figure. The system receives the commands from the user via the Telegram application. The command from the user can be received from anywhere through the internet.

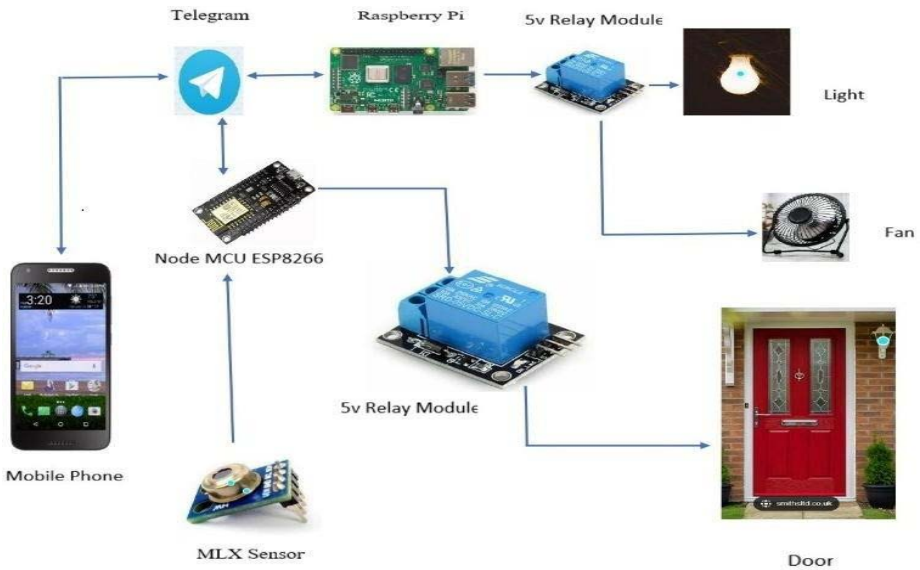

Figure 1: System Architecture

The Raspberry Pi and Node MCU process the instructions received and operates the loads (light and fan) to switch them ON/OFF and, the door lock to lock/unlock according to desired user commands respectively. Thus, we automate light, fan and door over the internet using Raspberry Pi and Node MCU. Raspberry Pi, Node MCU esp8266 hardware, MLX90614 sensor, and Telegram application are at the core of smart home automation. The system is divided into two halves based on Raspberry Pi and Node MCU. For the initial half, Because of its user-friendly features and cost-effectiveness, the Raspberry Pi was chosen as the system's processing unit. A python-coded programming has also been put into the Raspberry Pi, which is connected to the internet through a wireless wi-fi interface and can access and send data to the Telegram application. The Household Electrical Devices to be monitored were interfaced with the Raspberry Pi using a relay driver circuit due to the different power ratings of the devices and the Raspberry Pi. The latter half contains the microcontroller, Node MCU esp8266 that connects the user to the door lock system through the Internet. This allows the user to lock or unlock the door lock from anywhere in the world using the Telegram application. The MLX sensor detects the person's body temperature and sends the information to the Telegram application through the Node MCU microcontroller embedded telegram server.

a) Raspberry Pi

The Raspberry Pi is a credit card-sized computer that plugs into a computer monitor or TV and comes with a standard keyboard and mouse as shown in Fig. 2. The Raspberry Pi is an open-source ecosystem for controlling electrical components in physical computing and exploring the Internet of Things. It's Linux-based and features GPIO (general-purpose input/output) pins (IoT). It provides individuals with low-cost, high-performance computers with which to research and resolve issues.

Figure 2: Raspberry Pi

b) Node MCU

Node MCU is an open-source platform based on the ESP8266 that enables the connection of devices and the trans-mission of data through the Wi-Fi protocol. Furthermore, by offering some of the most important microcontroller functions such as GPIO, PWM, ADC, and so on, it may be able to manage many of the project's demands on its own. The system's Node MCU esp8266 is shown in Fig. 3.

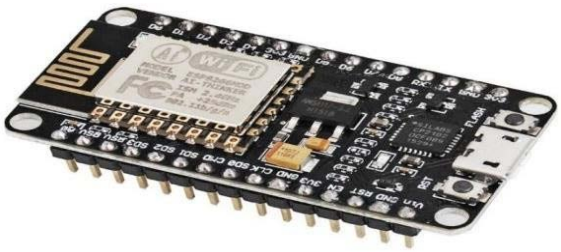

Figure 3: Node MCU ESP8266

c) Relay Module

The relay in Fig. 4, is essentially a control switch that employs electromagnetic to swap the switch, allowing it to be readily activated by a low voltage signal. It's utilised to keep the load from being supplied when it's needed.

Figure 4: Relay Module

d) Electric Door Lock

The motor is controlled by an electrical impulse, which may be activated in a number of ways, including an electronic card reader, a keypad, or a wireless remote control sensor, as shown in Fig.5. The electronic door lock is configured to engage the motor-driven actuator only after receiving the right electrical input in either instance.

Figure 5: DC 12V Solenoid Electric Door Lock

e) MLX Sensor

It is a contactless infrared temperature sensor with exceptional precision. Due to its great accuracy and precision, it may be utilised in a number of business, health-care, and home applications, such as room temperature monitoring and body temperature measuring. The MLX90614 sensor, which is used to monitor body temperature, is shown in Fig. 6.

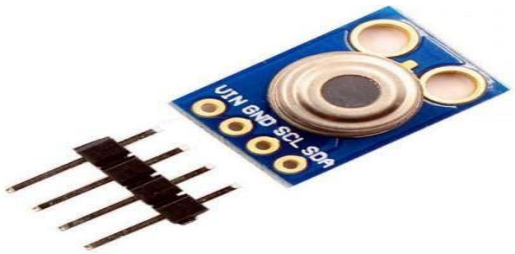

Figure 6: MLX90614 Sensor

f) Telegram Bot

A Telegram Bot is a software that works in the same way as a conventional chat partner but adds extra functionality. It does predetermined tasks on its own, without the user's involvement. Bots are Telegram accounts that are controlled by software rather than humans, and they commonly incorporate artificial intelligence elements. It could also use the Internet of Things to teach, play, search, broadcast, remember, connect, interact with other services, and even transmit instructions.

V. Results

The Fig 7 and Fig 8 shows the photograph of the experimental setup while performing the actual experiment. The system uses Telegram mobile application to control the light, fan and door lock. Experimental results of Home Automation System corresponding to the commands received from the user and response from telegram bot is shown in Fig 9 and Fig 10. It shows that the light, fan and door lock functioned accurately with the proposed idea.

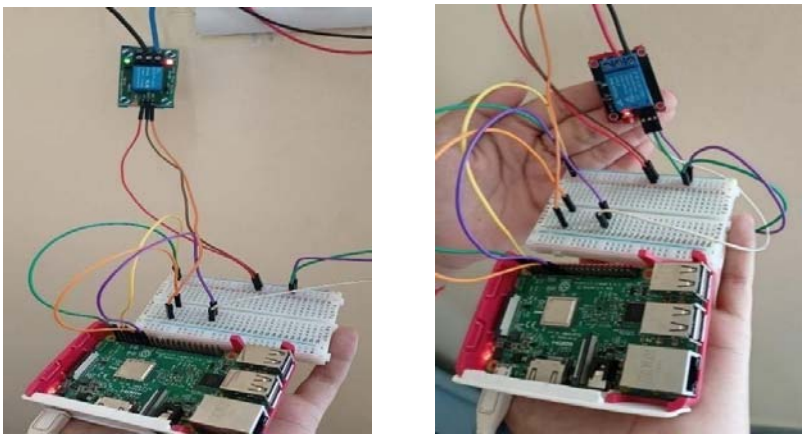

Figure 7: Smart Light and Fan

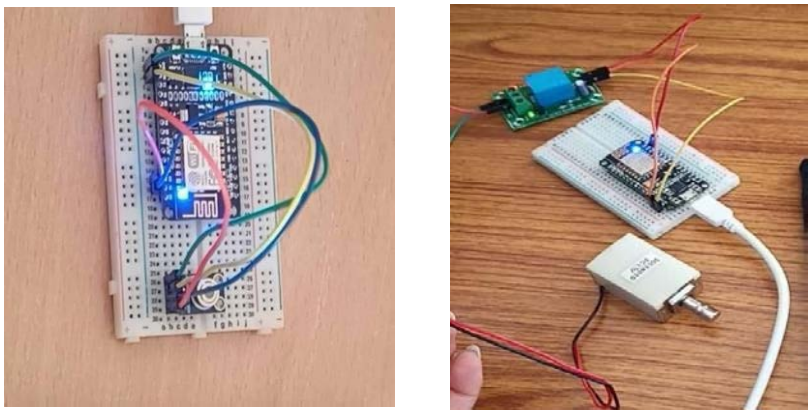

Figure 8: Smart Door and MLX sensor

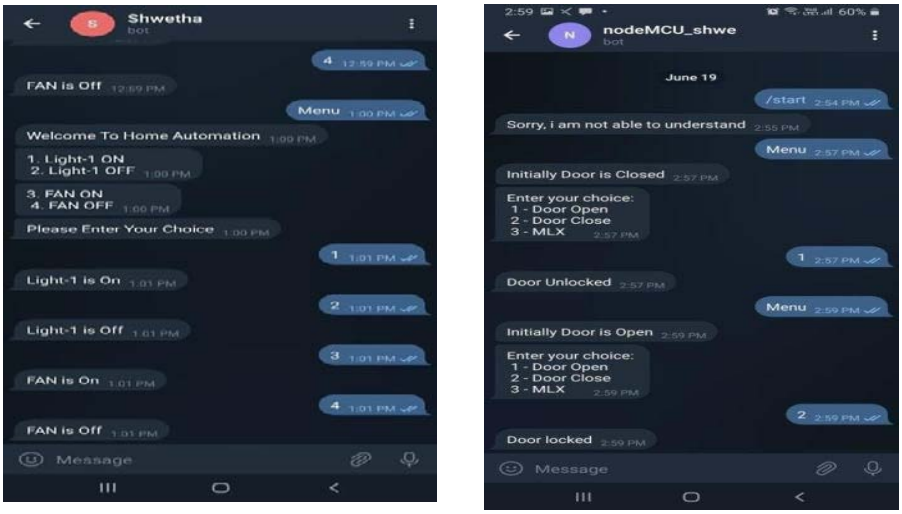

Figure 9: Commands given by the user via Telegram

Figure 10: Commands given by the user via Telegram

VI. Conclusion and Future Work

The Raspberry Pi and Node MCU ESP8266 with internet through mobile phones, tablets, and computers have been operating effectively for home automation. Telegram notification is one of the proposed system's benefits. Telegram notifications are simple to use for older generations because they do not require an email address or a Twitter account. In addition to this, it has MLX sensor which can be used for detecting body temperature. The designed method is smart, inventive and secure, as well as low-power and inexpensive. It may be used to cut down on electricity waste by properly scheduling and monitoring equipment. The proposed system may be utilised to dramatically minimise the danger of unwanted entry in a range of places, including banks, hospitals, labs, and workplaces. The system might be enhanced in the future to include fan speed adjustment, smart doors with identification, and a voice assistant.

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Might be Hydrocavitation Monitored only on Hydraulic Manner and Laws

By Zoran Karastojković

Abstract- Cavitation is a serious problem at hydraulic components, especially at pumps, hydroenergy turbine runners, ship propellers, even at blades from windpower generators, when performances of those elements/machines deplete. It means that the cavitation is caused by flowing liquid or gas over the metal surface. Severe cavitation always leads to the erosion at the impigement metal surface.... Many conclusions were stated that for cavitation are responsible the hydraulic demands while material properties commonly not.

In many hydraulic approaches the starting point is the speed flow of running fluid (water, oil or gas) and also other data about hydraulic circumstances and laws (Bernuli equation, etc). Also, in studying the nature of loads which act on turbine runner/blade, many attempts were made on measuring the noice, frequency signals, etc, but without deeper understanding the characteristics of used material. Cavitation here will be considered as a result of contact flowing water – metal at turbine runner, mainly from aspect of material characteristics not from a hydrodynamic flow demands.

Keywords: hydrocavitation, stainless steel, stabilizing elements, grain size, coatings.

GJRE-A Classification: FOR Code: 091399

Strictly as per the compliance and regulations of:

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Zoran Karastojković

Abstract- Cavitation is a serious problem at hydraulic components, especially at pumps, hydroenergy turbine runners, ship propellers, even at blades from windpower generators, when performances of those elements/machines deplete. It means that the cavitation is caused by flowing liquid or gas over the metal surface. Severe cavitation always leads to the erosion at the impigement metal surface.... Many conclusions were stated that for cavitation are responsible the hydraulic demands while material properties commonly not.

In many hydraulic approaches the starting point is the speed flow of running fluid (water, oil or gas) and also other data about hydraulic circumstances and laws (Bernuli equation, etc). Also, in studying the nature of loads which act on turbine runner/blade, many attempts were made on measuring the noice, frequency signals, etc, but without deeper understanding the characteristics of used material. Cavitation here will be considered as a result of contact flowing water – metal at turbine runner, mainly from aspect of material characteristics not from a hydrodynamic flow demands.

More attention will be payed on the characteristics of materials, preferably used for producing of turbine runners, such as crystal grain size or shape, the presence of: non-metallic inclusions or (micro) alloying elements.

Keywords: hydrocavitation, stainless steel, stabilizing elements, grain size, coatings.

I. Introduction

Standard definition of cavitation is widely accepted at a lot of national standards, so *cavitation is the formation and subsequent collapse, within a liquid, of cavities or bubbles that contain vapor or gas, or both, in the ASTM G32-03 standard.* If the cavitation is markably progressed, than may cause significant implications at surface, up to the damage(s). From such definition and aproach, the appearance of cavitation is monitored as result only from the hydrodynamic influences. It is believed that careful machining (for low roughness for example) of turbine runner or other components is obviously, while other tasks often are neglected or remain undefined. In analysing the hydrosystem one can found just general constatations that turbine should be reliable and, of course, needs quality components. It is an abstraction approach but not enough for producing a good component, here means a water runner. The cavitation could not be fully avoided but only decreased.

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Materials for building of any hydraulic component should be carefuly chosen. It is clear that flowing water continuosly is in contact with the turbine runner, and from that point is clear that used material must be kind of stainless steel. The hardness of such stainless steel should be on a higher level than at other structural steels, because the increased hardness usually is welcome for achieving higher strength, and however for improving the resistance to cavitation progress. It is stated that martensitic kind of stainless steel represnts the good choise as material for water turbine runner.

Every shock wave acts firstly as the compressive and than tensile stress. Cavitation may led to the material erosion, is enhanced by vibrations and noise. So, the major mission for engineers is to understand the mechanisms of cavitation appearing and lowering its level. One usefull aproach is first to understand and change the metal properties, if is needed just from the melting (it means refining, applying stabilizing elements, carbide or nitride formers for strenhthening an alloy, improving the corrosion resistance, etc.) and up to the servicing periode (when fluid mechanics plays an important role). Heat-treating methods, as quenching does, may bring up an imroving of mechanical properties but usually are not available for large runners, main reason for that is distorsion after heating up to the pretty high temperatures. So, (micro) alloying and coating technologies (for deposition hard coatings) may play an important role for farther decreasing the cavitation level, generally both for hydro- or thermopower elements, but the complex geometry of those components still is a great problem. Here will be discused some speciffic important material properties, which one need to know for successfuly decreasing hydrocavitation and damaging at surface of water runner, made from stainless steel, comonly martensitic class.

There are many questions about the metallurgical treatment of every turbine component: what main alloying elements should be used, kind of microalloying elements, refining and casting procedures, kind and amount of non-metallic inclusions, dendritic shape, grain size, kind of heat-treatment and obtained microstructure, mechanical properties, (braze) welding, kind of coatings to be used, etc. Most of these questions depend of the nature of flow water, water acidity/alkalinity, presence of abrazive particles

(commonly SiO_2, $CaCO_3$), or from influences. Any hydrosystem infact is both simple but a complex. When the machine components were exposed to cavitation to a relatively long time, erosion will occurs. As the erosion represents progressive loss of original material from a solid surface, some solutions for surface protection may be applied [18-24]. These factors do not belong to the hydrauics, and need some detailed explanations.

II. Demanded Properties of used Material

For achieving the projected properties, either mechanical or technological, that product must possess, many facts should be known, but keep in mind that most of those properties may be achieved just at the periode of metallurgical making of an alloy. More precisely, the alloying elements must satisfied demands for higher hardness, strength, also a good corrosion resistance. Another important demand in producing a water runner lies in its complex geometry, Fig. 1.

a) b)

Figure 1: Two types of ranners for: a) Francis and b) Pelton turbine

For achieving the desired shape of water runner, casting is commonly applied and used material (stainless steel) also must possess a good fluidity for fullfilling such complex mold cavity. The structural stainless steel used for this purpose belongs to martensitic class, it means the contest of about 0,3% carbon and up to 12% chroium, for achieving the good corrosion resistance and durability. As those martensitic steels show pretty low ductility they need some amount of nickel. The dezoxidation of melted steel is an obvious operation, at least by aluminium, silicon or better with more effective elements to react with oxygen from melted steel, as titanium does, or other dezoxidizers which may react with sulfur and/or phosphorous.

For stabilizing the structure, into such steel should be added carbide or nitride forming elements, as titanium and vanadium are, rarely is used zirconium. Copper may be added for improving the corrosion resistance. It is well established that as-casted products have no mechanical properties on the level as deformed (forged or rolled) material, and from that point of view into the used alloy should be carefuly added (micro) alloying elements. These elements will lowered intergranular corrosion and cavitation/erosion phenomena.

Microlloying elements are adding to react with carbon, nitrogen, rarely boron, at the same time they may be partially dilluted into ferrite or austenite, so their another important role is in refining the grain size. Exactly, it is expected that large crystal grains as well as dendrites will be *refined*, after that almost both mechanical and servicing properties will be markably improved.

III. Some Examples of Cavitation at Francis Turbine Runner

Few characteristic examples of cavitation at Francis turbine blades are shown in Fig. 2.

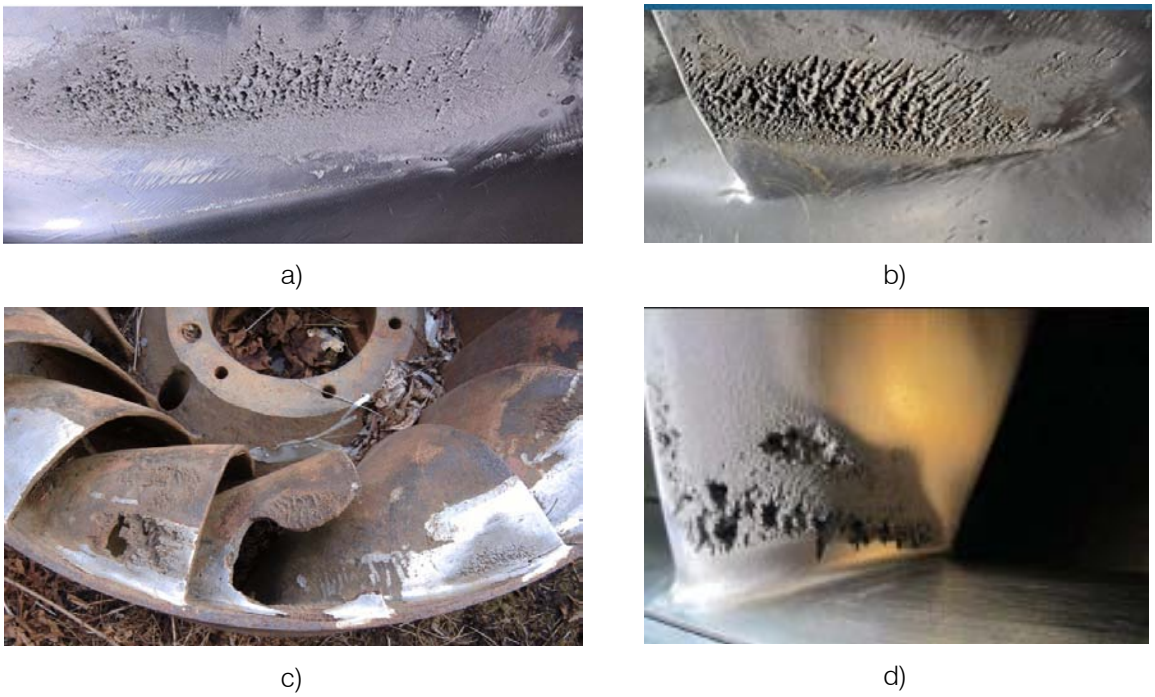


Figure 2: Few examples of generated cavities on blades a) and b); serioua damage c) and d) at Francis turbine runner surface

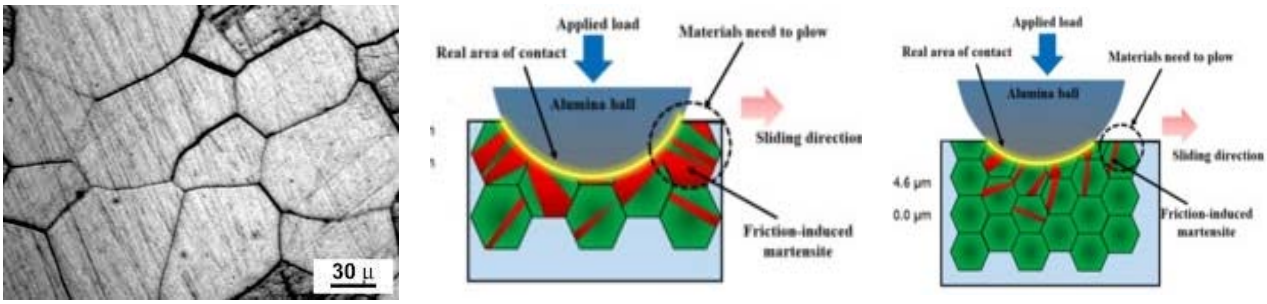
From. figs. 2b) and c) is clear why cavitation deplets the performance not only at the blade nut the whole turbine equipment.

IV. Cavitation and Grainsize

Grain size plays an important role in strengthening of solid solution [1-6,20], but in these discusions such approach is not of primary interest. Concept of hydrodinamic cavitation consists from the process of: vaporisation, than bubble formation and after that bublle implosion, which finaly are resulted in cavitation. From the metallurgical view the cavitation level is amplified if in the structure of turbine runner material are present large crystal grains. Mechanical properties of used material as well as chemical composition commonly undergo to detail control, but it seems that such approach was not enough.

As turbine runners usually are produced by casting it is expected the larger crystal grains than in deformed metal, indeed. The size of crystal grains effectively may be changed in processes of plastic deformation processes (forging, rolling) and/or by heat-treating (quenching), but those processes are useless for components with complex geometry, as turbine runner does. So, the grain size should be controled in the periode of casting, just before solidification of melt begins. For that purpose serve numerous elements, so called grain refiners, almost known are Ti and V, which at the same time made carbides and/or nitrides. For strengtening may be used W or Mo, for forming carbides but they also may forming so called intermetallic compounds. All of those metals are welcome into the steel for making a water runner, the only limitation might be their price.

One metallographic view at a steel microstructure could be seen from Fig. 3a), where dark fields usually consist of impurities. The metallographic approach is well known and applied in the whole metallurgy. Such impurities are not welcome at any steel, paricularly at qualitative steel. Harder compounds frequently are distributed along the grain boundaries, if so than the ductility is lowered. The grain size implies the kind of wearing under load. During servicing periode the surface of a watter runner is also loaded, so the mechanism of damaging or cavitation along the grain borders near the surface, however, is not same as in wearing [20], but may be similar according to skethes from figs. 3b) and c).



a) b) c)

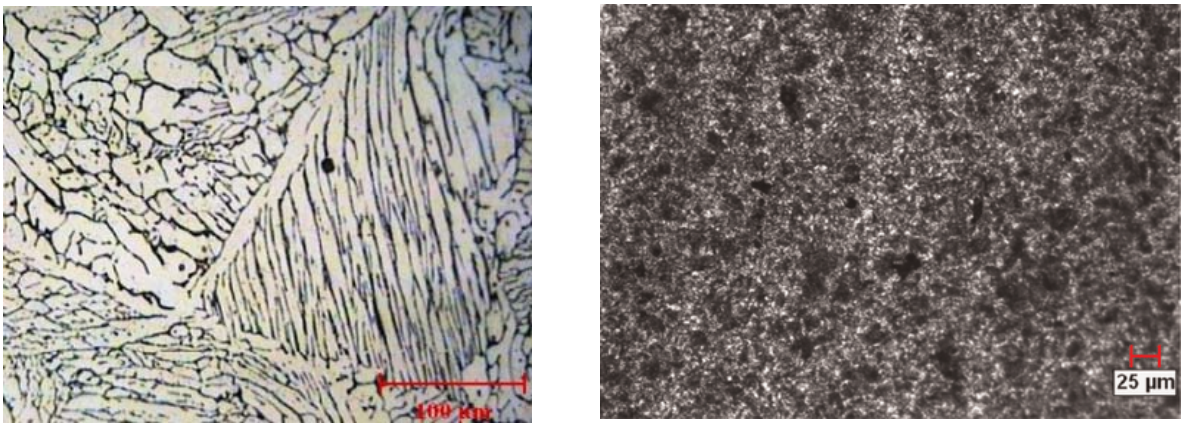
Figure 3: Microstructure of one steel with impurities at grain borders a); schematic representation of wearing under load at: coarse b) and fine c) crystal grains [20]

It is needed to underline that possible cavitation mechanism may be described as follow: the damaging along the borders of coarse (large) crystal grains easilly will widespread out, Fig. 3b), while the fine (smaller) grains become a barrier for widespreading along grain borders, and than the damaging will be lowered, Fig. 3c).

The grain size is well defined in metallography [1-6] and at many national standards.

a) Shape of Crystal Grins

As mentioned, the large grain size are not welcome but another attention should be payed on the shape of grain size. The care for obtaining the fine grains must beggins just in the periode of solidification, exactly in foundry production. How looks like one dendrite structure is shown in Fig. 4a). Large dendrites, however, must be avoided, and for their refining serve metallurgical approaches. Heat-treating of water runner is applicable on a limited manner, and this fact represents a shortage. Keep in mind that geometry of such product is complex. so the quenching is impossible, and than only an annealing operations are applicable, as normalizing or normalizing+tempering. Tempered martensite offers advantage for improving the toughness.



a) b)

Figure 4: Dendrite structures after casting stainless steel with dominant: a) austenitic and b) martnensitic (mixed with ferrite and bainite)

It is wotrhy to mention that dendrite structures, as like in Fig. 4a), frequently are more characteristic for austenitic type of stainless steel than in martensitic steel, Fig. 4b). Anyway, great martensitic needles even plates should be avoided in the structure. If coarse grains dominate into microstructure, than as a result between large dendrites will be produced greater level of cavitation than at fine grain material. The hydrocavitation is pretty well explained by hydraulic manner, for example: the shock wave first produces a compressive stress on the solid surface, and then when it is reflected, produces a tensile stress that is normal to the surface. But, the resistance to such shock waves also depends, however, from the kind of used material and its production history during metallurgical treatment(s).

V. Influence of Non-Metallic Inclusions on Steel Properties

The influence of non-metallic inclusions on the properties of solidified any metal, also on steel, is great,

however in a negative sence. With the presence of non-metallic inclusions in steel, the strength properties (tensile strength or yield point) will be decreased. while the toughness properties will be markable lowered. Presence of any kind of non-metallic inclusions are favorable places for cavitation appearing, so their amount must be controled.

a) Assessment of Amount of Non-Metallic Inclusions

The evidence of presence of an amount of non-metallic inclusions into metals, indeed at steels, could be assessed indirectly by one or more mechanical test methods. But more closely assessment of the presence of non-metallic inslusions is providing only by using a metallographic examination. The national standards of many industrial countries recognized the need for succsessful assesssing the amount of non-metallic inclusions, based on the microsopic examinations. Scale for microscopic assessing of amount and shapes of non-metallic inclusions for one important group of steels is standardized, in Fig. 5. is ilustrated just one part from standard [13]. There are, however, another important types of inclusion, as oxide and silicate types. All of them show detrimental effect on material properties, and may represent difficulty for applying a kind of protective technology for decreasing coeffitient of friction and lowering the wear rate.

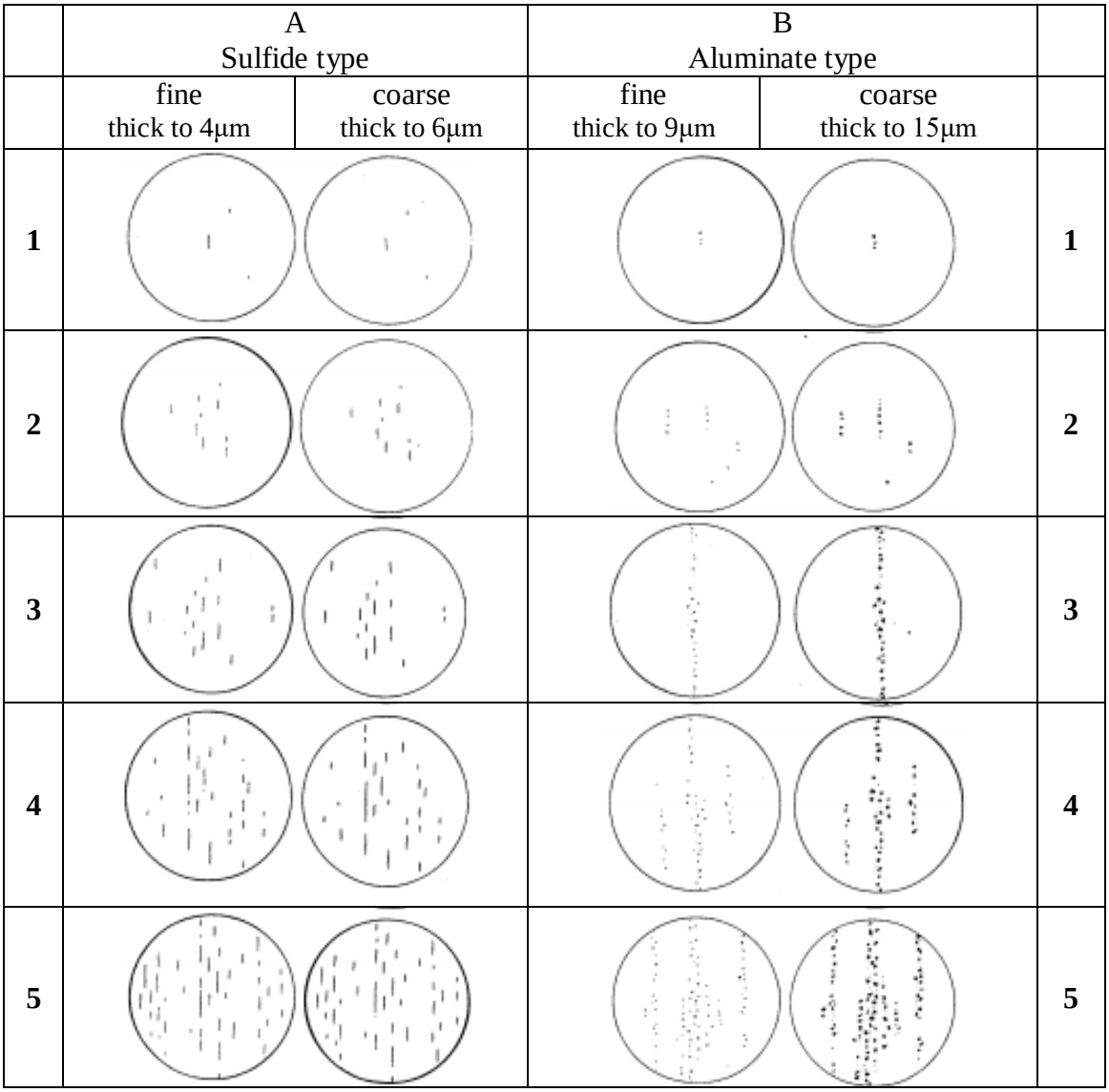


Figure 5: Part of a scale for metallographic observation of two types of non-metallic inclusions (black spots) in bearing steel 100CrAl

This steel commonly is used as a bearing material. However, this kind of steel is not same as steels usually applied for water runner at hydroturbine, but those pictures on a good manner ilustrate the distribution of non-mettalic inclusions, in this case into (hot) rolled bars. The level and/or shape of non-metallic inclusions at as-casted steels are not identical as in deformed material, but it is well known that at as-casted

structure the non-metallic inclusions usually are greater than in deformed material. The scale commonly is devided into four columnes, here are shown two types, from the most known non-metallic inclusions groups: sulfides, aluminates, silicates and/or globular oxides, and every column is graduated into five levels (1-5), from the smallest to greater one, see Fig. 5. On this way the content of non-metallic inclusions must be strictly controled, especially at qualitative steels.

Even small defects such as corrosion pits also are critical for fatigue. Large non-metallic inclusions has a dentrimental influence on cavitation level.

Farther, fatigue cracks at any machine component can start from intrinstic defects, mostly from nonmetallic inclusions, which may significantly influence on the lowering the servicing characteristics, here is mentioned the fatigue strength.

VI. Coating Methods for Hydraulic Components

A lot of hydraulic components are protected by using an anticorrodive and hard coatings. Susch coating (layer) besides good anticorrodive must poses also good antifriction properties. For obtaining desired coating (layer) on hydraulic components, there are available different techniques which belong to one of the next principal groups:

- Electrolytic (galvanic) methods,
- Electroless (chemical) methods,
- Metallizing and
- Thermodiffusional methods.

Those methods are applicable on many hydraulic components, but water runner makes a problem for deposition, first of all from its great gabarit and complex geometry.

At first three methods the coatings are obtained by deposition of the layer material, while at the fourth method the layer is formed by diffusion. Diffusion (as nitriding) requires elevated temperatures, after that the treated component will be deformed. The adhesion of diffusion layer is greater than layers deposited by other techniques. Coatings deposited either by electrolytic or electroless method are similar but there exist some principal differencies, as shown in Fig. 6.

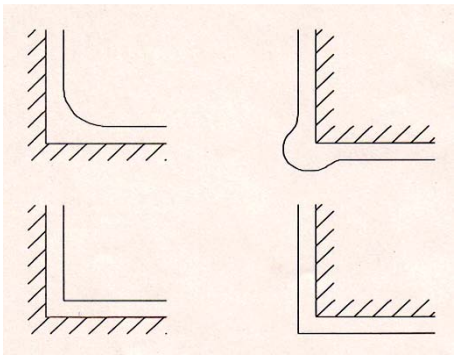


Figure 6: Principal geometrical characteristics between: a) electrolytic and b) electroless deposition; at inside (I) or outside corners (II)

The elecrtolytic deposition is pretty well known, one of the most known is hard chromium, so it would not be farther discused here.

a) Electroless (Chemical) Nickel

Nickel has long been used as a plating material because of its excellent appearance coupled with good corrosion resistance. Prior to 1946, nickel coatings were applied to most substrates by using electricity (electroplating). Since that time methods have been developed that allow electroless nickel plating on most metals and also on many nonmetallic substrates. Most electroless nickel coatings contain from 5 to 15% phosphorus+boron.

Also, unlike electrolytic nickel, the thickness of electroless deposits is distributed evenly over the entire surface, compare Figs. 6a) and b), even at parts with complex geometry. Blind holes, threads, small diameter holes, recesses or internal areas receive the same amount of plating as sharp corners, edges or curved (concave or convex) surfaces. On such way, close tolerances can be maintained - for hydraulics it is of an extra importance.

With proper surface preparation, excellent adhesion can be obtained. As plated, electroless nickel deposits have an average microhardness of 500-550$HV_{0,5}$. This can readily be increased to approximately 1,000HV by heat treating (age hardening) at 400°C, but this temperature also is unavalilable for water runner of Francis turbine.

Farther, the risk of damaging the water runner after electroless nickel is deposited, lies if parrent metal posses a remarkable amount of non-metallic inslusions.

b) Metallization

Although for metallization could be applied wide spectrum of materials, including a pretty hard materials (oxides, carbides or nitrides), but those methods are unavailable for machine components with complex geometry, as runner does.

All of those facts one should to knows very well before trying/applying to protect the surface of any kind of turbine blades.

VII. Conclussion

Cavitation, as an unavoidable problem, in practice rather is considered on hydrodinamic manner than from aspect of material properties. The local control of cavitation level, however, is of importance, but control only this characteristic will not gives a satisfied result. It means that the care for grain size and all other properties, which are needed for a final product, should start just at the making choise of (micro) alloying elements, melting & refining processes and heat-treatment in producing the water runner. Precise machining of any hydraulic components is understanding.

Chosen steels for production hydraulic components usually posses a good mechanical and anticorrosive properties, but eventhough damaging on cavitation manner is appearing. The regular control of chemical composition (on main alloying elements as well as microalloying elements), and mechanical properties (hardness, strength, toughness) of used material should be advanced, in the sence for more detailed control about grain size and non-metallic inclusion contest.

Non-metallic inclusions are one of the key factors in determining the quality of used steel, indeed for a cavitation appearance. If those inclusions are large and in great amount than the cavitation will be advanced, at the same time wiith reduced the servicing life.

As shown above, the problem of cavitation should not be considered only on a hydraulic manner but taking acount the state of the material, it means properties after melting, reffining, using (micro) alloying elements, casting and/or heat-treating of used steel, also possibilities for applying a coatings, here is represented on the case of water runner from Francis turbine, but those procedures are available to other versatile hydraulic components.

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Acknowledgments

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

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It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

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The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

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A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

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Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

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Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

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7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

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10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

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Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

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- Submitting a manuscript with pages out of sequence.
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- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
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- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

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Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

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- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
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Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

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This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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