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Invention of a Portable Bobbin Winder for the Ghanaian Indigenous Weaving Industry

Gbadegbe Richard Selase[1], Vigbedor Divine[1], Quashie Mawuli[1], Bijou Asemsro[2]

[1]Department of Industrial Art, Ho Technical University, Ho, Ghana

[2]Department of Fashion Design and Textiles, Ho Technical University, Ho, Ghana

Email address:
richotat@yahoo.com (G. R. Selase)

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Abstract: Weaving consists of the interlacing of warp and weft yarns at right angles to form a fabric. Fabric is usually woven on a device known as a loom. Before weaving is carried out on the loom, the warp and weft yarns are prepared using some special devices. The warp yarns or ends are prepared using the warping mill while the weft is prepared using the bobbin winder. In Ghana, different versions of the bobbin winder exist. A cursory glance at the types of bobbins in Ghana reveal that manually operated bobbin winders used by local weavers are slow and yarns produced from them slough off very easily due to uneven tensioning during winding. Aside that, the use of automatic bobbin winders is limited to only places where there is electricity and they are too big and heavy to carry around. This study is therefore aimed at producing an efficient and portable bobbin winder to be used by students and local artisans in the field of weaving for weft preparation. The descriptive research method was employed for the study. A major finding of the study is that a number of bobbins were prepared within two minutes using the three gear train device. It is therefore recommended that more gear trains are introduced into the machine to enhance the speed and efficiency of winding.

Keywords: Bobbin Winder, Bobbin, Warp Yarn, Weft Yarn, Warping Mill and Fabric

1. Introduction

Weaving is one of the fabric construction techniques used in Ghana 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 Ghana, the indigenous weaving industry is very vibrant and lucrative. Woven fabrics such as *fugu*, napkins, curtains and *kente* are produced on hand-looms or what we call foot power looms to satisfy the fabric needs of society. In Ghana, the *kente* loom, table loom and broad loom are the most common looms used for weaving. Adu-Akwaboah [1]

Before weaving commences, there are certain preparatory processes that have to be carried out to ensure smooth and efficient weaving. These preparatory processes are in two stages 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. Ross [2]. The weft yarns on the other hand are prepared by using a device known as a bobbin winder. According to Badoe and Opoku-Asare [3], 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. This repeated action results in the formation of the woven fabric.

Available literature on the subject matter reveals that different types of bobbin winders exist in Ghana and across the world. Picton [4]. 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 Ghana is slow and yarns produced from them slough off very easily due to uneven tensioning during winding. Aside that, the use of automatic bobbin winders is limited to only places where there is electricity. Quite apart from that, most of the automatic bobbin winders are too big and heavy to carry about.

This study therefore focuses on designing and invention of a portable bobbin winder which can easily be carried around and used anywhere; whether there is electricity or not. The device will have three train of gears attached to a spool and upon the rotation of a lever or a handle; the spool will wind the yarn onto the bobbin. Apart from giving motion to the spool, the gears will prevent sloughing off of yarns from the bobbin. The portable bobbin winder is small and light-weight and can be carried easily from one place to another. In addition, the bobbin winder will have a clamp which will enable it to be attached to a table or any solid surface for winding to take place.

2. Review of Related Literature

This session of the study is dedicated to the review of related literature on the topic under discussion. Various literature sources including books, journals and internet have been consulted to obtain adequate secondary data for the study. For the purpose of cogent and logical presentation, the session has been sub-divided into the following headings: History of weaving, Types of loom accessories, Types of bobbin winders and summary of discussions.

2.1. History of Weaving

Weaving is the production of fabric by interlacing two sets of yarns so that they cross each other, normally at right angles, usually accomplished with a hand or power-operated loom. The earliest evidence of weaving, closely related to basketry, dates from Neolithic cultures of about 5000 BC. Weaving apparently preceded spinning of yarn; woven fabrics probably originated from basket weaving. Cotton, silk, wool, and flax fibres were used as textile materials in ancient Egypt; cotton was used in India. Anni [5]

In weaving, lengthwise yarns are called warp; crosswise yarns are called weft, or filling. Most woven fabrics are made with their outer edges finished in a manner that avoids ravelling; these are called selvages. They run lengthwise, parallel to the warp yarns. The three basic weaves are plain, twill, and satin. Fancy weaves—such as pile, Jacquard, dobby, and leno—require more complicated looms or special loom attachments for their construction. Collier [6].

According to Broudy[7], there are some indications that weaving was already known in the Paleolithic era, as early as 27,000 years ago. An indistinct textile impression has been found at the Dolní Věstonice site. According to the find, the weavers of Upper Palaeolithic were manufacturing a variety of cordage types, produced plaited basketry and sophisticated twined and plain woven cloth. The artefacts include imprints in clay and burned remnants of cloth.

The oldest known textiles found in the Americas are remnants of six finely woven textiles and cordage found in Guitarrero Cave, Peru. The weavings, made from plant fibres, are dated between 10100 and 9080 BCE.

The earliest known Neolithic textile production in the Old World is supported by a 2013 find of a piece of cloth woven from hemp, in burial F. 7121 at the Catalhoyuk site suggested to be from around 7000 B.C. Further finds come from the advanced civilisation preserved in the pile dwellings in Switzerland. Another extant fragment from the Neolithic was found in Fayum, at a site dated to about 5000 BCE. This fragment is woven at about 12 threads by 9 threads per cm in a plain weave. Flax was the predominant fibre in Egypt at this time (3600 BCE) and continued popularity in the Nile Valley, though wool became the primary fibre used in other cultures around 2000 BCE. Weaving was known in all the great civilisations, but no clear line of causality has been established. Early looms required two people to create the shed and one person to pass through the filling. Early looms wove a fixed length of cloth, but later ones allowed warp to be wound out as the fell progressed. The weavers were often children or slaves. Weaving became simpler when the warp was sized. Dolni Vestonice and Pavlov sites "[8]

According to Rozentals [9], Weaving is acknowledged as one of the oldest surviving crafts in the world. The tradition of weaving traces back to Neolithic times – approximately 12,000 years ago. He further reveals that even before the actual process of weaving was discovered, the basic principle of weaving was applied to interlace branches and twigs to create fences, shelters and baskets for protection.

20,000 – 30,000 years ago early man developed the first string by twisting together plant fibres. Preparing thin bundles of plant materials and stretching them out while twisting them together to produce a fine string or thread. The ability to produce string and thread was the starting place for the development of weaving, spinning, and sewing. Jenkins [10].

Stone Age Man’s early experiments with string and thread led to the first woven textiles. Threads and strings of different sizes were knotted and laced together to make many useful things. Finger weaving, lacing and knotting together of threads by hand, is still used today by many weavers. During the Neolithic Era mankind developed great skill in weaving cloth. Every household produced cloth for their own needs. Weaving cloth remained an activity associated with the family unit for thousands of years. Sam [11].

By the 11th century, many of the weaving patterns used today had been invented. Skilled weavers developed highly specialized cloth. During this time the task of weaving cloth began slowly to move away from the family unit into specialized work places. Cloth weaving became a mechanized industry with the development of steam and water powered looms during the Industrial Revolution (1760 – 1815). The invention of the fly shuttle removed the need to have a weaver place the weft thread into the warp by hand. Pacey [12]

John Kay of Bury, England, first discovered flying shuttle in 1733 which speeded the process of weaving and the production was almost doubled. A fly shuttle is a long, narrow canoe-shaped instrument, usually made of wood, which holds the bobbin. The Jacquard Machine was developed in the early 1800s. This revolutionary machine used a punch card mechanism to operate the loom and is credited as the basis of modern computer science. A textile woven on a loom with a Jacquard Machine can have very complicated patterns. Rozentals [9]

The technological innovations in cloth production made during the Industrial Revolution dramatically changed the role of the weaver. Large volumes of inexpensive cloth were now readily available. Weaving had been changed to a manufacturing industry. Textile workers were among the founders of the modern labour movements. Maya [13]

Today most of our textile needs are supplied by commercially woven cloth. A large and complex cloth making industry uses automated machines to produce our textiles. However, there are artisans making cloth on hand looms, in home studios or small weaving businesses, who keep alive the skills and traditions of the early weavers. Smith [14]

2.2. Types of Loom Accessories

The study basically bothers on weaving accessories and these are identified and described in the following section of the write up.

2.2.1. Reed

This is a comb-like device on a loom that separates the warp yarns and also beats each succeeding filling thread into the fell of the fabric. The reed usually consists of a top and bottom rib of wood into which metal strips or wires are set. The spaces between two adjacent wires are called dents (or splits) and the warp is drawn through these dents. The fineness of the reed is calculated by the number of dents per inch. There are different types of reed sizes ranging from 15 inch reed, 18 inch reed, 20 inch reed, 25 inch reed, 30 inch reed and so on. The higher the reed size, the finer the weave.

Figure 1. *Reed.*

2.2.2. Reed Hook

This is a flat metallic piece used for passing the warp ends through the dents of the reed. It has a hook at one side and sometimes comes with two hooks at both ends as shown in the next figure.

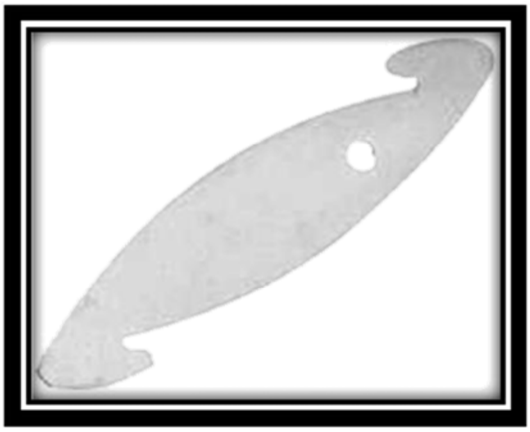

Figure 2. *Reed Hook.*

2.2.3. Heddling Hook

This is a thin rod with a hook and wooden handle employed for passing the warp yarns through the eyes or centre loops of the healds or heddles. The heddling hook is used in drawing the warp yarns through the healds eye held on the shafts.

Figure 3. *Heddling Hook.*

2.2.4. Shuttle

This is a boat-shaped device usually made of wood with a metal tip that carries filling yarns through the shed in the weaving process. It is the most common weft-insertion device. The shuttle holds a quill or pirn, on which the filling yarn is wound. It is equipped with an eyelet at one end to control the rate of releasing the filling.

Figure 4. *A pair of Shuttles.*

2.2.5. Bobbin

In textile production, a cylindrical or slightly tapered wood, cardboard or plastic core on which yarns are wound for operations such as weaving and dyeing among others is referred to as a bobbin. It has a hole in the centre so that it will fit on a spindle, skewer, shaft or other holding devices like the shuttle.

Figure 5. *Bobbin.*

2.2.6. Bobbin Winder

It is a wooden or metallic frame used for winding yarns onto bobbins. It has a wheel with handle against a rod which is used for holding bobbins during winding of weft yarns. This accessory is used for winding the weft yarns on cone packages onto the bobbins.

Figure 6. *Bobbin Winder.*

2.2.7. Raddle

This is a device used for spreading out warp yarns evenly and aligns the ends parallel to each other as they are wound onto the warp beam. It is wooden and comb-like in structure with dents but has wider dents per inch as compared to the reed.

Figure 7. *Dents per inch Raddle.*

2.2.8. Tensioning Box

This is a wooden box loaded with weight that is used for stretching the warp yarns under tension during beaming.

Figure 8. *Tensioning box.*

2.2.9. Warping Mill

A vertical wooden frame used for warping or milling. The warp yarns are wound around this accessory under the guide of a measured length of thread. It has two poles at the top and a pole at the lower part of the mill. The two poles are responsible for making crosses whilst the single pole is for holding the tail end of the yarns under tension.

Figure 9. *Warping Mill.*

According to a survey of Badoe and Opoku-Asare [3], weavers in Agortime community in the Volta Region rely on manual single bobbin winders that had no tension devices and as a means to control the winding process to achieve conical shaped bobbins that would withstand yarn slough-off. Below is the type of bobbin winder used by the local / indigenous weavers in the Agortime community.

2.3. Types of Bobbins

Before the yarn is woven into fabric, it has to be prepared and made suitable for weaving to take place. There are two main preparatory processes that are carried out. These are: the weft preparation and the warp preparation. During weft preparation, the yarn to be used as weft has to be wound onto pirns for power loom weaving. Pirns are specially designed bobbins with tapered ends used on the power loom. Yarns are wound onto pirns by a machine called pirn winder. In case of broad loom weaving, the weft yarns are wound onto small bobbins designed to fit into broad loom shuttles.

According to Adu-Akwaboa[1], hanks and cheeses are fixed on a skein winder and a spool rack respectively and wound onto bobbins with the help of a bobbin winder. The number of plies for the weft depends on the design to be produced. If the fabric to be produced should be thick, then the plies are increased. If two ply or four ply yarn is needed, two or four hanks or cheeses are fixed on the skein winder or spool rack respectively.

Badoe and Opoku-Asare [3] state that bobbin winding is an integral aspect of weft preparation for weaving. Bobbin winders used by cloth weavers in the indigenous Ghanaian textiles industry have capacity to produce single bobbins only at a time, which lengthens the yarn preparation and weaving periods, and reduced productivity of cloth weavers.

According to them, they have produced a Multiple Colour Bobbin winder which is semi-automatic, capable of winding multiple bobbins with single or multiple coloured yarns of uniform tension concurrently within a short time for higher rate production of woven fabrics in direct contrast with existing bobbin winders. The picture of the Multiple Colour Bobbin winder is as follows:

Figure 10. *Multiple Colour Bobbin Winder.*

As Olaoye [15] suggests for the indigenous weaving industry in Nigeria, innovations are required in the global weaving industry as technology and development abound in recent times. It is appropriate therefore to explore the possibility of modernizing traditional crafts instead of abandoning them altogether. In this respect, the tools, equipment and operations of the traditional weaving industry in Ghana is also open to modernization for improved processes and products.

As Olaoye (1989) states, there is also the need for small-scale technological improvements in the industry to be within the control of the weavers. Weft preparation primarily revolves around bobbin winding, which essentially involves the use of a manual bobbin winder that enables the weaver to unwind yarns from their packages onto pins. Bobbins or the yarns that are packaged on pins are inserted into a shuttle and in the course of weaving, the shuttle traverses an open shed and leaves in its trail, the weft yarn that interlaces with the warp yarn to form a woven fabric.

In non-electrical applications, a coil of wire carrying a current has important magnetic properties. As used in spinning, weaving, knitting and sewing, or lace making, the bobbin provides temporary or permanent storage for yarn and may be made of plastic, metal, bone or wood.

Bobbin lacemaking is a handicraft which requires the winding of yarn onto a temporary storage spindle made of wood, previously bone, often turned on a lathe. Many lace designs use dozens of bobbins at any one time. Exotic woods are extremely popular with contemporary lace makers. Both traditional and contemporary bobbins may be decorated with designs, inscriptions, or wire inlays. Often, the bobbins are spangled to provide additional weight to keep the thread in tension. A hole is drilled near the base to enable glass beads and other ornaments to be attached by a loop of wire. Again, in the modern context of the hobby of bobbin lacemaking, this spangled bobbin provides a means of self-expression in the decoration of a tool of the craft. Both antique and unique bobbins, sometimes spangled, have become highly sought after by collectors. In the case of an electric transformer, inductor or relay, the bobbin is a permanent container for wire, acting to form a shape of the coil (and ease assembly of the windings into the magnetic core.). The bobbin may be made of thermoplastic or thermosetting (for example, phenolic) materials. This plastic often has to have a TUV, UL or other regulatory agency flammability rating for safety reasons.

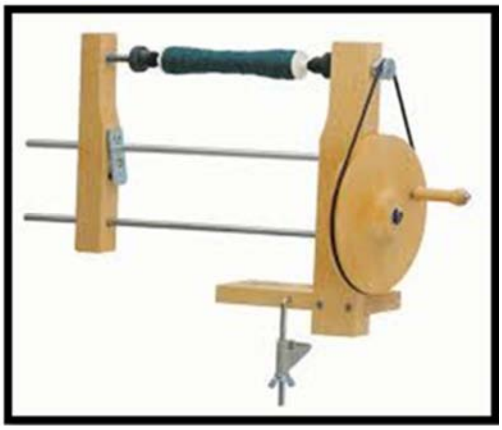

Figure 11. *Local Bobbin Winder.*

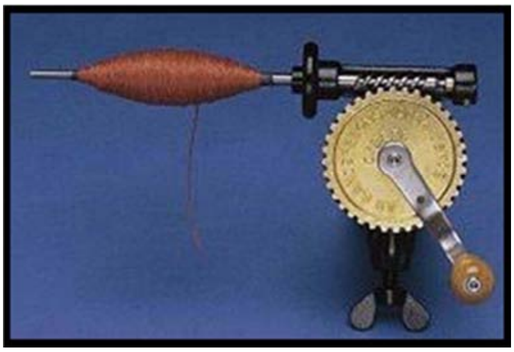

Figure 12. *Advance Manual Bobbin Winder.*

2.4. Summary of Discussions

This section of the paper was dedicated to the review of literature from various sources related to the study. It was introduced by the historical background of weaving where various historical accounts were reviewed on weaving. Also an attempt was made to catalogue the weaving accessories which exist in Ghana and the world over. Additionally, the different types of bobbin winders on the textile market were reviewed and it was observed that there are different categories of manually operated bobbin winders that exist, however none of them has the features of the portable bobbin winder. It is therefore an undeniable fact that the project is a novelty.

3. Methodology

3.1. Overview

This part of the study describes the various research methods and approaches adopted to collect and interpret data. It is divided into Research Design, Population of the Study, Sampling Technique, Data Collecting Instruments and Summary of Discussions.

3.2. Research Design

The study employed the descriptive research methodology to describe the various stages involved in constructing the Portable Bobbin Winder. It was combined with observation and the questionnaire approach to solicit relevant information from respondents.

3.3. Population of Study

The population of the study is made up of 40 traditional weavers in the Ho Municipality, 15 lecturers of the textiles section of Ho Technical University, 45 Textiles Students of Ho Technical University and 20 Textiles Tutors of selected Senior High Schools in Ho and its environs. Hence the total population of the study is 120 respondents.

3.4. Sampling Technique

The sampling technique used for the study is purposive sampling technique. This type of sampling technique was adopted for the study because according to the judgement of the researchers, the selected respondents have the requisite knowledge on the research topic.

3.5. Data Collecting Instruments

The data collecting tools used for the study are observation and questionnaire. The Observational approach was used to observe already existing bobbin winders in the local textiles industries in Ghana. It was observed that a good number of the bobbin winders being used by the traditional weavers are obsolete and lack the necessary features that will enhance effective weaving.

The survey (questionnaire) approach was adopted to sample the objective view of respondents on the topic under discussion. A 3-page questionnaire copy was administered to Traditional Weavers, Textile Lecturers, Textiles Tutors and Textiles students of Ho Technical University. The questions bothered on the following:

i. The knowledge of respondents on weaving in general.
ii. Whether or not they are conversant with the weaving processes.
iii. Whether they could mention the equipment used for weaving.
iv. Whether the respondents are conversant with the process of weft preparation and the equipment used.
v. Their knowledge was also tested on the types of bobbins that exist.
vi. Efficiency of the bobbins being used by cottage weavers in Ghana.
vii. Whether or not they are satisfied with the efficiency of the existing bobbin winders in the country.

3.6. Summary of Discussions

This section of the study presented the various research methods employed to collect and interpret data. It also discussed the sampling techniques as well as the research instruments used for collecting data. The next part of the paper will discuss the analysis and interpretation of data.

4. Analysis and Interpretation of Data

4.1. Overview

This section of the study presented the various research methods employed to collect and interpret data. It also discussed the sampling techniques as well as the research instruments used for collecting data. The next part of the paper will discuss the analysis and interpretation of data

Table 1. *Status of respondents.*

Status of Respondents		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	HTU Students	45	37.5	37.5	37.5
	Textiles Lecturers	15	12.5	12.5	50.0
	Traditional Weavers	40	33.3	33.3	83.3
	Textiles Tutors	20	16.7	16.7	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

Table 1 above displays the status of respondents sampled for the study. In all, 120 respondents were purposively sampled for the study. And out of this, 37.5% of them were HTU students, 33.3% of them were Traditional Weavers while 16.7% of the respondents were Textiles Tutors.

Table 2. *Age of respondents.*

Age Distribution		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below30	65	54.2	54.2	54.2
	31-40	35	29.2	29.2	83.3
	41-50	14	11.7	11.7	95.0
	51-60	6	5.0	5.0	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

In table 2 above, the age distribution of respondents has been described. As much as 54.2% of the respondents fell below the youthful age of 30 years. This explains the relative high number of youth engaged in weaving. Additionally, 29.2 % of the respondents were from 31 years of age to 40 years. Meanwhile, 11.7% of the respondents fell within the age bracket of 41 to 50. Furthermore, 5% of the respondents who participated in the study range from 51 to 60 years.

Table 3. *Gender of respondents.*

Gender Distribution		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	83	69.2	69.2	69.2
	Female	37	30.8	30.8	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

The table above presents the Gender distribution of respondents. The table indicates that 69.2% of the respondents are male while 30.8% are female. This is indicative of the fact that more males are involved in weaving than female.

Table 4. *Educational level.*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Tertiary	80	66.7	66.7	66.7
	SHS	14	11.7	11.7	78.3
	JHS	26	21.7	21.7	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

In table 4 above, the Educational Level of respondents has been analysed. It is evident from the results that most of the respondents (66.7%) are products of tertiary institutions while 21.7% of the respondents are JHS leavers. Also, 11.7% of the respondents are SHS leavers.

Table 5. *Testing respondents' knowledge about weaving?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	120	100.0	100.0	100.0

Source: Field Data June 2018.

The table above (table 5) presents test results obtained after testing respondents' knowledge on weaving. It became clear from the results that all (120) respondents have some knowledge about weaving. This justifies the reason why the researchers chose Purposive Sampling technique for the study.

Table 6. *If yes, specify the type of loom quizzing respondents to mention some weaving devices.*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Traditional loom	64	53.3	53.3	53.3
	Table loom	22	18.3	18.3	71.7
	Broadloom	18	15.0	15.0	86.7
	Mechanical loom	16	13.3	13.3	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

In table 6 above, respondents were quizzed to mention some of the weaving devices that they know. After collating the results, it became crystal clear that most of the respondents (53.3%) mentioned traditional loom while 18.3% of the respondents mentioned table loom. Additionally, 15% of the respondents stated that they were more conversant with the broad loom. Meanwhile 13.3% of the respondents intimated that they were more conversant with the mechanical loom.

Table 7. *What equipment is used for warp preparation?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Warping mill	44	36.7	36.7	36.7
	Reed	29	24.2	24.2	60.8
	Pirn winder	27	22.5	22.5	83.3
	Spool rack	11	9.2	9.2	92.5
	Warping machine	9	7.5	7.5	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

In table 7 above, respondents were again asked to mention some more weaving equipment but this time round they were specifically quizzed on the device or equipment used for warp preparation. The results obtained are quite revealing: as many as 36.7% of the respondents mentioned warping mill. Also, 24.2% of the respondents mentioned reed while 22.5% of the respondents mentioned pirn winder. Additionally, 9.2% of the respondents categorically stated that spool rack is used for warp preparation. Finally, 7.5% of the respondents mentioned warping machine.

Table 8. *What equipment is used for weft preparation?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weft board	18	15.0	15.0	15.0
	Pirn winder	30	25.0	25.0	40.0
	Bobbin winder	63	52.5	52.5	92.5
	Weft winding machine	9	7.5	7.5	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

The results obtained after questioning respondents on the equipment or devices used for weft preparation have been presented in table 8 above. The results are as follows: most of the respondents (52.5%) selected bobbin winder while 25.5% mentioned pirn winder. Additionally, 15% of the respondents mentioned weft board and 7.5% mentioned weft winding machine.

Table 9. *Have you ever used any winder for your weft preparation?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	120	100.0	100.0	100.0

Source: Field Data June2018.

The result presented in table 9 above is an affirmation that 100% of the respondents are conversant with weaving and its processes. However that doesn't preclude the researchers from drawing the conclusion that not all the respondents know the equipment or devices used for warp and weft preparation as shown in table 7 and 8 above.

Table 10. *How efficient was the winder?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Best	14	11.7	11.7	11.7
	Fairly good	85	70.8	70.8	82.5
	Bad	21	17.5	17.5	100.0
	Total	120	100.0	100.0	

Source: Field Data June 2018.

The results obtained after testing the efficiency of existing bobbin winders used by the respondents is displayed in the table 10 above. As many as 70.8% of the respondents corroborated the inefficiency of the existing bobbin winders. Furthermore 17.5% of the respondents added that the existing bobbin winders were not in the best of conditions. Meanwhile only 11.7% of the respondents gave some positive comments about the existing bobbin winders.

Table 11. *What are some of the deficiencies of the existing bobbin winders?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sloughing off	14	11.7	11.7	11.7
	Uncontrolled speed	62	51.7	51.7	63.3
	Uneven winding	32	26.7	26.7	90.0
	Bulkiness of yarn	12	10.0	10.0	10.0
	Total	120	100.0	100.0	100.0

Source: Field Data June 2018.

In table 11 above, the test results obtained after quizzing respondents about the deficiencies of the existing bobbin winders are displayed. The results obtained are quite revealing. In the results, 51.7 % of respondents stated that the existing bobbin winders have uncontrolled speed. Also, 26.7% of the respondents mentioned uneven winding as one of the deficiencies found on some of the existing bobbin winders. Furthermore, 11.7% of the respondents mentioned sloughing off as one of the deficiencies found on the existing bobbin winders. Meanwhile 10% of the respondents categorically mentioned bulkiness of yarn as one of the deficiencies.

Table 12. *In your opinion will a portable winding device be appropriate to solve the inefficiency in the current winding device?*

		Frequency	Percent	ValidPercent	CumulativePercent
Valid	Yes	120	100.0	100.0	100.0

Source: Field Data June 2018.

At this stage of the research, a prototype of the portable bobbin winder was shown to the respondents to test its suitability for weft preparation. After having a feel of its mode of operation, 100% of the respondents (as shown in table 12) were certain that the portable bobbin winder will be able to solve the inefficiencies associated with the current winding devices.

Table 13. *Would a three (3) gear winder be appropriate to solve the bulkiness and maintain constant speed in winding?*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	120	100.0	100.0	100.0

Source: Field Data June 2018.

Knowing very well that the portable bobbin winder will have a 3 gear system, the researchers thought it wise to test the view of respondents on the innovation. There was a 100% affirmation of respondents to solve the problem of bulkiness of yarn using a 3 gear winder.

4.2. Production Processes

There are various ways to prepare weft yarns for insertion into the warp shed or opening during weaving. The traditional devices used for weft preparation are bedeviled with multiple challenges. The researchers therefore designed and constructed the "Portable Bobbin Winder." The device is made of a three (3) gear train made of cast iron and nylon materials. It also comes with the following features including a handle made of metal and wood that drives the three train gears, a flat metallic plate fashioned to hold the gears and other metal supports welded unto the frame to accommodate the shaft and the gears as well as the bobbin spindle. It is secured well onto a table or flat body with the help of a stopper and guide plate. The Portable Bobbin Winder which is (22cm x 14cm x 3cm) in size, can easily be carried everywhere for winding and does not require electricity for its operations. The winder operation is less stressful and easily manipulated by an individual.

4.3. Tools and Materials

The following tools and materials were used to design and construct the bobbin winder: welding machine, file, grinding machine, electrode, hacksaw, tape measure, vice, pencil and eraser, bolts and nuts, screws, various taps and dices, galvanize metal plate, brush, washers, mild steel rod, nylon block, and sand paper. The gears used for the production of the bobbin winder are in the ratio of (1: 2: 7).

4.4. Production

i) After a critical observation of the existing traditional bobbin winders, it was noticed that most of the winders are made solely of wood with a pulley and belt transmission.

On the other hand, foreign winders which are made of metal had only two gear trains mostly made of worm and bevel gears. The three gear train mechanism which is more efficient was adopted by the researchers. This comprises 137T, 41T and 19T gears. With the help of the lathe, the 137T was turned and machined with perforated whole to make the gear light in weight. The other two 41T and 19T were machined from a nylon rod giving it a light weight and prevent rapid wear and tear by meshing with 137T gear made of cast iron.

Figure 13. *137T Gear.*

Figure 14. *41T Gear.*

Figure 15. *19T Gear.*

Secondly, three pieces of a 4mm flat metallic plate of 5cm wide was cut 21cm long with the aid of a hacksaw. The pieces were welded and re-shaped to the required dimension to serve as the main framework to which all the other parts of the bobbin winder will be fixed. The other components were cut and welded onto the frame. These were made up of a metal block (5cm x 1.5cm x 1.5cm) to hold in place the 41T and 19T gear shafts with screws.

Front

Back

Figure 16. *Welded Metallic Plate to form the structural frame work of the device.*

Figure 17 below depicts how the 137T gear is centred with a machined shaft, threaded at both ends and secured with a locker pin to keep the shaft taut. The picture depicts the right side of the shaft squared to hold the squared handle to enable a good grip when turned. Figure 18 on the other hand depicts how the handle has been fitted to the shafts.

Figure 17. *Shaft secured on gear 137T.*

Figure 18. *Handle fitted to the shaft.*

The 41T gear was then drilled in the middle and a brass bushing fitted into it to prevent the wear and tear of the shaft and also to ensure smooth running of the shaft as shown in figure 19 below:

Figure 19. *Shaft and bushing in 41T Gear.*

The 19T gear was fitted onto a spindle and secured with a locker pin. On the shaft is a groove which is attached with a screw to keep the gear in check during winding. The spindle reduces in size as it moves to the tail end for easy fixing and removal of the bobbin as depicted in figure 20 below.

Figure 20. *Spindle imbedded into 19T gear.*

The three gear train was then mounted onto the main framework well meshed and aligned and secured with screws and nuts as shown in figure 21. Figure 22 shows the picture of a fabricated metal cover which was used to cover the set of gears in order to prevent dust and other unwanted materials from causing the entanglement of the gears and to also avoid the spread of oil and grease onto the yarns.

Figure 21. *Assemblage of three gear train.*

Figure 22. *Metal cover.*

The fabricated metal cover was fixed and secured with screws as shown in figure 23. It also shows how the handle has been fixed and secured with washer and nut.

Figure 23. *Handle Fitted onto shaft.*

4.5. Finishing

Finally, the apparatus was given a finishing treatment by smoothening all the welded areas with the grinding machine and polishing with sand paper. This was followed by priming and painting with a grey colour with the help of a brush.

Figure 24. *Finished product.*

4.6. Mode of Operation

The Portable Bobbin Winder can be used anywhere and needs no electricity for its operations. The device is easy to operate without any difficulties. To use the device, a flat surface (ie table, board) is required to mount the machine and tighten it with an adjustable screw to keep it stable.

The empty bobbin is fixed onto the spindle and the yarn to be wound is wrapped around and after that the handle is used to drive the 137T gear which in turn drives the 41T and subsequently drives the 19T which carries the spindle to which the bobbin is fixed. This is followed by winding the yarn gradually onto the bobbin.

The yarn to be wound is controlled by one hand and the other hand regulates the handle which gives the motion to the three train gears. After the required size of the bobbin is complete, the bobbin together with the yarn is removed and another empty bobbin is replaced on the spindle and the operation continues till enough bobbins are prepared for weaving.

4.7. Testing of Machine

After the construction of the device, it was tested using an empty bobbin which was fixed onto the spindle. Using the three gear train devices, a number of bobbins were prepared and winding was done within a short period of time and the process was less stressful since the gear ratio used was 1:2:7. It took less than two minutes to get the bobbin full.

Figure 25. *Demonstrating the winding process.*

Figure 26. *Results after winding.*

5. Summary of Findings, Conclusion and Recommendations

5.1. Findings

The following main findings of the study have been itemized:

i. The traditional bobbin winding devices for weft preparation are bedevilled with challenges.
ii. The speed of the traditional bobbin winders can be increased by increasing the number of gears.
iii. The Portable Bobbin Winder can easily be maintained and used anywhere without training.
iv. The enhanced speed of the bobbin winder will have a positive impact on the production rate of weaving.

The device has relatively high speed as compared to the traditional winder and less stressful and little effort is used in the winding operation.

5.2. Conclusions

The textile industry has undergone remarkable changes in its machineries from semi-automated to fully automated machineries including the bobbin or pirn winding machines to meet the demand of the high speed weaving machines.

In the traditional weaving set-up, the winding of bobbin plays a vital role in ensuring a smooth weaving operation. The weaver needs to prepare enough weft bobbins before weaving begins, since winding on the conventional winders are tiresome and cumbersome, the services of other operators are engaged to do a such work.

With the introduction of the Portable Bobbin Winder, the weaver does not need any extra hands to do such a job but can easily wind enough bobbins for their daily work with little effort and time. Moreover the device is handy and working with it makes work less stressful and gives higher productivity. Additionally, the bobbins that are produced using the new device are not too bulky to be loaded into a shuttle. Also, the yarns on the bobbins do not slough off easily.

A conclusion can therefore be drawn based on the findings of the study that the Portable Bobbin Winder is capable of solving the teething problems encountered by the indigenous Ghanaian weavers such as sloughing off, bulkiness of weft package, low productivity and low efficiency during weft winding.

5.3. Recommendations

The following recommendations have been given based on the findings. It is hoped that the recommendations will be implemented to the latter.

i. The machine must be maintained regularly.
ii. The machine must be oiled and greased regularly to prevent corrosion of the metal parts.
iii. Future researchers should use a step-up motor to automate the winding device.
iv. The local weavers must adopt the "Portable Bobbin Winders" to enhance their weaving operation.

It is hoped that the government of Ghana will assist the researchers financially to produce the device on a large scale.

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