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DESIGN AND FABRICATION OF ELECTRIC YARN WINDER FOR HAND-WOVEN FABRIC PRODUCTION

BY

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Abstract:

Hand weaving is a traditional craft that produces unique and intricate fabrics. However, the manual winding of yarn onto bobbins is a time-consuming and labor-intensive process that hinders the productivity of hand-weavers. To address this challenge, this study presents the design and fabrication of an Electric Yarn Winder (EYW) specifically tailored for hand-woven fabric production. The Electric Yarn Winder automates the yarn winding process, significantly improving the efficiency and productivity of hand-weavers. The system consists of a motor-driven yarn winder mechanism, a tensioning unit, a yarn length measurement system, and an intuitive control panel.

The design of the EYW prioritizes ease of use, reliability, and versatility. The motor-driven yarn winder mechanism enables consistent and uniform winding, ensuring high-quality bobbins ready for use in the weaving process. The tensioning unit ensures appropriate tension control, preventing yarn breakage and ensuring optimal yarn feed. The yarn length measurement system provides accurate measurement and monitoring of the yarn length wound onto each bobbin, enabling precise yarn management during weaving.

The control panel of the Electric Yarn Winder allows the user to set desired parameters such as winding speed, tension levels, and yarn length requirements. The system also incorporates safety features such as emergency stop buttons and overload protection to ensure operator safety. The fabrication of the Electric Yarn Winder involves selecting appropriate materials, precision machining, and electrical integration. Prototypes were built and tested to validate the design and evaluate the performance of the system. The results demonstrate that the

Electric Yarn Winder effectively reduces the time and effort required for yarn winding, leading to enhanced productivity and efficiency in hand-woven fabric production. The Electric Yarn Winder presents a significant advancement in the field of hand-weaving by combining traditional craftsmanship with modern automation technology. This innovation empowers hand-weavers by minimizing the repetitive manual tasks, allowing them to focus more on their creative process and craftsmanship. The system offers potential benefits to small-scale weaving businesses, artisans, and hobbyists by streamlining the yarn winding process and improving overall productivity.

Keywords: Clothe Weaving-Design-Fabrication- traditional craft

Introduction

Clothe weaving is a traditional craft that has been practiced for centuries. It requires a high level of skill and patience, as well as a range of equipment and tools, (Ross, 2017). One of the most time-consuming and physically demanding aspects of clothe weaving is the process of winding yarn onto bobbins, which is typically done manually by the weaver. This process can be particularly challenging for weavers who suffer from physical limitations or who are working on large projects, (Vosburg, 2015). To address this issue, there is a need for an electric yarn winder designed specifically for hand weaving. An electric yarn winder could help automate the process of winding yarn onto bobbins, saving time and effort for hand weavers while allowing them to focus on other aspects of the weaving process. Weaving according to Al-Sabbagh & Al-Sabbagh, (2019) is one of the fabric construction techniques used in Nigeria and the World over to produce fabric. It involves the interlacing of warp and weft yarns to form a fabric. The warp yarns are those longitudinal set of yarns which run vertical in the loom while the weft yarns or picks refer to those set of yarns which are interlaced with the warp to form a fabric. The weft yarns mostly interlace the warp at right angles and they are horizontal in the weave. In Nigeria, the indigenous weaving industry is very vibrant and lucrative. Woven fabrics such as Aso-Oke, Okene Cloth, and Akwuete Cloth are produced on hand-looms or what we call foot powered looms to satisfy the fabric needs of society. In Nigeria, the Vertical loom, Horizontal Loom, Table loom and Floor Loom are the most common looms used for weaving, (Alesagba, 2011).

Before weaving commences, there are preparatory processes that have to be carried out to ensure smooth and efficient weaving. These preparatory processes are in two stages

Print ISSN 2735-5357
VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN 2735-5365

namely: warp preparation and weft preparation. The warp preparation which basically involves the calculation and winding of the number of warp ends, required to weave a piece of fabric is done using a warping mill or warping board, Zaman & Islam (2010). The weft yarns on the other hand are prepared by using a device known as a bobbin winder. According to Badoe and Opoku-Asare (2014), bobbin winding is a critical component of the weft preparation and weaving process. The weft is prepared by winding the yarn taut onto a bobbin. In other words, even tension of the yarn is required before winding it onto a bobbin to prevent sloughing off during weaving. The loaded bobbin is then fixed into a shuttle and used for weaving. A shuttle is a boat-like device which contains the weft package. During weaving, the shuttle containing the weft package is inserted into the shed (an opening in the warp) and the weft yarn is subsequently beaten to the fell of the cloth. These repeated action results in the formation of the woven fabric. Available literature on yarn winder reveals that different types of bobbin winders exist in Nigeria and across the world, (Gao, et al. 2019). These include: manually operated bobbins, fully automated bobbins, semi-automatic bobbins and multi-colour winding systems. A cursory glance at these types of bobbins reveal that manually operated bobbin winders used by local weavers in Nigeria is slow and yarns produced from them slough off very easily due to uneven tension during winding. Quite apart from that, most of the automatic bobbin winders are too big and heavy to carry about.

This study therefore focuses on the design and development of an electric yarn winder which can easily be carried around and used anywhere; to make the job of yarn preparation easier. The device has a motor to spool the yarn and upon the rotation of the motor; the spool wind the yarn onto the bobbin. Apart from giving motion to the spool, the motor prevents sloughing off of yarns from the bobbin. The speed of the bobbin winder is controlled with the use of the foot pedal.

-Materials and Methods

2.1 Material

The materials used for the project work include;

i. Square Pipes
ii. An Electric Motor
iii. A Motor Pedal
iv. Fan Regulator
v. A Dimmer
vi. Bolts/Nuts

Print ISSN 2735-5357
VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN 2735-5365

vii. Machine Antenna
viii Connector
ix. Electric Cable
x. Washers
xi. Plug
xii. Stand Pad
xiii. Alco Board
xiv. Yarn

2.2 Methods

The following methods were carried out to achieve the aim of this research work.

The research work was on the design and development of electric winder for hand woven fabric production. A conceptual design was done on the use of winding machine as preparatory stage for the fabric production followed by design analysis. A conceptual design flow chart for the research methodology is presented in Figure 1.

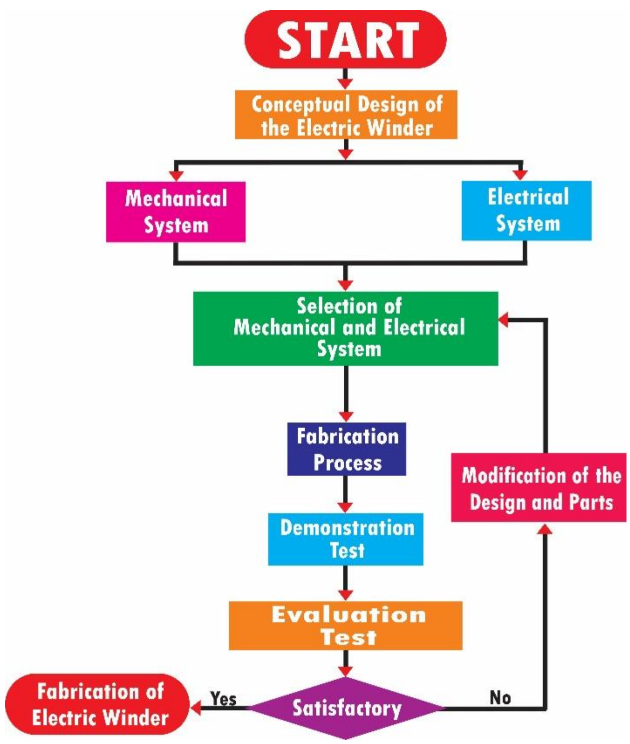

Figure 1: Design Methodology Flowchart for the development of Electric Yarn Winder
Source: Researcher's fieldwork (2022)

Print ISSN 2735-5357
VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN 2735-5365

3. Design Consideration

Designing the electric yarn winding machine, the researcher put into considerations the following:

Design for Factor of safety:

The machine frame designed was done considering factors of safety in order to validate the functionality of the electric yarn winding machine. The factor of safety used helped to prevent any form of structural failure of the designed frame for the electric yarn winder for hand woven fabric production. The factor of safety was determined from Equation (1).

$$Fs = \frac{Ys}{Ws}$$

Where,

Ys = Yield strength of the square steel material for the frame

Fs = Factor of safety

Ws = Working stress of the square steel material for the frame

$$Fs = \frac{5.29x10^{8}}{4.04x10^{8}} = 1.31$$

Configuration of the Machine:

Figure 2 shows the sketch for the proposed machine

Figure 2: Brainstorming and Rough sketch of an electric yarn winder - *Source: Researcher's fieldwork (2022)*

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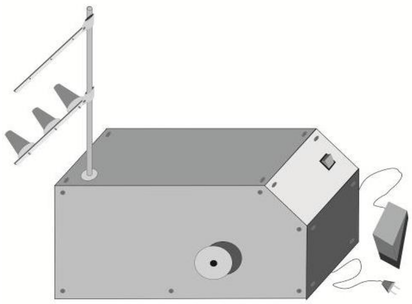

Figure 3: Detailed Drawings of the electric winder using CorelDraw Application
Source: Researcher's fieldwork (2022)

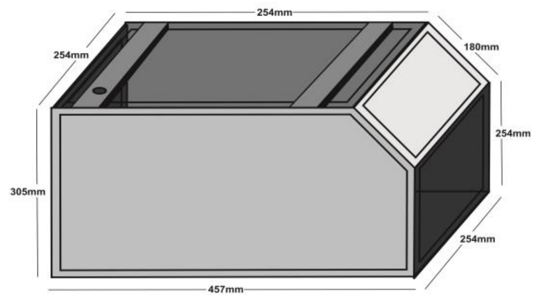

Figure 4: Detailed Drawings of the electric yarn winder with dimensions.
Source: Researcher's fieldwork (2022)

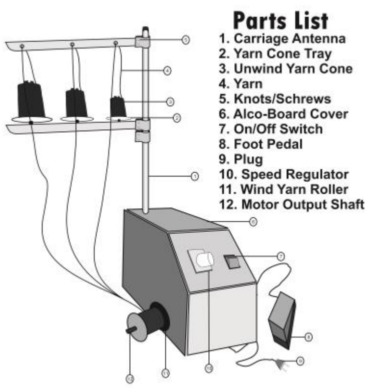

Figure 5: Three Dimensional Drawings of the Winder with label
Source: Researcher's fieldwork (2022)

Figure 6: The Complete View of Fabricated Electric Yarn Winder for Hand Woven Fabric Production.
Source: Researcher's fieldwork (2022)

4. Fabricating, Evaluating and Test-Running the Electric Yarn Winder:

Print ISSN 2735-5357 VOLUME 6, ISSUE 1, 2023, 167 – 181. Online ISSN 2735-5365

Plate 1: Cutting the pipes into sizes
Source: The Researcher's fieldwork (2022)

Plate 2: Welding the pipes together to for form the machine frame
Source: The Researcher's fieldwork (2022)

Plate 3: Painting of the machine frame to prevent rust
Source: The Researcher's fieldwork (2022)

Plate 4: Fastening the electric Motor unto the frame of the machine.
Source: The Researcher's fieldwork (2022)

Plate 5: Conducting the electrical connections

Plate 6: Connecting the speed regulator on the

of the electric yarn winder.
Source: The Researcher's fieldwork (2022)

machine
Source: The Researcher's fieldwork (2022)

A speed regulator was introduced into the fabricated machine after the researcher discovered that the speed of the motor which is a high-speed motor was too high to achieve the set objects.

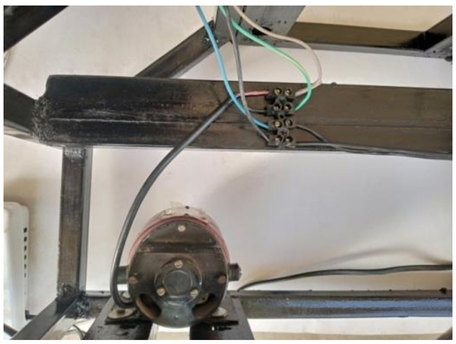

Plate 7: Inserting a Connector as the central point of all connections to avoid electricity shock during operation
Source: The Researcher's fieldwork (2022)

Plate 8: Setting and fixing of the Alco-board on the fabricated electric yarn winder.
Source: The Researcher's fieldwork (2022)

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Components used for the fabrication and their functions

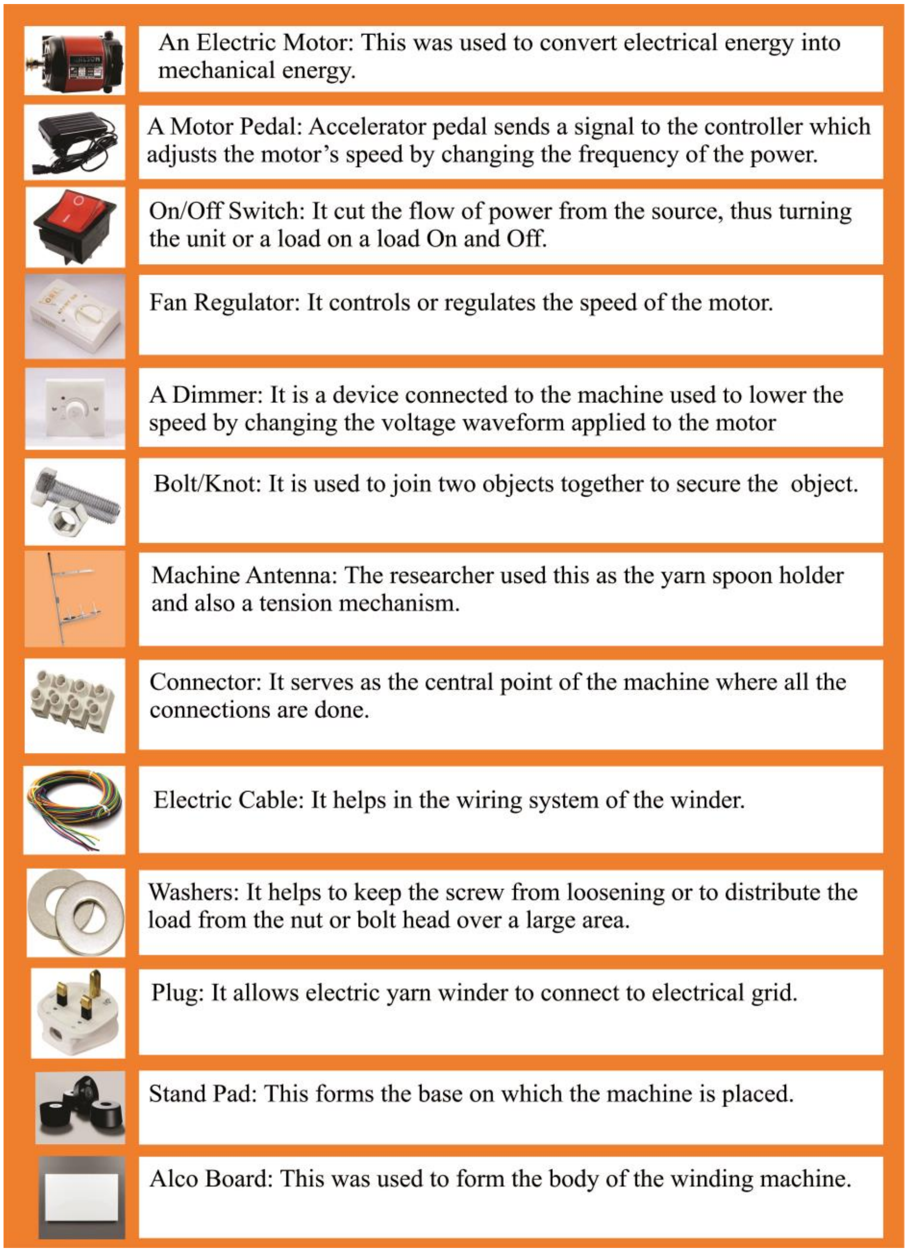

Figure 7: Components used for the fabrication and their functions.
Source: *Researcher's fieldwork (2022)*

Print ISSN 2735-5357
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Online ISSN 2735-5365

5. Results and Discussion

An electric yarn winder has been designed, fabricated and evaluated using procedures that are standard. The results for rotational speed and machine capacity were obtained and presented in Table 1.

Testing Parameters

Data collected was carefully recorded and used for the analysis of the electric yarn winding machine using the following output parameters:

i. Machine capacity (Kg/hr)
ii. Rotational speed (rpm)
iii. Winding Time (minutes)

The machine parts were assembled firmly and lubricated within the rotating parts. Without wobbling or making of noisy sound, the motor freely rotated during testing without load. When fully loaded, the electric yarn winder wound yarn into the bobbing from the cone within a short time. Manually, the 3 cones of yarn were placed into the yarn trays on the machine antenna from where they were wound on the bobbin already fixed on the motor shaft. The time taken to wind the yarns were recorded for 10 experimental runs using different speed ranges as calibrated on the hand regulator.

Plate 9: The Yarn Winding Process.
Source: *Researcher's field work (2022)*

Plate 10: Researcher Monitoring the Winding Process.
Source: *Researcher's field work (2022)*

A set of ten (10) test samples were carried on the Electric Winding Machine for rotational speed and time taken. The following results were obtained:

Print ISSN
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VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN
2735-5365

Table - 4.1 Results of Rotational Speed (rpm) and Time Taken (minutes)

Experimental Runs	Rotational speed (rpm)	No of Bobbins Wound.	Time taken (minutes)
Test 1	40.5	1	9.46
Test 2	42.6	1	8.5
Test 3	43.3	1	7.9
Test 4	43.8	1	6.32
Test 5	44.3	1	5.32
Test 6	45.4	1	4.38
Test 7	46.2	1	4.1
Test 8	47.6	1	3.80
Test 9	49.1	1	2.80
Test 10	50.2	1	2.2
	Total Speed= 453 Average 45.3r.p.m	Total Bobbins = 10 Average 1	$\sum = 54.78$ Average 5.48 minutes

A DT – 2234C$^+$ Tachometer was used to measure the rotational speed of the shaft and the above values were recorded as shown in Table 2.
Ten (10) experimental replicates were carried out using the electric yarn winder with 3 varying yarn trays. In an average time of 4mins the experiments were carried out with records taken per duration of time.

Print ISSN
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VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN
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Table 2: Bill of Engineering Measurement and Evaluation (BEME) used for the design and fabrication of the Electric Winder for Hand-woven Fabric Production.

S/N	Description	Materials	Quantity	Rate	Total Cost (₦)
1	Mild Steel	2x1 Pipe	2	₦ 2,000:00	₦ 4,000:00
2	Alcoboard	4x3 Ft	1	₦10,000:00	₦10,000:00
3	Electric Motor	0.5 Amps (50Hz)	1	₦28,000:00	₦28,000:00
4	Paint	1 ltr	1	₦ 2,000:00	₦ 2,000:00
5	Welding Electrods	Guage 14	1 Packet	₦ 2,000:00	₦ 2,000:00
6	Condemned Sewing Machine Antenna	Yarn Carriers	1 set	₦ 3,500:00	₦ 3,500:00
7	Bots and Nuts/Screws	Steel M 101.25	80	₦ 50:00	₦ 4,000:00
8	Dimmer Regulator	Hand Control	1	₦ 1,200:00	₦ 1,200:00
9	Sewing Machine Pedal	Foot Control	1	₦ 3,500:00	₦ 3,500:00
10	On/Off Switch	Power Supply	1	₦ 1,500:00	₦ 1,500:00
11	Electric Cables/Wires	1.5X3cores	8yrds	₦ 500:00	₦ 4,000:00
12	Electric Connector	4units	2	₦ 1,000:00	₦ 2,000:00
13	Labour			₦ 6,000:00	₦ 6,000:00
14	Miscellaneous			₦ 5,000:00	₦ 5,000:00
TOTAL				**₦66,250:00**	**₦76,700:00**

Print ISSN
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VOLUME 6, ISSUE 1, 2023, 167 – 181.
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2735-5365

Table 2. Bill of Engineering Measurement and Evaluation (BEME)

With the above presentation of the finished fabricated electric yarn winder for hand woven fabric production using locally sourced materials as shown in plates 4.1 and 4.2, the researcher could be said to have achieved object two of the research work.

6. Conclusion

In conclusion, the development of an electric yarn winder for hand woven fabric production has significant benefits in terms of efficiency, accuracy, and speed over traditional manual winding methods. Electric yarn winders are capable of handling large volumes of yarn and producing consistent, high-quality results. The results of the performance evaluation showed that the electric yarn winder has a machine capacity of 641Kg/hr., average winding time of 5.48 minutes and average rotational speed for using the pulley at 45.3 rpm. Maintenance of the machine is easy as rotating parts are lubrication and cleaned after usage. The design of an electric yarn winder involves several components, including a motor drive system, tensioning mechanism, and control unit. The motor and drive system provide the power to wind the yarn, while the tensioning mechanism ensures that the yarn is wound tightly and evenly. The control system on the other hand helps to regulate the speed of the winder per time depending on the desire of the operator. Overall, the development of electric yarn winders has revolutionized the fabric production industry, making the process faster, more efficient, and more accurate. With this new electric yarn winder, the problems of duration, quality and quantity of cloth weaving preparation associated with manual winding have been eliminated. The electric yarn winder is environmentally and user friendly and does not require any special skill to operate.

7. Recommendations

Based on the current findings by the researcher on the development of electric yarn winders for hand woven fabric production, the following recommendations were made:

1. There should be Continuity in the improvement of the precision and accuracy of electric yarn winders: While electric yarn winders already provide more consistent results than manual winding methods, further research and development should focus on improving their precision and accuracy to meet the increasing demands of the fabric production industry.

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VOLUME 6, ISSUE 1, 2023, 167 – 181.
Online ISSN 2735-5365

2. Weavers are encouraged to explore the use of advanced materials and technologies: The use of advanced materials and technologies, such as nanofibers and microfluidic channels, could potentially improve the efficiency and performance of electric yarn winders. Research in these areas could lead to the development of new and innovative yarn winding technologies.

3. Develop more energy-efficient electric yarn winders: While electric yarn winders are already more efficient than manual winding methods, there is still room for improvement in terms of energy consumption. Future research could focus on developing more energy-efficient motors and drive systems to reduce the environmental impact of fabric production.

4. There is need to investigate the use of artificial intelligence and machine learning: The integration of artificial intelligence and machine learning technologies could potentially improve the performance and efficiency of electric yarn winders. These technologies could be used to optimize the winding process by adjusting parameters in real-time based on feedback from sensors and other sources.

1. Textile friendly policies such as reduction of tax should be adopted by the government of the day to ensure improved economic incentives.
2. Government should focus mainly on providing strong support for technical training as well as educational programs related to the textile industries just like the Chinese Textile industries who have invested much on training the workforce in modern technology and management skills.
3. The government should demand an improvement in the output and productivity from Textile industries to encourage innovations, and innovators periodically come together and sell their innovations to other industries.

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Online ISSN 2735-5365

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