HARNESSING PRODUCTION OF INTERLOCKING STONE WASHING MACHINE TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT IN NIGERIA

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Abstract
People often use hand brushes, scraping knives, and other manual implements to wash and rinse interlocking stones. Since technology is seen as the driving force behind rapid development, this research aims to produce a 220-volt mobile interlocking stone washing machine. The magnetic field is used as a coupling medium between electrical and mechanical systems. The electromechanical energy conversion takes place through the medium of a magnetic field. This research sought to use technology in the washing of interlock stones. It adopted electromechanical energy conversion through the use of an inverter, battery, electric motor, and cup wire brush. The device was tested on dirty interlock stones, and the efficiency was compared with manual washing. The result in time percentage between manual washing and the use of the device washing was compared in 3 areas of its effectiveness. The graphs and pie chart of the results show that the interlock washing machine is more effective with less stress and more accomplishment. It is recommended that this device be used by private, public, and corporate institutions; be used by students of electrical and electronic engineering who are researching electromechanical principles, energy conversion, and scientific research; be used by Kenule Beeson Saro-Wiwa Polytechnic management for local and international exhibitions; be expanded upon for further research; and, on a bigger size of this machine, the innovators be sponsored for mass production.

Keywords*: Interlocking stones, Electromechanical, Inverter, Battery, Conversion, Technology*

Introduction

Technology is the brain for the rapid development in industrial sectors, marine, manufacturing, drilling, construction, marketing down to domestic activities in the world in general. Technology is the application of scientific knowledge to the practical aims of human life and the environment. In residential and office spaces, interlocking stones are used for beautification, landscaping, gardens, high traffic areas such as a driveway or walkway, and the flooring of the entire compound space. Oluwapelumi (2012), defined interlock stones as a modified exfiltration system permeable interlocking concrete pavement.

Interlock stone compositions are either natural or precast bricks that come in different shapes, designs, and colors. These stones are subject to fading, color changes, especially when it is not properly taken care of after installation. The compositions are made of asphalt, concrete or cement that gives way to dirt when there is no regular sweeping, washing, and rinsing, to prevent stains and keep the pavers clean always.

The washing and rinsing are often done manually with hand brushes, scraping knives, and other manual implements. Since Technology is seen to be the brain for rapid development, the question that quickly comes to mind is, could interlocking stones be washed with the use of technology? If interlock stones is to be washed with the use of technology, an electrical power supply, components, and other operating systems need to be employed. Technology changes current modes of cognition and action to enable makers and/or users to take advantage of important opportunities or to cope with consequential environmental threats (Mario, 2019). This definition agrees with different entities being put together to form a system for an interlock washing machine to solve problems identified on interlock stones. One of these entities is the electric motor used in converting electrical energy to mechanical energy.

Statement of the problem

The benefits that come from the use of interlocking stones in different areas have been stated. These benefits cannot be sustained if proper maintenance of it are not kept. Realizing the benefits that accrue from consistent washing and rinsing, different manual methods have been adopted. Unfortunately, these manual methods have caused different problems ranging from acute stress, pain, injury, longer time, and ineffective washing. Observing these problems of using the manual method in washing interlock stones has led to the research of using a technological approach in washing interlock stones

Aim of the Study

The aim of the study was specifically to design and construct a 220V interlocking washing machine.

Purpose of the Study

The purpose of the study is to construct an interlock washing machine to:

1. Eliminate acute stress during washing
2. Facilitate effective washing
3. Eliminate longer time in washing
4. Construct a Prototype

Relevance of the Study

The relevance of the research will go a long way in solving problems resulting from the manual washing of interlock stones, if effectively applied. The students in higher institutions will actually gain from it, as research relating to electromechanical principles is employed. The management of Kenule Beeson Saro-Wiwa Polytechnic, Bori could utilize it at local and national exhibitions, through which the institution's image will be enhanced. When mass production of the machine is achieved, the general public will greatly benefit from it, as the crude method of washing interlock stones has been transformed into a technological technique. The research is basically for the use of a washing interlock stones machine, with the use of 0.23amps, 1500 rpm, a 50-watt motor, and a single-phase 1000-watt inverter, 220V AC voltage, 2x12 volts batteries.

Electric Motor

The electric motor plays a vital role in electrical engineering in converting electrical energy into mechanical energy with the use of a pulley, chain, belt, or coupling. This research takes into consideration electromechanical principles as presented in Fig.1 when selecting the practical, technical, and economic characteristics to satisfy the needs, to achieve goals, and solve problems identified that led to this research. Mathematically, the principle of energy conversion of motor action could be presented as: Electrical energy input = mechanical energy output + stored energy by field + total energy losses.

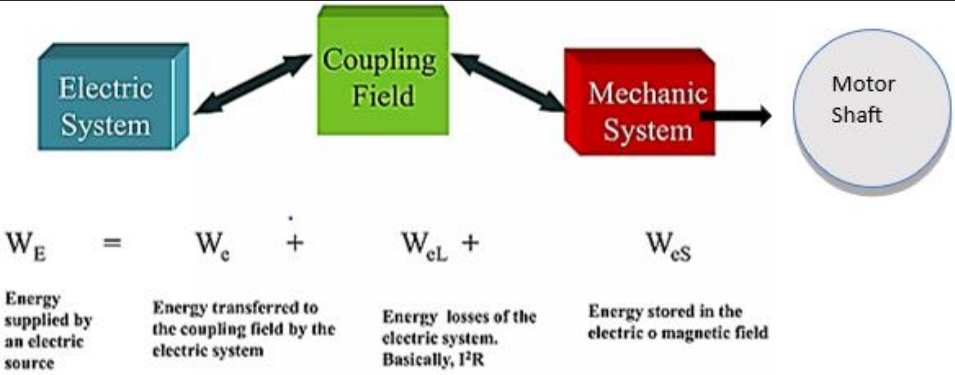

Fig.1 Electromechanical energy conversion (Begamudre, 2007).

The analysis of energy conversion above shows how energy is supplied from electrical source (W_E) which produces energy to coupling field (We), energy losses (We_L), and energy stored in magnetic field through force that is produced to turn the shaft of an electric motor to accomplish the purpose of the project (Begamudre, 2007).

This is further broken down in Fig.2 electromechanical conceptual framework module, where all the variables are linked together for energy conversion as it relates to this research. The relationships among the variables for relevant objectives for this research are shown in the module below. A conceptual framework is a structure that provides a theoretical or conceptual foundation for research, allowing researchers to examine and analyze complex phenomena. It is a tool that researchers use to guide the research process by defining the key concepts, ideas, and theories that underpin their study. The module for the conceptual framework in Fig.2 of this research spells out the philosophy behind this work as the variables are linked together as a network to achieve a set target.

When electromechanical energy conversion takes place from electrical energy to mechanical energy, the converter is known as a motor (Ramy, 2022). In electrical machines, conversion of energy from electrical to mechanical is adopted to apply technology in the washing of interlocking stones with a view to eliminating acute stress during washing, facilitating effective washing, and eliminating longer time in washing. In harnessing technology of which this innovative and creative decision-making is based on the application of basic study, mathematics, sciences, and engineering to transform a specific desire into a desire goal (Al- Badrawy et al, 2022). Smart construction is closely related to lean construction, which was coined by Koskela (2020) as a new production philosophy that focuses on concepts, principles, and methodologies within the construction industry. This is seen in different processes in the construction of an interlocking washing machine in

converting electrical energy to mechanical energy in line with the electromechanical principle. The main electrical component is the motor that obeys another principle known as Fleming's left-hand rule this research also depends on.

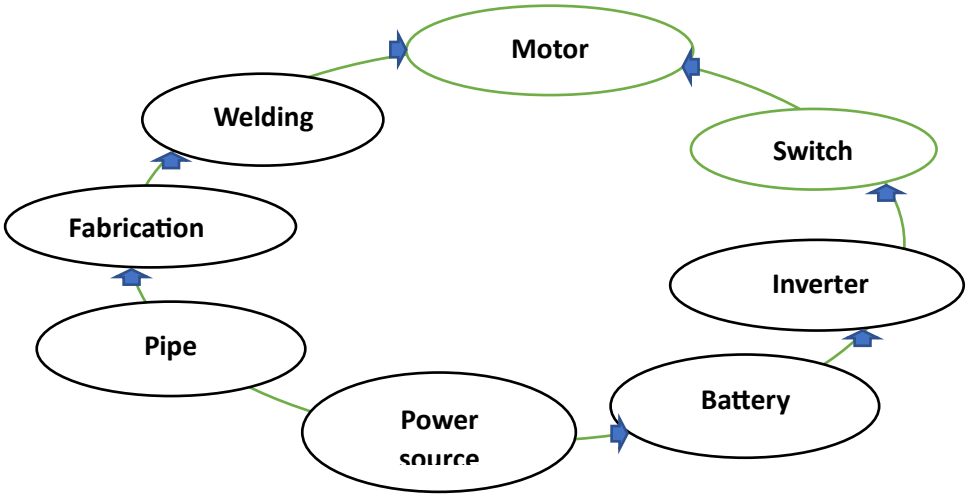

Figure 2: Conceptual Framework Module Researcher field work, (2024)

The electric motor is one core components in electrical engineering, as such it plays a vital role in this research. Electric motor comes in different forms, sizes, functions, and applications. All electric motor obey Fleming's left hand rule, which states that if we arrange our thumb, forefinger and middle finger of the left-hand perpendicular to each other, then the thumb points towards the direction of the force experienced by the conductor, the forefinger points towards the direction of the magnetic field and the middle finger points towards the direction of the electric current (Arshad, 2019). This rule is an essential rule applicable in magnetism and electromagnetism because it does not determine the magnitude; instead shows only the direction of the three parameters (magnetic field, current, force) when the direction of the other two parameters is known, as presented in Plate 1 below.

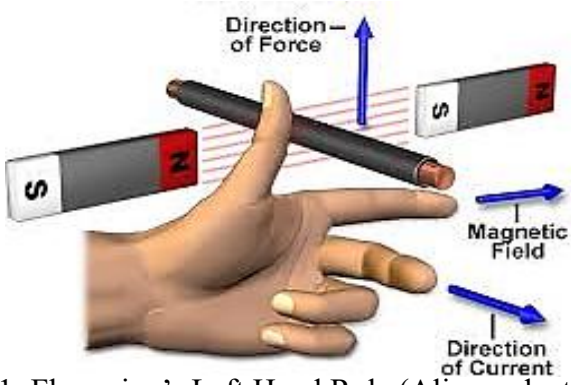

Plate 1: Flemming's Left Hand Rule (Alimorad, et al 2014).

In electric motors, Fleming's Left-Hand Rule helps to determine the direction of the force exerted on the current-carrying conductors within the magnetic field, leading to the rotational movement essential for the set target of this research. By applying this rule, engineers can design and predict the behavior of electric motors with accuracy. The motor for this research is mobile, electrically operated, and therefore, an inverter will be employed to provide the energy source of power.

Inverter

An inverter system is a device that converts Direct Current (DC) from a battery to Alternating Current (AC), which can be used for appliances (Alimorad, et al, 2014). The functions and understanding of the inverter have led to be inclusion in this research. The inverter will supply an inductive load, meaning that the output current is going to lag the output voltage (Alimorad, el tal 2014). Using an inverter is very safe, and they are also not that difficult to handle and operate. The portability and ease of handling have informed its use in this research. An inverter cannot function without a battery; that is why it will also be used in this research.

Battery

Another basic component in this research is the battery through which power will be fed to the inverter. The battery is often connected directly to the inverter through ac voltage supply to the motor. It is typically a collection of cells connected in series to give the desired output voltage and Watt-Hour capacity.

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Related Work

The interlock washing machine is one of the machines that research has not given attention to. At the time of this research, no literature has given any detailed information on the design and construction of an interlocking washing machine.

The only resemblance to an interlock washing machine found in the literature is a vacuum pump. Its concept is the use of gas, which is very expensive and complex. (Chew, et al 2015), stated that they have come to take for granted the vacuum and its application, in all its degrees, from vacuum forming, metallurgy, integrated circuitry fabrication, to space simulation. The current provision, the engineering innovations, and global availability bear testament to the technical and commercial pioneers of the 19th and 20th centuries. Plate 2. below shows a typical vacuum that cannot be used for the washing of interlocking stones. Similar to this project is the engineering innovation and technical fabrication that is adopted.

Plate 2 Vacuum Pump(Chew, et al 2015)

Knowledge Gap

In researching related work, there was no specific literature found to be used for similar work. This research work has succeeded in bridging the gap between a vacuum pump and an interlocking stone washing machine. This knowledge is an innovative, creative thinking that can be tapped by any person to produce similar work.

Material and Methods

Materials

This research adopted a mixed research methodology that embraces experimental and innovative research methodologies, which focuses on the identified problem and devises innovative processes to solve the problem. Sangarappillai et al (2015) stated that research methodology is commonly acknowledged as the most important part of any research work that needs to be established before the actual data collection program begins. Abdul (2014), defined experimental research as

that which is carried out to collect data to be analyzed and studied in the laboratory, in the field, or using computer numerical models. The research adopted an experimental design through which fieldwork was carefully planned and coordinated. Patricia (2023) defined Innovative Research Methods as a community-based space for exploring new and creative ways of conducting, displaying, and utilizing academic research. Therefore, this research employed the method of collecting materials, testing of components, analyzing components, voltages, component parameters, and fabrication in the workshop. Foreign and local materials will be used in order to harness local content in our environment, applicable to technological breakthroughs.

Component Functions

To achieve the goal of this project, the following materials were used:

i. Switch
ii. Cable
iii. Cup wire brush
iv. Plywood board
v. 600 watt inverter
vi. 2 x 12 volt battery
vii. Bolt and knots
viii. Insulation tape
ix. 6 inches pvc pipe
x. 20mm galvanise pipe
xi. Charging pot
xii. Electric motor

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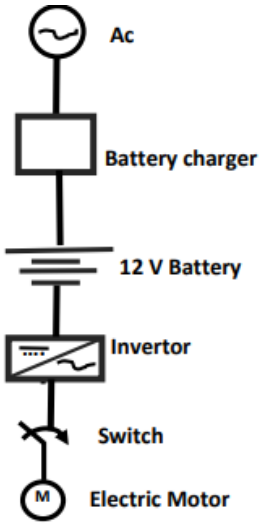
Circuit Diagram

The circuit diagram of Fig.2 below is the interlock machine operating circuit, carefully designed and constructed to achieve the purpose of this research. It serves as a visual tool for the design, construction, and maintenance of the equipment. The images are distinct components of standard symbols to present a simplified depiction of the circuit's elements and their interconnections.



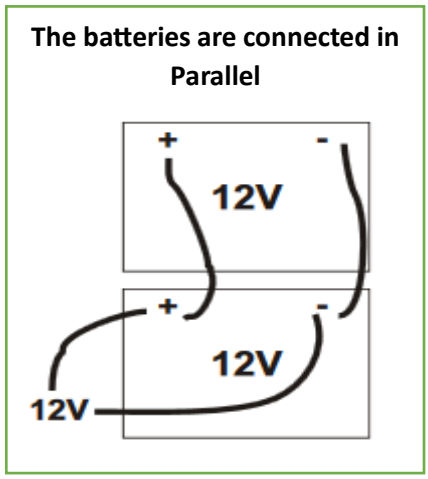


Fig.3 Operating Circuit Diagram Researcher (2024) field work circuit. Fig.4 Battery Connection

Fabrication Drawing

The fabrication drawing of the plate.2 sections below and views containing dimensions, welding, and bolting information of the galvanized pipe, and the PVC pipe. The fabrication details are created to simplify the process and steps of fabrication, and coupling to the fabrication drawing in Plate 2 and Fig.5 gives clearer views to every reader and researcher of the exploded model.

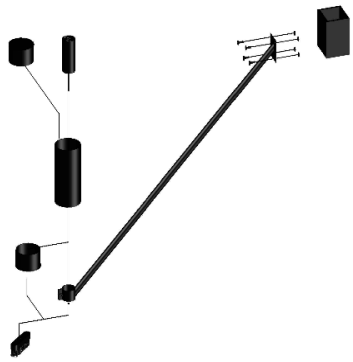


Plate.2 Prototype Completed Picture. Researcher's(2024) Fig.5 Expoded Model Researcher's (2024)

Results and Discussions

Results

Ability to use innovation to eliminate acute stress during washing interlock stones. Stress is a popular topic these days, and it is rarely a week that passes without hearing or reading about stress and its effect on human health. Given the negative impact of stress on human health, many types of stress management therapies have been put forward in order to decrease stress and to promote wellbeing (Roos et al, 2022). There is a great paradox in the field of stress research, and it relates to the fact that the popular definitions of stress are very different from the talking about, and working on very different aspects of the stress system.

However, this research is not on medical therapy to cure stress, but stress is an identified problem facing humans in society; hence, this research is chosen as part of different research to eliminate acute stress. As stress research becomes increasingly interdisciplinary, this project in the electrical engineering discipline will offer a solution in the area of this research for eliminating acute stress during the washing of interlocking stones. Stress is the force exerted on the unit area of a substance (Soo-Quee & Choon-Huat, 2007). The effect of stress on a body is referred to as Strain, which also occurs through manual washing of interlock stones. Stress causes deformations in the body to which it is being applied. Stress is when the direction of the deforming force is perpendicular to the cross-sectional area of the body.

Stress Formula is given as $\sigma = F / A$ (1)

Here,

σ = the stress,
F = the force applied
A = the area of the surface.
Stress Formula is used to find the stress applied to any given body if the force and the area on which the force is exerted are provided. Stress is also caused by the volume of work engaged in and the time spent in carrying out that work. Fig.6 and Fig.7 show the effect when interlocking stones are washed manually and when it is washed with a machine.

Ability to Facilitate Effective Washing
The graph of Fig.6 is the washing of interlocking stones manually. The individual meter space covered with respect to time are clearly indicated.

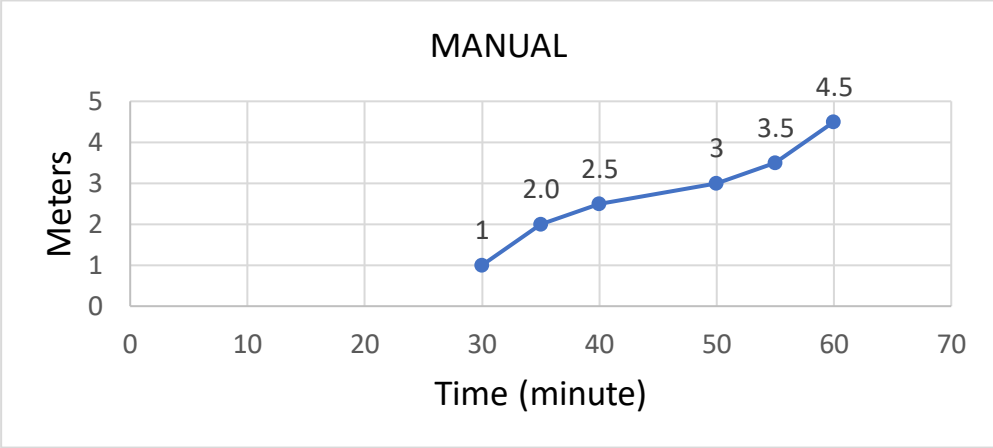


Fig. 6 Manual Washing of Interlocking Stones

In analyzing the above result, 30mins is used in washing 1.5 $m^{2,}$ 40mins for 2.5m^2, 50mins for 3.5m^2, and 60mins for 4.5$m^{2.}$ These results will be compared when machine is used for the same work.

Ability to Facilitate Effective Washing
The graph of Fig.7 is the washing of interlocking stones with machine. The individual meter space covered with respect to time are clearly indicated.

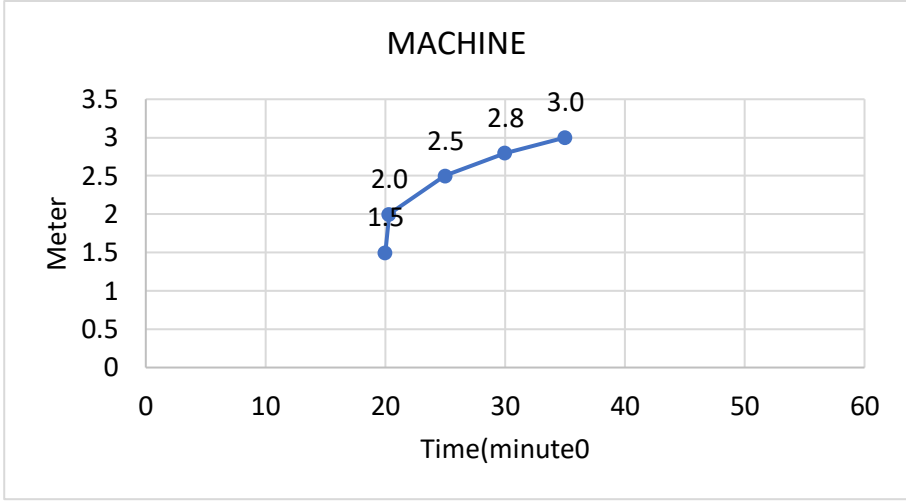


Fig. 7 Machine Washing of Interlocking Stones

In analyzing the above result, 20min is used in washing 15m^2, 25mins for 2.5m^2 30mins for 2.8m^2, and 35mins for 3m^2 . The results show a clear prove that the use of machine facilitate effective washing, less stress, and less time. The effective time percentage are also indicated in Fig.8 and Fig.9 below.

Ability to Eliminate longer time in washing

Respective percentages with time are shown in Fig.8 when manual washing is carried out. This will be compared when machine is used for the same work.

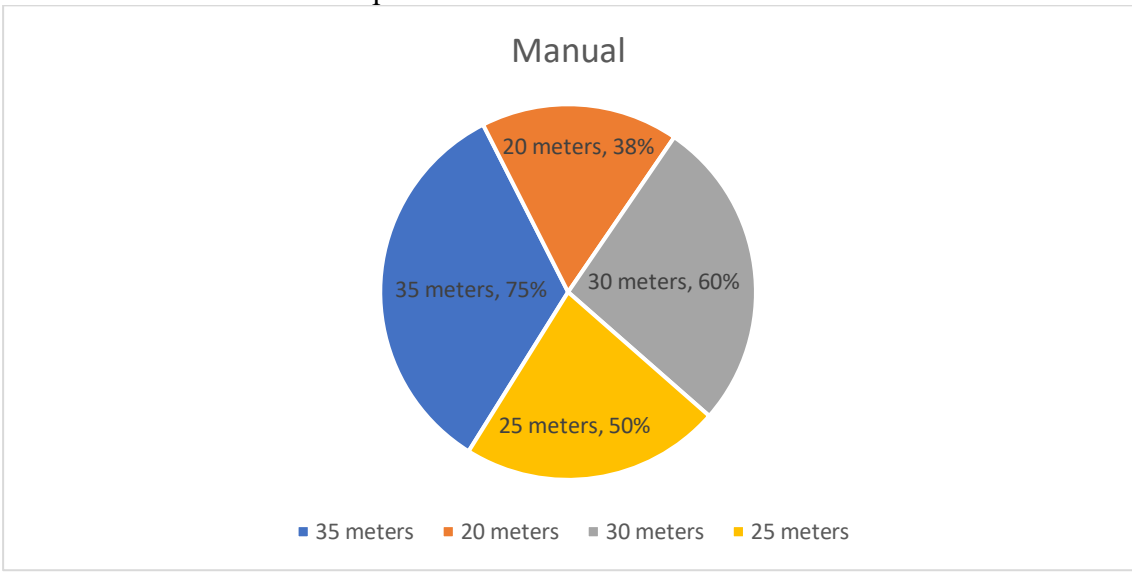


Fig. 8 Time/Meter percentage in manual washing

Third objective of this research tested the output time percentage of the space that was able to be washed with respect to time. Fig.8 shows clearly manual percentage washed with corresponding meter space. The result will be compared with machine percentage in time wash with corresponding meter space.

Ability to Eliminate longer time in washing

Respective percentages with time are shown in Fig.9 when machine washing is carried out. This will be compared when manual washing is used for the same work.

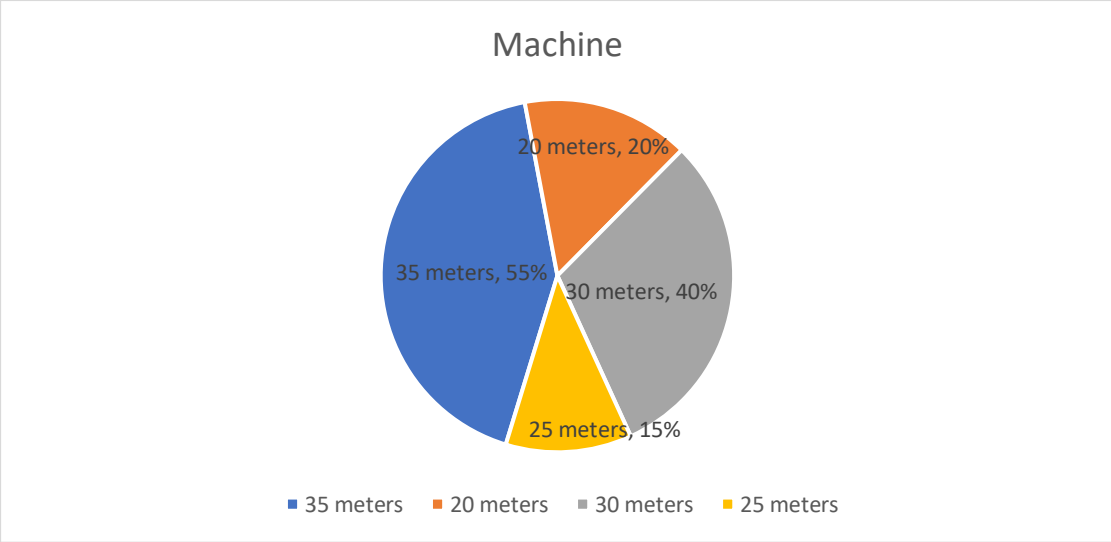


Fig. 9 Time/Meter percentage in machine washing

Figure 9 is the machine percentage in time washed with the corresponding time. When manual washings are compared with machine's, there is clear evidence that less time is spent covering wider areas in meters.

Design Analysis

Dc v Battery (max)

V_{out} = V(max)

V_{in}(max) = Inverter input voltage

Load I(max) = max load current for the work

V_{in} = 24v Dc

V_{out} = 220v

Load I (max) = 3A

Load V(max) = 220v

Motor speed(max) = 1500rpm

For parallel battery connection $Tv = V_1 = V_{2=12v}$ (2)

$T_I = I_1 + I_2$ (3)

Load I = P/V = 600/220 2.7A ≅ $\boldsymbol{3A}$ (4)

Summary, Conclusion, and Recommendations

Summary

The research work was a result of identified stains, debris, a filthy environment on interlocking stones, difficulties in washing them, pains taken in washing them, and time involved in washing.

In analyzing the results realized in this work, it is possible to use interlocking stones machine innovation technology in removing:

i. acute stress,
ii. facilitating washing, and
iii. less the time in washing interlocking stones.

Conclusion

Considering the approach adopted in harnessing interlocking stone washing machine technology is seen to be a creative innovation for sustainable development in Nigeria. The analysis and test results also authenticate its experimental engineering satisfaction. Therefore, this achievement is worth recommending for public, private, corporate, institutional, and international exhibitions.

Recommendations

The satisfactions derived from the production of this work in it scientific, engineering, creative, and innovative aspects employed in all aspects qualify it to be recommended. The methodology, analysis, and results of this research stand a true test of time; hence, it is to be recommended thus:

i. Be used in private, public, corporate, institutional, and international exhibitions.
ii. Be used by students of electrical and electronic engineering research on electromechanical principles, energy conversion, and scientific research.
iii. Be used by the Kenule Beeson Saro-Wiwa Polytechnic management for local and international exhibitions.
iv. Be expanded upon for further research and a larger size of this machine.
v. The innovation to be sponsored for mass production

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