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DESIGN AND PROTOTYPE FABRICATION OF POWER DRIVEN SPINNING WHEEL FOR SMALL AND MICRO ENTERPRISES (MSEs)

Bahir Dar University

Ethiopian Institute and Fashion Technology

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DESIGN AND PROTOTYPE FABRICATION OF POWER DRIVEN SPINNING WHEEL FOR SMALL AND MICRO ENTERPRISES (MSEs)

By

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ABSTRACT

Ethiopia, with it's a variety of cultural backgrounds and a variety of natural resources has a rich heritage of crafts of skills. Textile craft, for example considered to be one of the most important and widely spread activities. In Ethiopia, hand spinning and hand weaving are mostly used to produce culture- oriented casual wears. These wears are in good demand from at domestic and international markets. This increases high demand of weft yarn. As part of the handicrafts heritage, Ethiopia has therefore diverse traditional textile products. This sub-sector provides large-scale employment. Hand spinning, is simple value-chain activity. It is pivotal in the cotton sectors that they bind the rural and urban households together. Nowadays very few spinning wheels was made to meet household need and demand for clothing, and then gradually grew to be an additional source of income as an off-farm activity. To create job opportunity and bring foreign currency, providing the sector with technologies is very important. Currently, Far East countries such as China, for example, have been imitating and producing our cultural textile products and export it for us and most developing nations in the world. So, this technological innovation improves the design and fabrication of power driven textile fiber spinning wheel for small and micro enterprises. This has long created good rest for society. It is very important in that it increases productivity and eases it for the spinners/operators and it is compact which requires less space.

Key words: Spinning wheel, Mag/weft yarn, MSEs

ADVISORS'APPROVAL SHEET

ETHIOPIAN INSTITUTE OF TEXTILE AND FASHION TECHNOLOGY (EiTEX)

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I certify that I have supervised /read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in quality and scope, as a thesis for the fulfillment of the requirements for the degree of masters of Textile Technology.

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ACRONYMS

EiTEX: Ethiopian Institute of Textile and Fashion Technology

GPTC: Gondar Polytechnic College

MSEs: Micro and Small Scale Enterprises

TVED: Technical, Vocational and Enterprise Development bureau

TVET: Technical and Vocational Education Training

ANRS Amhara National Regional Investment Office

CHAPTER ONE

INTRODUCTION

This research project proposal comprises of four chapters. Chapter One Introduction; 1.1.Background and justification, 1.2 Statement of the Problems, 1.3.Objectives 1.4.Significance of the research project 1.5 Scope of the research project and 1.6.Limitation of the research project. Chapter Two Literature review, Chapter Three Methodology; Chapter Four Conclusion and Recommendation; and References.

1.1 Back ground and justifications

Spinning is a major part/heart of the textile production process. It is part of the textile manufacturing process where fiber are converted into yarn, then grey fabrics, which undergo finishing processes such as bleaching to become textiles. The textiles are then fabricated into clothes or other products. There are industrial processes and hand craft available to spin yarn, and a handicraft community who use hand spinning techniques. Spinning is the twisting together of drawn out strands of fibers to form yarn, though it is colloquially used to describe the process of drawing out, inserting the twist, and winding onto bobbins.[1]

Hand spinning Hand spinning can be done by using a spindle or the spinning wheel. Spinning turns the carded fibres into yarn which can then be directly woven, knitted (flat or circular), crocheted, or by other means turned into fabric or a garment.

A spinning wheel a spinning wheel is a machine used to turn fiber into thread or yarn. This thread or yarn is then woven as cloth on a loom. The spinning wheel's essential function is to combine and twist fibers together to form thread or yarn and then gather the twisted thread on a bobbin or stick so it may be used as yarn for the loom. The action is based on the principle that if a bunch of textile fibers is held in one hand and a few fibers are pulled out from the bunch, the few will break from the rest. However, if the few fibers are pulled from the bunch and at the same time are twisted the few pulled out will begin to form a thread. If the thread is let go it will immediately untwist, but if wound on a stick or bobbin it will remain a thread that can be used for sewing or weaving. Many different kinds of fibers can be spun on a simple spinning wheel but different fibers require different kinds of pieces or bobbins placed on the spinning wheel and even call for spinning wheels of different size or configuration in order to spin the specific fiber more efficiently.

Early history and developments

Although it has yet to be discovered precisely when man first began spinning fibers into yarns, there is much archaeological evidence to show that the skill was well practiced at least 8000 years ago. Certainly, the weaving of spun yarns was developed around 6000 B.C., when Neolithic man began to settle in permanent dwellings and to farm and domesticate animals. Both skills are known to predate pottery, which is traceable to circa 5000 B.C. It is very likely that wool was one of the first fibers to be spun, since archaeologists believe that sheep existed before Homo sapiens evolved.

The simple spindle continued as the only method of making yarns until around A.D. 1300, when the first spinning wheel was invented and was developed in Europe into “the great wheel” or “one-thread wheel.” The actual mechanization of spinning took place over the period 1738 to 1825 to meet the major rise in the demand for spun yarn resulting from the then-spectacular increase in weaving production rates with the invention of the flying shuttle (John Kay, 1733). Pairs of rollers were introduced to thin the fiber mass into a ribbon for twisting (Lewis Paul, 1738); spindles were grouped together to be operated by a single power source the “water frame” (Richard Arkwright, 1769), the “spinning jenny” (James Hargreaves, 1764–1770) and the “mule” (Samuel Crompton) followed by the “self-acting mule” by Roberts (1825). In 1830, a new method of inserting twist, known as cap spinning, was invented in the U.S. by Danforth. In the early 1960s, this was superseded by the ring and traveler, or ring spinning, which, despite other subsequent later inventions, has remained the main commercial method and is now an almost fully automated process. Today, yarn production is a highly advanced technology that facilitates the engineering of different yarn structures having specific properties for particular applications.

Weavers in Ethiopia use three kinds of raw materials, a factory produced warp (which is locally known as Dir), Mag a weft which is spun by women mostly in the house and t'ilet; factory produced colored threads used for decorative borders (Freeman & Pankhurst, 2003). According to Freeman and Pankhurst the weavers produce three kinds of cloth: K'emis, is the name for women's dresses which are usually worn together with a Net'ela. The latter is a shawl, which may also be worn with other types of clothing. The third item is a gabi, a large cloth worn by both women and men in bed or in cold weather. The bulliko can be added to the list of cloth. It is a thicker and bigger cloth used as a blanket in bed. Except for the decorative borders and warp threads the remaining material used in these clothes are hand mad cotton weft yarns. This style of weaving has spread throughout Ethiopia, and the weaving styles, techniques, and spinning are the same as those used in other region [17]

1.1.1 Justification of the research project

Designing and fabrication of power driven textile spinning wheel for small and micro enterprise (MSEs), for those majority of the society as well as for Textile institutes has the following rationalizations, the machine did not require special ability to spin, simply anyone who has hand spinning skill can adapt it easily even the beginner. Since it is power driven/semi automatic it is simplicity to operate by any person (children, adults, women, physically impaired). Promote income generation at home, it enables to satisfy local market, Nowadays in our country the major challenges in textile craft industry is accessing weft yarn for local weavers so, this power driven fiber spinning wheel will solve the current need of weft yarn in Gondar and its surroundings purposely as well as regional and national demands.

In Ethiopia, Currently it is the time of Cultural Revolution as far as textile craft is concerned and it is common to see peoples wear cultural clothes in different ceremonies, holydays, and events even in working days this implies that there is an increasing demand of weft yarn by local weavers. Of course this is good opportunity for textile crafts development in Ethiopia. So we have to balance this need of raw materials. Therefore this project will maintain such challenges. In this era of globalization we cannot make any border or use close door policy that is why Chinese being producing and export to our endogenous and cultural clothes like "Netela" "Kuta" Gabi" and "Kemis" to Ethiopia. So, this project will minimize and finally evacuate such challenges. The other and major rationale of this research project is it will rescue our way of weft yarn manufacturing system with its attractive texture and cultural clothes. It contributes to bring foreign currency because our cultural textile materials have high demand by the so called Diaspora even by foreigners. Spinning wheel has a long history in different parts of the world. But in Ethiopia there is no power driven spinning wheel or no enterprise which can produce power driven spinning wheel even conventional spinning wheel as per standards. Designing, modifying and Improving the technology has various functions.

As it stated by project initiator power driven textile spinning wheel make small and micro enterprises and local spinners to increase their productivity, since it is designed to be compact compared to conventional one it occupies less space and easy to move from place to place. Partial impaired/disabled persons can operate it and they can be contributing their role in the country economy. To access with reasonable price since main part of the machine can be manufactured by local MSEs (beneficiary). It contributes a great role in technology transfer activities, for both Technical and vocational education colleges and Universities to make our local spinners competitive at different level.

This research project topic is prior than other topic in general it can substitute imported manually operated spinning machine, modifying the flyer, and minimize its size by half and more compared to conventional one and minimize working load of the operator. So, the design and fabrication of power driven fiber spinning wheel will increase productivity with considerable quality, simplicity and comfortable to operate, use small space, can be operate by partially disabled persons, substitute imported spinning wheels, create job opportunities for citizens those of who are interested in textile spinning especially women and for those who are engaged in metal and wood work manufacturing even for motor professionals. Make it accessible in local market within a reasonable price, it will contribute productivity with considerable quality products for local consumption and exports and the like.

1.2 Statement of the problem

In this research project I will try to identify the factors affecting the productivity of local spinners and also identify the possible solution to increase productivity. Nowadays, the Textile industry is highly competitive, regulated and in a permanent state of change. Customers demand immediate attention, while suppliers require comprehensive leading edge services with regard to their products. Competitors are always inventing new technologies to satisfy their customer. Local spinners have a number of problems that are critical for achieving success in the productivity. In my observation majority of local weft yarn suppliers/spinners make the weft yarn by their hands and the rest they were organized by non-governmental organization make the weft yarns using poor quality manually operating spinning wheel which is tedious and non productive. At these instant Ethiopian endogenous and cultural clothes are being manufactured and imported by Chinese, Unless we retrieve and preserve our way of weft yarn manufacturing with its attractive texture by supporting modified and advanced technologies it will be patented by foreigners and make our cultural textile products endanger. No further project based research is conducted as far as spinning wheel is concerned in EiTEX, TVET colleges, research centers and Universities. No power driven/semi automated spinning wheels are available in craft industries and textile institutes. The existed manually operated spinning wheels relatively consume more space, tiresome for the operator, not productive; they are not easily portable and agreeable for those partially impaired peoples. Besides to these drawbacks the costs which require to import manually operating machine is expensive since it creates scarce of foreign currency. So this research based project proposal attempts to answer the following questions.

- ☞ How to increase weft yarn productivity with considerable qualities in MSEs and local community?
- ☞ How to minimize space utilization of manually operated spinning wheel?
- ☞ What modifications are required to solve challenges in manufacturing using spinning wheel?
- ☞ How can partials disabled persons participate in this cottage industry?
- ☞ How to create job opportunity?
- ☞ What is the cause of weft yarn scarcity for local weavers?

1.3 Objective

1.3.1 General objective

- The general objective of the research project is to design and prototype fabrication of power driven fiber spinning wheel using locally available materials with some improvements i.e. driving mechanism, the flyer and its allover size.

1.3.2 Specific objectives of this research project are

- To increase productivity of locally manufactured weft yarn and create job opportunity
- To improve and modify the parts of manually operated fiber spinning machine.
- To make accessible the machine for women, children and partially disabled people and to substitute import.

1.4 Significance of the research project

This research project study will be of benefit for those, hand spinners and manually operating spinning wheel/local weft yarn producer, MSEs those who are engaged in metal and wood work manufacturing, partial impaired peoples, Women, Technical Vocational Education Training Colleges, University/ textile institutes to deliver training on it and to be center of technology transfer, distributer and wholesalers. To make locally weft yarn spinners increase productivity and considerable quality products, enable peoples to manufacture weft yarn with in small spaces at their homes, make available motor operated spinning wheel in our local market with a reasonable price.

1.5 Scope of research project

The research project will be prepared and practically executed by the harmonious collaboration of Bahir-Dar University Institute of Textile, Garment and Fashion Technology /EiTEX/ and Gondar polytechnic college in Amhara Regional State Technical, vocational Education and Enterprise development Bureau. And the scope of this project covers up to manufacturing of weft yarn for weft with bobbin/spool.

1.6 Limitation of the research project

While I am doing this project it is possible to say not much limitation except few like time, sort of budget, recent literatures on cotton spinning cottage industries, most machines in the work shop out of function and some

CHAPTER TWO

LITERATURE REVIEW

2.1 Evolution of spinning

Spinning is the twisting together of drawn-out strands of fibers to form yarn, and is a major part of the textile industry. The yarn is then used to create textiles, which are then used to make clothing and many other products. There are several industrial processes available to spin yarn, as well as hand-spinning techniques. Cotton spinning is an important operation in small scale and cottage textile industries in Ethiopia. Hanna. (2010) Dhananjay (2011) also describes that large number of women workers in these industries perform cotton spinning task adopting squatting posture in traditional workshops. [18,5]

2.2 Hand spinning

Hand spinning can be done by using a spindle or the spinning wheel. Spinning turns the carded fibers into yarn which can then be directly woven, knitted (flat or circular), crocheted, or by other means turned into fabric or a garment.[11] staple-fibre spinning is an ancient craft. Although the precise date of its origin has yet to be known, there is archaeological evidence of 'string skirts' dating back around 20,000 years ago, to Paleolithic times. The early skill of spinning a thread from staple fibres, however, is believed to have been in existence at least some 8000 to 10,000 years ago. The early spinning technique seems likely to have been accomplished without the use of tools, by stretching out a thin bunch of fibres with one hand (the attenuating action being referred to as drawing) while twisting together the fibres of the attenuated length between the fingers of the other hand. To gain more twist the yarn would then be fastened to a stone called a 'whorl' which was twirled by hand and allowed to drop vertically, thereby generating the twisting torque Figure2. 1. [12]

http://textilelearner.blogspot.com/2013/02/an-overview-of-developments-in-yarn

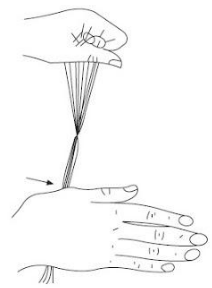

Figure2. 1 Hand spinning

2.3 A spinning wheel

A spinning wheel is a machine used to turn fiber into thread or yarn. This thread or yarn is then woven as cloth on a loom. The spinning wheel's essential function is to combine and twist fibers together to form thread or yarn and then gather the twisted thread on a bobbin or stick so it may be used as yarn for the loom. The spinning wheel is an ancient invention that helped to turned plant and animal fibers into thread or weft yarn, No one knows for certain who invented the first spinning wheel or when. Some evidence points to the invention of the spinning wheel in India between 500 and 1000 A.D. Bellis,M (2017), indicates it was invented in China and then spread from China to Iran, Iran to India and then India to Europe. All that is known for certain is that by the late middle Ages and during the early Renaissance, spinning wheels appeared in Europe via the Middle East. Nevertheless, scientists have never been able to pin down the origins of the spinning wheel. [1]

Xungai (2009), states that In fact, the early spinning wheel in its handheld form helped to spin all of the threads for the fabrics in which Egyptian mummies were wrapped. It was also the primary tool used to spin ships' ropes and sails. In "Ancient History of the Spinning Wheel," F.M. Feldhaus traces the origins of the spinning wheel back to ancient Egypt not India or China where before the development of modern technology it began as the distaff which is a stick or spindle upon which wool, flax or another fiber is spun by hand. Thus began the true conversion of the spinning wheel into a "powered, mechanized component of the Industrial Revolution."

Although a precise date has yet to be determined, it is believed that it was within the geographical region of either India, China or Persia (now Iran) linked to the Eastern wool, cotton and silk trade, during the period 500–1000 AD, that the spinning wheel was invented. With this system the spindle is switched from vertical rotation and secured to rotate in the horizontal position. The whorl is replaced by a pulley wheel, which effectively is a thick whorl with a groove cut into its peripheral surface. [3]

2.4 Continued Evolution of textile spinning

Bellis,M. (2017), indicates It was a natural evolution that spinners invented a way to mechanize the process. The hand spindle the distaff was held horizontally in a frame and turned, not by hand twisting but, by a wheel-driven belt. The distaff was held in the left hand and the hand-driven wheel belt was slowly turned by the right hand. Britannica.com writes that the distaff version of the spinning wheel evolved into a stationary vertical rod with a bobbin, and the wheel was "actuated by a foot treadle, thus freeing both of the operator’s hands."

In 1764, a British carpenter and weaver named James Hargreaves invented an improved spinning jenny, a hand-powered, and multiple spinning machines that was the first real mechanized invention to improve upon the spinning wheel. Britannica.com also reports that it was in the 18th century when the real demand for mechanical spinning wheels began after the improvement of the earlier version created a yarn shortage. [1, 13]

2.5 The Saxon, or Saxony, wheel

Introduced in Europe at the beginning of the 16th century, incorporated a bobbin on which the weft yarn was wound continuously; the distaff on which the raw fibre was held became a stationary vertical rod, and the wheel was actuated by a foot treadle, thus freeing both of the operator’s hands. The improvement of the loom in 18th-century Great Britain created a yarn shortage and a demand for mechanical spinning. The result was a series of inventions that converted the spinning wheel into a powered, mechanized component of the Industrial Revolution. [14] https://www.britannica.com/technology/spinning-wheel.

The Saxon Wheel The spinning of long fibers, including flax and hemp, was somewhat more cumbersome on the simple spinning wheel, largely because long fibres are usually much coarser and therefore the yarns spun with them are also much coarser. Consequently, not only would drafting with one hand while turning the large wheel with the other be more difficult, but the amount of yarn that could be would onto the spindle would be much smaller. The development which overcame these disadvantages, and also led to the concept of a continuous spinning process, was called the long-fiber wheel or the Saxon wheel Figure2. 2. http://textilelearner.blogspot.com/2013/02/an-overview-of-developments-in-yarn.html, [16]

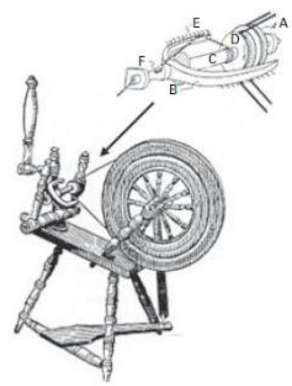

Figure2. 2 Saxon wheel

5.2.1 Different Parts of spinning wheel and their functions

- **Table** – Used to mount flyers' Mother-Of-All and electric motor in place.
- **Table stand** – A stand that holds the table flyer, motor, wheel stand and pedal
- **Electric Motor –** A source of power which helps to Rotates the flyer via Flyer Whorl
- **Electrical Speed regulating Nob/ switch –** a device used to regulate the speed of motor to deliver the required optimum speed to the flyer.

- **Crank shaft–** The function of the crankshaft is to translate the linear reciprocating motion into the rotational motion
- **Drive Wheel** – The wheel that rotates when treadling and causes the other various parts to operate.
- **Drive Band** – A cord that goes around the fly wheel and the flyer whorl, which can be a soft cotton cord which is about 1/16" thick (an eight or ten-ply butcher or pack- age twine works fine). A soft drive band allows you to use less tension than a harder,
- **Flyer** – A U-shaped piece of wood with metal bar slider spring up on one or both arms. The sliders are used to store the yarn evenly on the bobbin. The flyer is rotated by the drive band which as a result puts the twist into the fiber.
- **Flyer/Spindle Whorl –** A pulley attached to the flyer and operated by the drive band. The different sized grooves on the flyer whorl determine how fast the wheel will spin.
- **Maidens** – The upright posts that hold the flyer and the bobbin.
- **Mother-Of-All** – The bar that mounts the maidens, flyer, bobbin, and tension knob which holds in place.
- **Scotch tension or Flyer-lead mode** – Attach the Scotch tension spring to the spring bar on the right rear of the mother-of-all. Loop the cord over the large bobbin/pulley end and insert it into the front hole in the Scotch tension rod. Push about 1/2" of the cord through the hole. Loosen the thumbscrew slightly to allow the Scotch tension knob to turn. Used to increase the amount of take-up of your yarn onto the bobbin, turn the Scotch tension knob in the clockwise direction. To decrease the amount of take-up, turn the Scotch tension knob counter-clockwise.
- **Bobbin** – Rotates on the spindle along with the flyer and stores the yarn. It can operate with or independent of the drive band.
- **Treadle –** The pedal(s) that operates the wheel by using your feet.
- **Orifice** – The opening at the end of the spindle where the yarn goes through to connect to the hooks of the flyer
- **Slider** – The sliders are used to store the yarn evenly on the bobbin

- **pedal arm** – a wooden lever used to rotating the crank shaft [8]

2.6 Arkwright's Water Frame spinning machine

As indicated by Carl A. Lawrence,(2003) Arkwright's Water Frame was The first device for replacing the manual skill of hand drafting is attributable to Lewis Paul who obtained a patent in 1738 for the mechanism of roller drafting. Coupling the idea of roller drafting with the flyer and spindle combination, in 1769, five years after Hargreaves' spinning jenny, Richard Arkwright developed the first technically powered spinning machine, called the water frame. The two important advancements that the water frame contributed to spinning development were the application of roller drafting and a modification to the winding of yarns by a flyer-spindle device. Anne.(2005) [9]

2.7 Hargreaves' Spinning Jenny

Hargreaves' Spinning Jenny The use of the spinning wheel for the two-stage yarn production process spread throughout Europe and was the method widely employed for producing cotton yarns and yarns from short wools up until 1764, when the demand for increased yarn production led to the invention of the 'spinning jenny' by James Hargreaves. At the time, the growing demand for spun yarns was a result of another weaver's invention John Kay's 'flying shuttle'. This greatly increased the rate of woven cloth production on the handloom. [11] https://en.wikipedia.org/wiki/Spinning_%28textiles%29Historically

2.8 Crompton's Spinning Mule:

Crompton's Spinning Mule Following the development of the water frame, Samuel Crompton in 1779 invented the spinning mule, so called because it was a combination of the spinning jenny and the water frame. The principle of the spindle drafting action was retained from the spinning jenny but the positions of the roving feed and rotating spindles were interchanged. Spindle-drafting was now obtained by the movement of the carriage housing the rotating spindles. The roving packages were mounted onto a creel and the rovings fed by rollers into the drafting zone, and the machine was powered by the mechanical means of the day Figure2. 3. Carl A. Lawrence,(2003) [9]

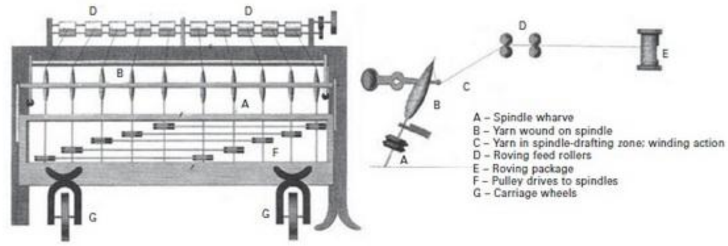

Figure2. 3 Spinning mule

Bellis,M. (2017) The mule spinning process enabled large-scale manufacture of fine and coarse yarns, as a single operator could tend up to 1000 spindles. In the 1830s the ‘self-acting’ mule was developed. It was called ‘self-acting’ because it provided a mechanical means for automating the carriage movements (spindle drafting and winding), and synchronizing them with the roving feed by the rollers. Mules, each with 1320 spindles, became widely used for spinning fine yarns from cotton and wool. The mule yarn was a fine, strong but soft yarn which could be used to produce all kinds of fabrics. The versatility of mule yarns made this method of spinning the most common from 1790 until about 1900; the process is still used today to produce fine yarns from specialty fibers such as cashmere, mohair, alpaca, angora, etc. [1]

2.9 Ring Spinning:

Ring spinning is currently the most widely used yarn production method. Initially developed in America in the 1830s, its popularity has survived the emergence of much faster spinning technologies. In addition to the superior yarn quality, ring spinning is extremely versatile. Ring spinning is, the conventional technology, in vogue, for spinning of yarn from, cotton, wool, spun silk, synthetic fibers and their blends, etc. With the threat from OERS technology, the ring spinning technology has, also advanced, considerably, during the last decade. Spindle speeds have gone up to 20, 000 rpm. Automation has been introduced for doffing of full bobbins. The latest development is, the linking of machines with, winding machines. However, these developments could not be a threat to OERS, due to limitation in, increase of speed of Ring Spinning. [16]

.http://textilelearner.blogspot.com/2013/02/an-overview-of-developments-in-yarn.html

2.10 Modern spinning technology:

Modern spinning technology has a number of advantages, over the ring spinning technology, such as, increased spinning speed (2 to 10 times of the ring spinning speed), absence of spinning preparatory machines, like, speed frames, draw frames (in case of very coarse counts), etc., as well as, absence of certain, post spinning operations, like, cheese/ cone winding, etc., which are needed, in case of ring spinning. Because of the absence of some, preparatory and post spinning operations, as well as high output per machine, Modern spinning (OERS) machines give a substantial, saving in labour cost.

State-of-the- art Modern spinning (OERS) machines are available with a high degree of automation, such as, auto doffing, automatic yarn piecing, automatic sliver can change, automatic yarn evenness control, automatic production and operating data recording, etc, as also, centralized computer control. Indigenous machines have speed up to 80,000 rpm; also, they lack most of automation features and are, by and large, manually controlled. Modern spinning (OERS) machining give, a better regularity of yarn which has, better stretch characteristics and, therefore, better suited to weaving, on high-speed automated looms. The limitation, of Modern spinning (OERS)machines, are: high power consumption, at spinning stage; lack of flexibility to take up various fibers/blends and count ranges, with the same configuration of machines; slightly lower strength of OERS yarns, difficultly in dyeing yarn of dark shades etc.

The latest addition, to the spinning technology, is the Air jet spinning technology, which was introduced, in the year 1980. The machine spins, cotton, synthetics, and their blends, in the count range of, 10s to 80s. The productivity for fine counts is, about, 15 to 20 times, higher than the ring spinning. The jet spin yarns are more uniform, but weaker in strength, than ring spun yarn, but stronger than the open-end spun yarn. Yarn cleaners are provided at each spinning unit, which give very uniform yarn. Fully automated version of air jet machines is available, with an auto-doffer, for change of full packages and auto-piecer for mending end breaks. The machines can be attached with computerized production information system and package transfer system, for storing the full packages. The jet spun yarn finds, only limited applications, due to harsh feel and is found to be, more suitable, for spinning, synthetic fibers and their blends with cotton.

www.http://textilelearner.blogspot.com/2013/02/an-overview-of-developments-in-yarn.l[16]

2.11 Previous Research on Ethiopian Hand spinning and Hand Loom

Hanna (2010), describe that there is a limited amount of literature concerning hand spinning of cotton and hand weaving in Ethiopia, but as there are some which is presented. Richard Pankhurst (1990), A social history of Ethiopia. Pankhurst writes about the Ethiopian social history from the middle Ages to the early nineteenth century. In his chapter on Handicraft workers weaving and spinning are presented and explained. Pankhurst's book is an overview and gives a good background. Julie Hudson & Christopher Spring (1995), The North African Textiles. The authors give a more detailed description of the treadle loom used in Ethiopia as well as what fabrics are produced in the country. Furthermore, some habits, colors and raw material of the Dorze weaving are described. Raymond A. Silverman (1999),

Ethiopia - traditions of Creativity. The book is a based on research of cultural traditions in Ethiopia edited by Raymond A. Silvermann. One of the cultural traditions the book focus on is the weaving in the Gamu-Gofa highland. The loom, the dressing of the loom, weaving, the market and the surrounding neighborhood are issues presented in the book. For example you can follow two weavers from the Gamu-Gofa highland which makes the descriptions very colorful. Dena et.al (2003), Peripheral People – the Excluded Minorities of Ethiopia. The authors seek to explain why minorities of Ethiopia, such as craft workers and hunters, are marginalized. Weavers are one of these minorities and the book gives an overview of the weavers' habits. That is, for example: What they produce, their livelihood and their social interaction. [18]

2.12 Current status of spinning wheel in Ethiopia

Investment Office ANRS (2008) disclosed that manufacturing of weft yarn using spinning wheel in Ethiopia is not a prominent. Of course federal small and micro enterprises agency deliver training on spinning wheel operation for those who are organized as cooperatives and individuals but because of several reason the number of enterprises which are engaged in this sector is limited. So many reasons can be mentioned like cultural view (working culture), limited accessibility of technologies for cottage industry and the like. Amhara National Regional Investment Office ANRS (2008) [19]

2.13 How to choose your spinning Wheel

As Amy C. M, (2009) indicates traditional-style wheels take more space and usually are not very easy to transport.   Some upright wheels are designed to fold or to separate into several parts to make them more portable. The smallest wheels are the lightweight, compact wheels that are designed for easy portability. Generally, portable wheels are not as stable as full-size wheels and often do not have as many features or options available.

On bobbin-lead wheels, also known as Irish- tension wheels, the bobbin is turned by the drive wheel and there is an adjustable brake on the flyer. It is easy to change bobbins on these wheels, and once the brake band is set, it usually does not need to be adjusted. These wheels usually have bigger bobbins and are best-suited for spinning heavier weights of yarn, novelty yarns, and for plying. Spinners with several wheels often keep a bobbin-lead wheel to use for plying.

Although bobbin-lead wheels can be used to spin finer yarns, a flyer-lead wheel would be a better wheel if you are planning on spinning cotton, silk, or other finer yarns. On flyer-lead wheels, also known as scotch-tension wheels, the flyer is turned by the drive wheel and there is an adjustable brake on the bobbin. This system offers the most control in spinning a large variety of different-size yarns and in the amount of twist that you insert in the different yarns. However, as the bobbin fills with yarn, the tension on the bobbin brake needs to be readjusted. A flyer-lead wheel is a good choice for spinning fine fibers and yarns.

On double-drive wheels, both the bobbin and the flyer are turned by the drive wheel, usually with the bobbin turning faster than the flyer to wind on the spun yarn. Double drive wheels are good for spinning large amounts of consistent yarn in the fine to medium range of yarns. They are also good for spinning soft-spun yarns. Many double drive wheels have the option of being set up as single drive flyer-lead wheels. If you are planning to do a lot of spinning with fine fibers, you may want to consider a wheel that offers an optional high-speed flyer and bobbins. Also, some wheels have larger flyer and bobbins available for plying or spinning heavier yarns. [7]

Anne. F, (2005) mentioned that a full bobbin is heavier and greater in circumference than an empty bobbin, and will need more tension. Ashford double band wheels can be converted to the scotch tension system, giving the The drive band section turns the spindle whorl, which is not part of the flyer as it is with those scotch tension system. It is a separate whorl, which screws onto the flyer shaft. The other section of the band turns the bobbin whorl, which is smaller in diameter than the spindle whorl, making the bobbin revolve faster than the flyer. This pulls the yarn onto the bobbin. The groove on the bobbin whorl is U-shaped to allow some slippage, and the groove on the cm die whorl is V-shaped to provide plenty of erection [8]

Financial analysis/ Cost calculation include material cost, labor cost (direct and indirect cost), manufacturing over head cost, miscellaneous Cost, total cost of the machine, selling price and other. Cost effective design vs. raw material cost while one of the primary jobs of the product designer is to develop the most cost effective design; this often misled by specifying the material with the lowest price tag.[21]

2.13 Principles of Yarn Production

It can be reasoned that to obtain a high degree of fiber parallelism in a yarn, the fibers must be already straight and parallel in the fiber assembly presented for consolidation by twist or some other means. In the raw material state, fibers have no definite orientation or configuration. A high proportion will be entangled and, in the case of natural fibers like cotton and wool, dirt and vegetable particles and other impurities (e.g., grease) will be present. The first stage in a yarn production process is therefore the cleaning and disentangling of the raw material. Where grease has to be removed, the material is scoured. The final stage of disentanglement is called *carding,* where the fiber mass is separated into individual fibers that are collected together to form a twistless rope termed a *card sliver.* Because of the carding process, the fiber orientation is very close to the sliver axis; therefore, carding may be considered as the start of the parallel arrangement of fibers. However, only very few fibers in a card sliver have a straightened shape. To straighten hooked and folded fibers, and greatly improve fiber alignment along the sliver axis, the sliver is thinned by stretching; the mechanical action is called *drafting,* and the amount by which it is stretched is the *draft.* Clearly, the count of the sliver will decrease, so drafting is an attenuating action, and the draft is equal to the factor by which the sliver count is reduced. Carl A. Lawrence,(2003). [9]

$$\text{Draft} = \frac{\text{stretched length}}{\text{Initial length}} = \frac{\text{initial count (tex)}}{\text{final count (tex)}}$$

2.13.1 Yarn Twisting

Twist is the number of turns per unit length (cm, m or inch). In the manufacture of staple fibre yarns, twist is inserted into the fine strand of fibres to hold the fibres together and impart the desired properties to the twisted yarns. Without twist, the fine strand of fibres would be very weak and of little practical use. A change in the level of twist also changes many yarn properties, such as strength and softness. This section discusses the nature of yarn twist, the effect of twist on yarn properties, as well as twist measurement Xungai Wang (2009). [3]

According to Deep (2016) et al Twist is imparted to the yarn by the rotating traveler. Each revolution of the traveller imparts one turn of twist to the strand. The traveler rotates on the surface of the ring. The traveller does not have its own drive. It is dragged by the yarn that passes through it on to the bobbin surface which is mounted on the spindle. The yarn is pulled by the rotating spindle. The strength of yarn is manipulated by varying twist. Strength generally increases with twist. However too high twist make the yarn hard and also reduces productivity as twist is usually increased by reducing delivery. In order to change twist the delivery by front drafting rollers is changed. [2]

2.13.2 Nature of twist and Types of twist

Arindam. B. (2009) mentioned that there are two types of twist:

(1) Real twist- To insert a real twist into a length of yarn, one end of the yarn should be rotated relative to the other end. Spun yarns usually have real twist, which holds the fibers together in the yarn.

(2) False twist- When inserting false twist into a length of yarn, both ends of the yarn are clamped, usually by rollers, and twist is inserted with a false twister between the clamping points. If the yarn is not traversing along its axis, the twist will be in opposite directions above and below the false twister. If the false twister is removed, the opposite twists will cancel out one another, leaving no real twist in the length of yarn. [9] Beside the fibre properties, yarn structure is the most important factor which influences the properties. If the relationship is understood, the yarn structure can be modified for changing the yarn properties. The knowledge of the structure-properties relationship helps us in choosing ideal spinning system and parameters. [6]

2.13.2.1 Self-Twist Spinning System

Self-twist spinning is a process in which two fibrous strands are separately false twisted to give alternating S and Z twist along their lengths. Both strands are then brought together in frictional contact for the untwisting torque of the S–Z twist to ply the strands, producing an alternating Z and S twisted twofold yarn.

2.13.3 Doubling Principles

This is the process of combining two or more yarns by twisting them together. Before describing the structure-property relation of single yarns, it is desirable that a short reference be made to the operation known as doubling, plying, or twisting. Anne. F (2005), the basic objective of doubling is to attain a particular physical characteristic that cannot be obtained with a singles yarn of similar count to the plied yarn. Doubling is also used for the production of designed effects in yarns, but this involves a specialist type of doubling to produce what are called fancy yarns.[9] The singles thread you have spun onto each bobbin can be used on its own, but for most purposes a 2-ply yarn is needed. Not only does this strengthen the yarn, but it also makes it more even and balances the twist. In a perfect thread, all the thick places on one strand would match with all the thin places on the other strand. Anne (2005) [8]

2.13.4 Effect of twist level on yarn strength

The level of twist is usually expressed in number of turns per meter (tpm). Number of turns per inch or twist per inch (tpi) is also used in the industry. More twist gives greater radial component to any applied tension, so increases resistance of fibers to slip and the strength of yarn increases as a consequence. This is depicted by the 'coherence curve' Figure2. 4. On the other hand, if a bundle of parallel filaments is twisted, the twist will put the individual filaments under torsional stress. This stress weakens the filaments and the strength of the filament would decrease as the level of twist increases. This is depicted by the 'obliquity curve' in figure. Staple fiber yarns, these two curves combine to give the actual 'twist-strength curve' for a staple fibre yarn as shown by the heavy line in figure 2.4. Xungai Wang (2009). [3]

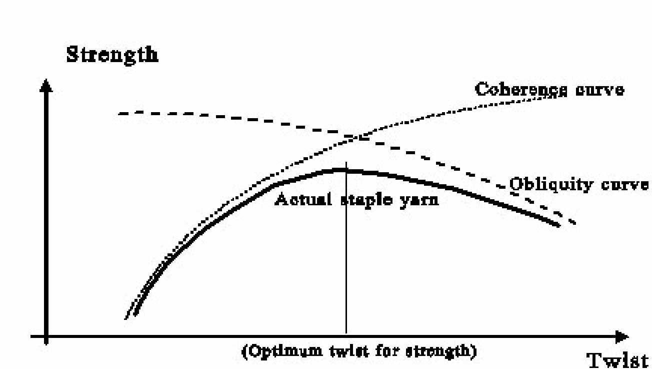

Figure2. 4 Effect of twist level on yarn strength

2.13.5 Twist angle

Xungai Wang (2009), describes that this is the angle of fibers to yarn axis, and this angle varies throughout yarn, from zero at centre to maximum at yarn surface. The fibers on yarn surface are the most important; as they bind the others into the yarn. While it is not common practice to measure the yarn twist angle, the surface twist angle made by the surface fibers in relation to yarn axis is a very important parameter. It determines the essential yarn characteristics such as yarn softness, yarn bulk etc, which in turn govern many essential fabric properties. The following example illustrates the point. Figure2. 5, yarn 1 and yarn 2 have the same twist level one turn each. But the surface fiber on the thicker yarn is obviously stretched more to accommodate this twist. This would mean the thicker yarn is more closely packed. As a consequence, yarn 2 will not be as soft as yarn 1. In other words, even though the twist level is the same in these two yarns, the yarn characteristics are quite different. Therefore, we cannot simply use twist level to represent yarn character. However, the surface twist angles of yarn 1 ($\theta 1$) and yarn 2 ($\theta 2$) are different. They can better reflect the yarn characteristics, regardless of the difference in yarn thickness. [3]

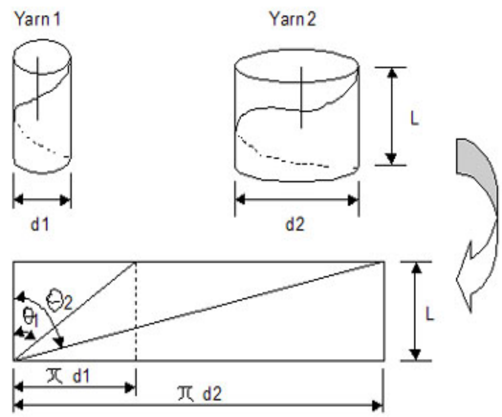

Figure2. 5Twist angle

2.13.6 Yarn Count Systems

The dimensions of yarns are expressed. In specifying the thickness of a yarn, we could refer to its diameter or radius this, however, is not a straightforward parameter to measure. Clearly, we would need to assume that the yarn is circular. Straightening the yarn length to measure the diameter involves tensioning the yarn, which also narrows the cross section by bringing fibers into closer contact and increasing the packing density. Although there are test methods for yarn diameter measurements that attempt to circumvent these difficulties, they are not appropriate for use in the commercial production of yarns.

Carl A. Lawrence,(2003). In spinning yarns, there is no direct relationship between spinning variables and yarn diameter, so it is not the practice to set up a spinning machine to produce a specified yarn diameter. A more useful and practical measure that indirectly gives an indication of yarn thickness is a parameter that is termed the yarn count or yarn number. The yarn count is a number giving a measure of the yarn linear density. The linear density is defined as the mass per unit length. In System International (SI) units, the mass is in grams, and the unit length is meters. In textiles, a longer length is used for greater meaningful measurements, since this would average the small, random, mass variations along the length that are characteristic of spun yarns. There are two systems by which the count is expressed, as described below.

• Direct system. This expresses the count as the mass of a standard length. The mass is measured in grams, and the specific length is either 1 km or 9 km.
• Indirect system. This gives the length that weighs a standard mass. The standard mass is either 1 kg or 1 lb, and the associated length is, respectively, in meters or yards. [9]

$$\text{Direct yarn count} = \frac{\text{Weight of yarn}}{\text{Given length}}, \qquad \text{Indirect yarn count} = \frac{\text{Length of yarn}}{\text{Given weight}}$$

2.13.7 Twist distribution in spun yarns

If someone twists your head, it is your neck that suffers most. That is because the neck is a 'thin' place and offers little resistance to being twisted. By analogy, if a yarn of varying thickness is twisted, it is usually the thin spot in the yarn that gets twisted the most. Invariably, yarns spun from staple fibres (e.g. wool, cotton) are not perfectly uniform, and there are thick and thin spots along the yarn length. This variation in yarn thickness will lead to variation in the twist level along the yarn length, because twist tends to accumulate in the thin place. The fact that twist tends to accumulate in the thin spot along the yarn has several important implications:

- It exacerbates the variation in yarn linear density. While variation in yarn linear density is the fundamental cause of twist variation, concentration of twist in the thin places will make those places even thinner, exacerbating the problem of yarn unevenness.
- It improves the evenness of a fibre assembly during "drafting against twist".

In the drafting stage of woolen ring spinning, the woolen slubbing is drafted while twist is inserted into the slubbing (drafting against twist) to control fibers during drafting. Because twist tends to accumulate in the thin spots, the fibers in thin regions in the slubbing are more difficult to draft than those in the thick places, which have less twist. As a result, the thick places are drafted more than the thin places, thus improving the evenness of the drafted material Figure2. 6. This is depicted in figure Xungai Wang (2009). [3]

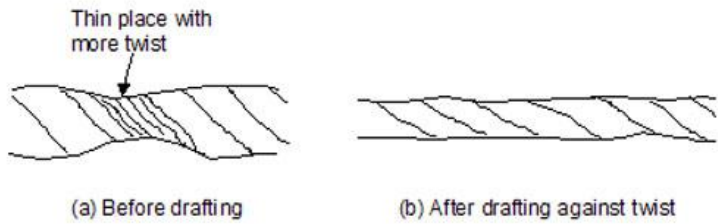

Figure2. 6 twist evenness

2.13.8 Package Formation

Robert C. Allen (2007) indicates for package formation the yarn needs to be wound around the package and laid uniformly across the entire length of it. As the traveller and spindle rotate in the same direction, the difference in the peripheral speeds of the traveller and the spindle causes the yarn to be wound on to the package. The speed difference is due to the lagging of the traveller relative to the spindle due to continuous delivery of yarn from front roller and traveller ring frictional drag. Since the traveller also acts as a guide for the yarn it is oscillated back and forth across the entire length of the package for laying the yarn uniformly. [4]

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Material Selection and Specification

Material selection should be selected according to the application and performance of machine parts Table 3.1 represents material selection and specifications

Table 3.1Shows the Material Selection and Specification

No	Material List	Specification	Unit	Quantity
1	Wood	Hard wood Wanza /Timber	In numb.	3
2	Plywood	MDF 13x200x300 mm.	In mm^2	1
1	Wood	Hard wood Wanza /Timber	In numb.	3
3	Metal flat bar	200x20x40 mm	In meter	0.2
4	Round metal bar	200x6 Ø	In meter	0.2
5	Round metal bar	200x 10Ø	In meter	0.2
6	Bronze rod	100mmx20 Ø	In meter	0.1
7	Phillips Screw	¾ length	In inch.	4
8	Bolt and nut	M 6x7	In numb.	4
9	Cotton	Sliver	In kg	0.5
10	Plastic strings		In meter	0.5
11	Hooks		In numb.	3
12	Wood fix		In Gram	0.25
13	Fixing glue	Epoxy	In tube.	0.5
14	Varnish		In liter	0.5

15	Drawing paper	A4&A3	In psc	5
16	Rubber belt	Standard	In numb.	1
17	Electric motor	220v	In numb	1
18	Speed regulator		In numb	1
19	Tape measure		In numb	1
20	Venire caliper		In numb	1
21	Wood Lath machine		In numb	1
22	Metal Lath machine		In numb	1
23	Sanding machine		In numb	1
24	regulator	Standard	In numb	1
25	Electric switch	Standard	In numb	
26	Electric cable	2.5 stranded	In meter	2
27	Oil	N10	In liter	½
28	Drill bit	6Ø,9.5 Ø&10 Ø	In numb	3
29	Bearings	Internal Ø 10	In numb	3
30	Tape Measure	Standard	In roll	1

3.1.2 Tools, equipments and machines used to produce power driven spinning wheel

To manufacturing any machine one should consider which machine, equipments and tools are required a head therefore the Table 3.2 represents the required machine, equipments and tools to manufacture power driven spinning machine.

Table 3.2 Tools, equipments and machines used to produce power driven spinning wheel

Tools	**Equipments**	**Machines**
Tri square	Jig saw	Lath machine
Venire caliper	Rotor	Combination wood working machine

Tape measure	Portable sander	Radial drill machine
Screw driver + & -		Welding machine
Adjustable wrench		Wood lath machine
Pliers		
Chisel		

3.1.3 Tools used for Assembly of modified power driven spinning wheel

- Pliers
- Adjustable wrench
- Screw driver flat and round head
- Different sizes of bolt and nut
- Washer
- Bearing puller
- Pressing machine

3.1.4 Accessories which are important for power driven spinning wheel

- Cabled cotton yarn
- Reserve Bobbins:
- Threading hooks:
- Operating manual/booklet
- Scissors
- Drive Band

3.2 Methods

3.3.1 Study and Observe the Functional Components of manually operated spinning wheel.

Nowadays manually operated spinning wheels are available in TVET college textile shops, cooperatives and MSEs which are locally manufactured and imported from different countries like, India, Australia … So I discern many parts and components which need modifications in order to make spinning process more productive with optimum quality and comfortable with minimum space utilization. Idea Screening is spots good ideas and drop poor ones as much as possible. Based on drawback of the existing manually operated spinning wheels and my observation I generate a number of ideas like changing the driving mechanism from manual to power driven, modifying the flyer by changing the hooks in to sliding mechanism using metal clips or spring rings and minimizing it's all over size by more than half percent and accessed with spare cop. Design conceptualization is important to achieve trade-off between functional properties (protection and comfort) to obtain an optimum solution.

Generally any design should meet simplicity from a product's user viewpoint, support to guide the user to the appropriate sequence; familiarity users should not have to learn too many new things to perform familiar tasks, encouragement to minimize irreversible consequences and safety less-hazard design, robust against misuse. There are also steps for design modification towards design/ conceptualization/ that is product justification (consumer, potential users, producer, regulation & liability), defining the design problem (broad & specific) and Gathering relevant information (type, source, credibility & accuracy, interpretation) Design concept formulation or modifications require (technical creativity, brainstorming, decision making and concept optimization).

The overall size of existed manually operated spinning wheel is larger which occupies more space but the modified power driven spinning wheel is small and compact and reduced the size by more than 60 % over the existed one which helped the operator to work within limited space at home and any place because it is portable and it can be mount and fasten on the table.

In case of electric power interruption the modified spinning wheel is designed and equipped with single pedal driven make this machine manually operated and power driven.

3.3 Product Design preparation /Working drawing/

Spindle whorl / flyer is the main part and of a machine which is used to insert twist and used for yarn package formation on the spool. All its dimensions are described in Figure3.1. The material will be made from hard wood Wanza

/Timber, metal road having 10mm. Ø, metal road having 6mm. Ø and bronze rod having 9 mm. Ø

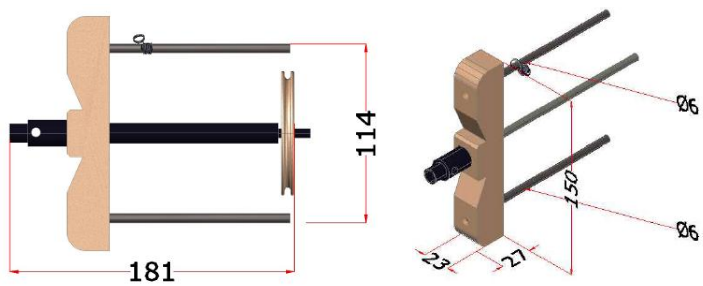

Figure3.1 Flyer/Spindle Whorl

Spool, it is one component of the machine used to wind and hold the yarn package on it and the dimension is indicated in Figure3.2 below, the material will be made from hard wood Wanza /Timber

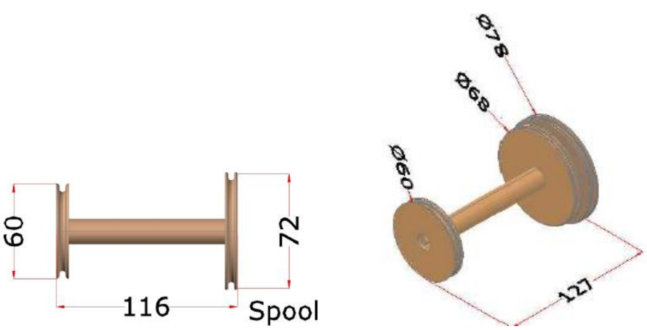

Figure3.2 Spool

Maidens are the upright posts that hold the flyer and the bobbin and Mother of all is the bar that used to mounts the maidens, flyer, bobbin, and tension knob. The dimensions should be according to the drawing and the material will be made from hard wood Wanza /Timber and flat bronze plate as per stated dimensions Figure3.3.

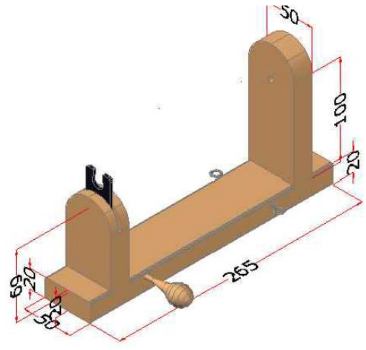

Figure3.3 Mother-Of-All and Maidens

Table of Mother-of-all or flyer is made from laminated MDF (medium density fiber board) used to hold Mother-of-all in place which make the machine easily portable Figure3.3.

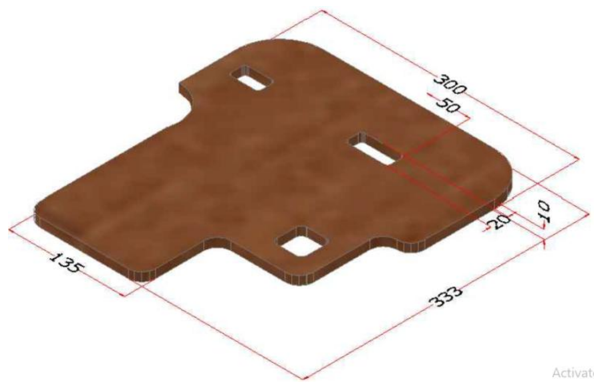

Figure3.4 Table of Mother-Of-All/ flyer

Figure3.5 shows Power driven spinning wheel and its all over dimension is 22.6x33.3x12.2 cm

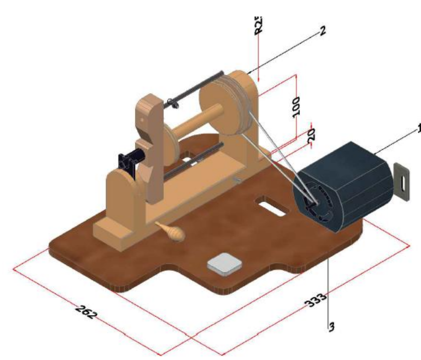

Figure3.5 Power driven spinning wheel

Main table stand is used to hold the main wheel in place and support the table bed made from 25x25cm square metal pipe and it has 60.5x50.0x33.0cm dimensions Figure3.6.

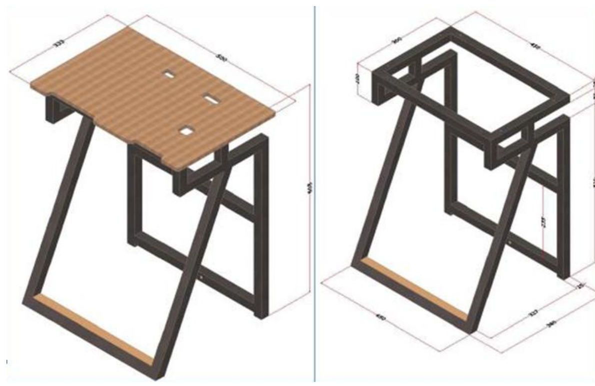

Figure3.6 Table stands front side view

Main table bed which is made from MDF (medium density fiber board) used to mount power driven spinning wheel Figure3.7.

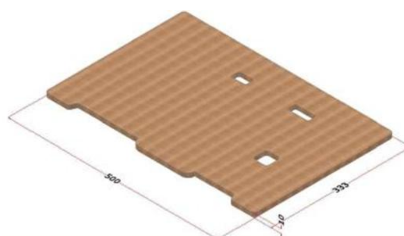

Figure3.7 Top view of main table bed

Figure3.8 describes wheel stand which is made from hard wood Wanza /Timber having the dimensions already stated on the drawing used to hold the wheel with table stand and allow free rotation of the wheel.

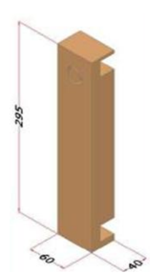

Figure3.8 Wheel stand

Wheel is relatively having larger diameter which is used to rotate when treadling and causes the other various parts to operate. It made from MDF (medium density fiber board) Figure3.9.

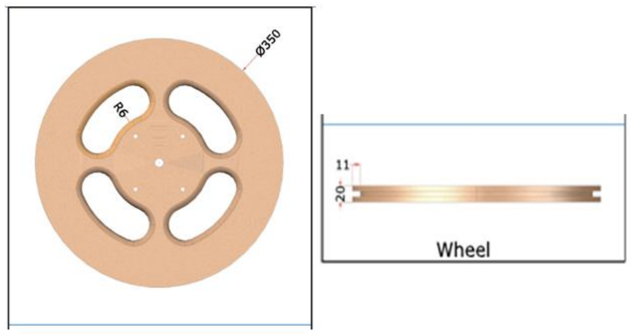

Figure3.9 Top and front view of main wheel

Crankshaft is to translate the linear reciprocating motion into the rotational motion and it is made from metal bar metal road having 12 mm. Ø and also the metal used to fasten the crank shaft with main wheel it has 4mm thickness with nut and bolt Figure3.10**.**

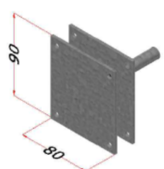

Figure3.10 Crank shaft with supporting plates

Figure3.11 Represents crank driver arm used to drive the crank to actuate rotational motion and it is made from hard wood Wanza /Timber

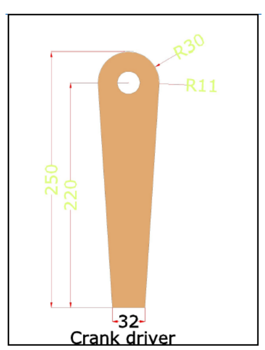

Figure3.11 Crank driver arm

Treadle the pedal that operates the wheel by using your feet and it is made from hard wood Wanza /Timber Figure3.12.

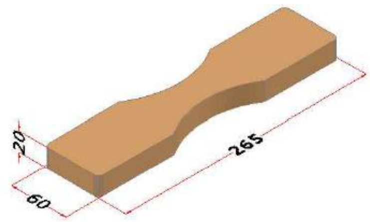

Figure3.12 Treadle

3.4 Prototype manufacturing procedure

Step1: Materials were procured based on its selection and specification

Step2: Based on the prepared design prepare the wood and metal parts with right length, thickness, width, shape and quantity

Step3: Based on the prepared design and manufacturing procedures fabricate parts and provide the necessary design, shape, and number. (cut, drill and make shapes for wheels and pulley)

Step 4: Prepare slider for packaging mechanism

Step 5: Assembling all parts according to the design

Step 6: Testing after right assembling. the next step is testing, the machine as I have tested, the machine have high productivity and produce good quality compared to "Enzert" handmade cotton yarn and manually operated machine, and the operators also commented that it is more comfortable to them and gives more attention on drafting/attenuation of sliver rather than driving the spindle/wheel by their leg. At the same time while we are testing the machine they appreciate the size of the machine simply they can move from place to place and can operate within less space. As I have mentioned in case of power interruption the operator can continue spinning by driving the wheel. Generally as

I have tested the machine it requires less space, productive with relative quality and can be managed by speed regulated device.

3.5 Assembling, Testing and Finishing the Project

3.5.1 Assembly procedure of modified power driven spinning wheel

To assemble modified power driven spinning wheel we need the above mentioned tools and flow the following steps.

1. First assemble the main wooden stand to driving wheel with main shaft/crank refer Figure3.13

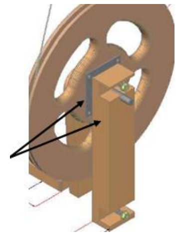

Figure3.13 wooden stand and driving wheel

2. Second assemble the stand and wheel to the table stand with larger bolt and nut Figure3.14.

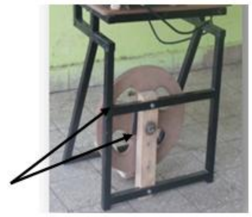

Figure3.14 table stand

3. Fasten the Maidens and upright posts on to the table with bolt and nut Figure3.15.

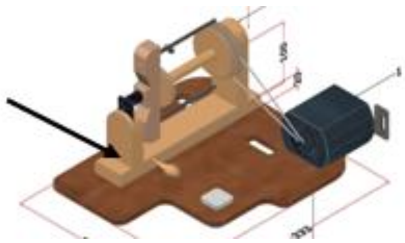

Figure3.15 power driven wheel

4. Attach the electric motor/dynamo and speed regulating Nob/ switch on the front side of mini table with bolt and nut refer Figure3.16.

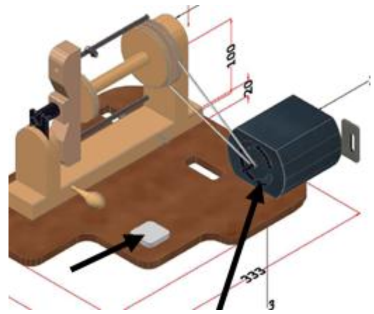

Figure3.16 Motor with speed regulator

5. Assemble the flyer whorl with flyer spindle, bobbin in to flyer spindle by tilting and attach the flyer/spindle with Mother-Of-All check Figure3.17

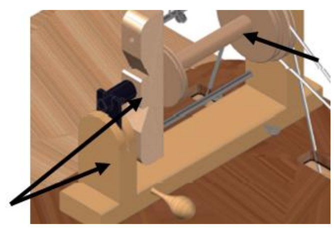

Figure3.17 Flyer whorl and spindle

6. According to Figure3.18 Assemble electric motor pulley and flyer whorl pulley with standard belt to if you want to operate the machine by motor.

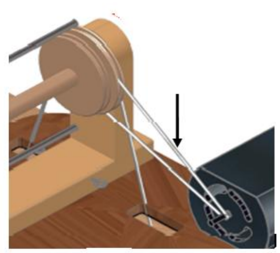

Figure3.18 motor pulley and flyer whorl

7. Assemble larger drive band on to main wheel and flyer whorl if you want to operate the machine manually **refer Figure3.19**

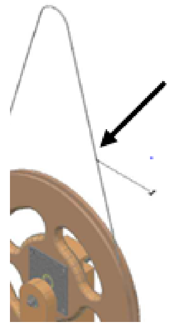

Figure3.19 drive band

8. Apply final finishing like by varnish Figure3.20.

Figure3.20 fully assembled modified power driven spinning wheel with stand.

CHAPTER FOUR

FINANCIAL ANALYSIS AND MACHINE OPERATION

4.1 Elements of Financial analysis

It refers to an assessment of the viability, stability and profitability of a business, sub-business or project. Financial analysis often assesses the following elements of a firm:

- **Profitability** - its ability to earn income and sustain growth in both the short- and long-term. A company's degree of profitability is usually based on the income statement, which reports on the company's results of operations;
- **Solvency** - its ability to pay its obligation to creditors and other third parties in the long-term;
- **Liquidity** - its ability to maintain positive cash flow, while satisfying immediate obligations; Both second and third points are based on the company's balance sheet, which indicates the financial condition of a business as of a given point in time.
- **Stability** - the firm's ability to remain in business in the long run, without having to sustain significant losses in the conduct of its business. Assessing a company's stability requires the use of the income statement and the balance sheet, as well as other financial and non-financial indicators.

4.2 Cost Analysis of power and manually driven spinning wheel.

In this project, financial analysis (Cost calculation) include manufacturing Cost of machine is equal to the sum of direct Material, direct labor cost, manufacturing and over head cost.

4.2.1 Direct Material Cost

Table 4.1 shows list of direct material costs

Table 4.1 List of Direct Material Cost

No	MATERIALS	Cost in Eth. Birr
1	Hard wood Timber/Wanza	60
2	MDF 16x200x300 mm	30
3	Laminated MDF 13x400x300 mm	45
4	Metal round bar 6 Ø	10
5	Metal round bar 12 Ø	40
6	Bolt and nut 10	40
7	Phillips Screw 4	8
8	Rubber belt	10
9	Varnish	20
10	Bronze rod	25
11	Sand paper	12
12	Wood fix	23
13	Fixing glue	15
14	Bearings	35
15	Rubber belt	15
16	Electric motor	400
17	Speed regulator	25
18	Drill bit 5,6,12&14	10
19	RHS pipe	120
20	Electrode	30
21	Total material cost	973

4.2.2 Direct Labor Cost

Manufacturing Cost having per dime of 80 birr and working for 16 hrs, the total cost will be 1280 eth birr

4.2.3 Manufacturing Overhead Cost

The manufacturing overhead cost includes house rent, cost of electric power, telephone, water supply and other miscellaneous costs which are presented in Table 4.2.

Table 4.2 Manufacturing Overhead Cost

Type of indirect cost	Unit Price	Total Price
Electric power	204	204
House rent	250	250
Miscellaneous	50	50
	Total	**504**

Total Manufacturing cost= direct cost + indirect cost

Total Direct cost = direct material cost + direct labor cost

= 973 birr + 1280 birr

= 2253 birr

Total Indirect cost = electric power + rent + miscellaneous

= 204 + 250 + 50

= 504 birr

Total manufacturing Cost of power driven spinning wheel is the sum of total direct cost and total indirect cost i.e. 2253 + 504 = 2757Eth.Birr. The price of imported manually operated spinning wheel is = 449 US dollar, which means 12,123 Ethiopian Birr. Therefore the modified power driven spinning wheel is feasible when we consider its price and its intended function.

When we fabricate it, therefore we can save the country currency

$$\frac{12123\ birr - 3446.15birr}{3446.15birr}\ X\ 100$$

$$= \underline{\underline{244.89\ \%}}$$

Profit before tax: Profit before tax is calculated as 25 % of the total manufacturing cost which is,

$$\frac{2757\ X\ 25}{100}$$

= 689.25 birr

Profit after tax (10%)

$$689.25\ \text{birr} - \left(\frac{689.25\ \text{X}\ 10}{100}\right)\ \text{Birr}$$

= 689.25 birr - 68.9 birr

= 620.35

Therefore, the selling price of power driven spinning wheel is computed as follows,

Selling price = Total Manufacturing cost + Net Profit + Tax

= 2757 birr + 620.25 birr + 68.9 birr

= 3446.15 birr

4.3 Commercial Feasibility

Federal MSE and Federal TVET Agencies 2018 report revealed that the number of TVET Colleges and institution increased from 1,137 in 2014, to 1556 in 2018.The number of MSEs estimated 563,665 to. From this data we can conclude that now a day in Ethiopia the number of TVET institution and MSEs are increasing drastically from time to time. In Amhara region by the years of 2006 E.C and 2009 E, C the number of MSEs established and engaged in textile and garment are 6216 and 7114 respectively. So, in 2001 during the time of revising TVET strategy Ethiopian Government, MOE imported manually operated spinning wheel for TVET colleges and institutes, for textile department in each regional state, but the number is around 296 totally in each all region/Amahara, Tigray, Southern Nation and Nationality, and Oromia.

Number of Imported manually operated spinning wheels per each Regions are Addis Ababa75, SNNR 5, Tigray56, Amahara150, Oromia10, Total 296. Source:- Federal MSE & TVET Agency, Amhara region TVED bureau. Currently this number is not sufficient to give training in for new and existed TVET colleges and institutes at national level.

According to my observation currently in Ethiopia within different regions there are a lot of TVET Colleges and institutions which are delivering training in textile technology and MSEs organizing peoples to create job opportunity besides to this a number of people which has hand spinning skill as livelihood at family level and need to be supported by technologies with such power driven spinning wheel to maximizing weft yarn productivity for local weavers. In my observation there is great commercial feasibility as far as this project is concerned. It is obvious that number of MSEs, TVET graduates in textile and private spinners & weaver and cooperatives are increasing from time to time. So, the commercial feasibility and requirement of power and manually operated spinning wheel will increase highly since it meets the needs of TVET graduates/trainee, MSEs, private spinners, partially disabled peoples and women, governmental and nongovernmental organization

4.4 Modifications on the existing technology

Currently local weft yarn manufacturer majority of them are females “spinners” done by their hand at their home using having a local name “Enzert”, they are producing 1kg of carded cotton per a week (1kg/week) which is not productive. (Source field visit and oral interview of spinner in Gondar town)

The spinning wheel which is existed (pedal driven) will be modify/replaced by electric power driven motor. The existed machine flyer has successively arranged hooks to build weft yarn package on a bobbin which is replaced by sliding metal spring (slider) to eliminate downtime of productivity, this is one of the advantage of this machine and help to build yarn package uniformly rather than transferring yarn end from one hook to the subsequent hook. Newly modified spinning wheel occupies less space and easily portable than the existed so the operator can use the machine any place if there is electric power. But the disadvantage of this modified power driven spinning wheel is depends on electric power so to overcome such problems the machine is designed to be operated by manually driven wheel just like the existed manual one.

Pedal driven spinning wheel which is locally manufactured cost 3100 Ethiopian birr and the imported one cost 12,123 Eth. Birr but this power driven costs 3446.15 Eth. Birr so when we consider productivity and quality it is feasible because it works both with electric power and manually.

Disabled persons having no or single leg/ can operate it, since it is designed to be operated by electric power and single pedal which will make it simplicity and friendly for those individuals. As we know that women have a lot of activities at their home and in farm places so unless we support them with modified technology i.e. spinning after other activities will be tedious non productive there for it is more preferable to address such technologies for them generally all and each parts can be dismantled and assembled within locally available tools for maintenance.

4.5 Operation of the machine

While operating manual spinning wheel there is difficulty of drafting/attenuation to attain relative quality yarn, but since this modified wheel is managed only by hand to draft which helps to give more attention to draft the sliver on the other hand the existed wheel which is driven by their foot affect the drafting process leads to poor yarn quality the reason is the operator give focus for both driving and attenuation. But in case of this modified power driven spinning machine the flayer is actuated by motor so this permit the operate to give more attention on drafting /attenuation activities which help to obtain quality weft yarn more than the manual one.

4.5.1 Changing bobbins

Hold the flyer with one hand and pivot the front maiden forward until the flyer orifice is out of the front maiden bearing. Hold the drive band up and out of the way as you pull the flyer towards you until the flyer shaft is out of the rear maiden bearing. Remove the flyer whorl.

4.5.2 Using different flyer whorls

The type of fiber you are spinning and the kind of yarn you want to produce will determine which flyer whorl to use. Spinning wheel comes with spare flyer whorls. The general rules to remember are: the larger (slower) the whorl, the thicker the yarn, the less the twist and the greater the take-up. Depending on how much or how little tension you put on the drive band, you can increase or decrease the take up. In Scotch Tension mode the amount of take-up is controlled by the amount of tension you put on the brake spring & cord the greater the tension the greater the take-up.

4.5.3 Practice drafting

Take a handful of cotton sliver in one hand and with the other hand, gently pull some of the fibers away from the mass and twist them in one direction with your fingers. Continue to pull out the fibers (drafting) and add twist. If you don't put enough twist in, the yarn will fall apart. If you put in too much twist, you won't be able to draft out the fibers.

4.5.3.1 Learn how to adjust the tension on your brake band on your wheel.

This device controls the rate the yarn is drawn onto the bobbin and acts essentially as a brake. Wheels have a brake band with a spring or rubber band over the bobbin, and some wheels have a strap or brake band over the flyer. In all cases, the tighter the brake band, the faster the yarn will be pulled onto the bobbin.

4.5.4 Lubricating moving parts

A good idea to oil your wheel before starting to spin use a drop of oil on the following parts every couple of hours while spinning: front maiden bearing

- rear bearing
- bobbin bearings
- drive wheel bearings
- crank bearing(s) – sparingly
- The flyer shaft should also be oiled where it touches the front and rear bearings and the bobbin bearings. Use medium weight oil such as 20 or 30 weight motor oil.

4.6 Disassembly of power driven spinning wheel

1. Remove drive band from main wheel and flyer whorl check Figure4.1

Figure4.1 Drive band and main wheel

2. Take out the bobbin from the flyer by tilting towards the whorl and then the flyer and spindle refer Figure4.2.

Figure4.2 Bobbin and flyer

3. Remove electric motor/electric drive/dynamo from mini table as it shown in Figure4.3.

Figure4.3 Motor and mini table

4. Untie the bolt and nut of Mother-Of-All from the table check Figure4.4

Figure4.4 Mother-Of-All and main table

5. Untie the larger bolt and nuts which are fastened the main wooden stand with metal table stand as shown Figure4.5.

Figure4.5 main wooden stand with metal table stand

6. Take away the treadle arm pin to remove the wheel from main wooden stand and remove the foot pedal Figure4.6.

Figure4.6 treadle arm pin

7. Untie bolt and nuts of wheel supporting plates and Takeout the main shaft/round bar from wheel and wooden stand check Figure4.7.

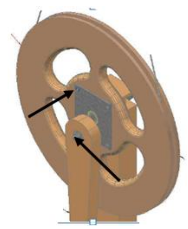

Figure4.7 wheel supporting plates

8. Finally Remove the string from pedal and pedal arm

Figure4.8 Disassembled parts of modified power driven spinning wheel

4.7 Quality comparison

The quality of modified power driven spinning wheel is better than when we compared with locally made manually operated spinning wheel, in case of locally made manually operated spinning machine there is poor way of material selections, dimensions and shapes of its parts are constructed carelessly which in turns high level of noise which affect the environment. At the same time due to lack of precise dimensions and miss alignments so it requires frequent maintenance and spares, but as far as concerning to the imported one has good quality but less productivity and consume more space as shown Figure4.9.

A B

Figure4.9 Manual machine (A) and electrical operating (B)

Quality comparison, locally made manually operated spinning machine (A) modified power driven spinning wheel (B)

Generally manufacturing cost is the total of direct and indirect material cost, direct and indirect labor cost and manufacturing over head and as well as other related cost has been done using current market condition.

In case of manual spinning machine the operator give more attention to dive the wheel by their foot which affects the drafting process. But in case of this modified power driven spinning machine the flayer is actuated by motor so this permit the operate to give more attention on drafting /attenuation activities which help to obtain quality weft yarn more than the manual one. In both cases it is difficult to obtain standard yarn packages, manually operated spinning machine have a flyer with successively arranged hooks to impart package which will be difficult to attain uniform package. But in the case of modified power driven spinning wheel the flyer is equipped with slider rather than successive hooks so it allows building better yarn package because we can slide the slider as per the required tolerance. The modified spinning wheel flyer’s round metal bar should be marked by divisions to control the slider while sliding to attain more uniform package.

Figure4.10 Sample yarn Product

4.8 Productivity calculation of power driven spinning wheel (minimum productivity)

Yarn Length wound in one minute

- RPM of main motor is 600
- Diameter of motor pulley is 0.8 cm
- Diameter of Spindle Whorl (pulley) is 7.6 cm

Therefore, expected RPM of the rotating flyer with Spindle, Whorl and bobbin is

$$= 600 \times \frac{0.8\, cm}{7.6\, cm}$$

$$= \mathbf{63.15}$$

- Diameter of the bobbin barrel is 2cm
- Circumference of bobbin barrel is

$$= \pi \times \text{diameter of bobbin cop}$$

$$= \boldsymbol{\pi} \times 2\ \text{cm}$$

$$= 6.28\ \text{cm}$$

- Therefore, length of yarn (m) which is required to be wound in one minute *is:-*
- $= \text{rpm} \times \text{circumference of bobbin barrel}$

$$= \text{rpm} \times \pi \times \frac{D}{100}$$

Where D = diameter of bobbin barrel and 1/100 is conversion from centimeter to meter

$$= 63.15 \times 6.28\text{cm} \times \frac{1}{100}$$

$$= \mathbf{3.96\ meters}$$

Rotating speed of the flyer with bobbin

Speed of the cop in m/sec

$$V = S(\text{m}) \div t(\text{sec})$$

$$= 3.96\ \text{m} \div 60\ \text{sec}$$

$$= 0.06\ \text{m/sec}$$

$$6\text{cm/s}$$

The length of traditionally formed weft yarn by free hand is calculated as follows

- Step1. Total average weight of single 'liq' , 10g
- Step2. Unravel 24m of yarn from randomly selected 'liq' (Average)
- Step3. Average weight of the 24m weft yarn is , 3g

Therefore the total length of manually formed weft yarn is 24m X 10g/3g= 80m/ 'liq'

- Bobbin package formed by motor driven spinning wheel has four times longer than the traditionally formed yarn, 4X80m = 320m

Time taken to build one full bobbin is:

$$= 320\text{m} \div 0.06\text{m/sec}$$

= 5333.3 sec.

$$= \mathbf{88.8\ minutes}$$

=1 hr.28.8 min

Number of full bobbins produced within 8 hour is:

$$= 480\text{min}/88.8\text{min}$$

$$= \mathbf{5}.4\ \textit{Bobbin}$$

- Manually operated spinning machine delivers 4 full bobbins per day, but the modified power driven spinning wheel can produce 5 and 1/2 bobbins per day.

$$= \frac{5.4 - 4}{4} \times 100$$
$$= 35\%$$

Therefore the newly modified spinning wheel has 35% more productive over the manual one.

4.9 Comparison of Manual spinning wheel with proposed Power driven spinning wheel

From the above discussions on design modification and financial analysis of power driven spinning machine prototype fabrication and test it is possible summaries in Table 1.

Table 2 Comparison of Manual spinning wheel with Power driven spinning wheel.

No	**Activities**	**Manual spinning wheel**	**Electrical operated**
1	Production efficiency	Low	High
2	Space utilization	large 45x73x83cm	Small 40x30x25cm
3	Quality	Low	Fair
4	Simplicity to operate	Difficult	Easy
5	Operational Mechanism	Manual	Electrical
6	Applicability	Only for able person	For all person
7	Job opportunity	Low	high
8	Cost	expensive **12123 Eth. birr**	Low cost **3446.15 Eth. birr**

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5. 1 Conclusion

This project base research modifies and develops design and parts of manually operated spinning wheel which are available in TVET colleges, federal micro and small enterprise agency training center and very few MSEs and cooperatives.

This modified spinning wheel has confirmed the working principle of manually operating spinning wheels. It has been designed and constructed to be power driven with speed regulating device, modified flyer with slider, easily replaceable spare cop can be made at home which make its operation easier, smooth and productive by 35% over the manually operated one. Since the machine is power driven, it yields considerable quality product interims of linear density as the operator gives more attention on drafting operation and non altering speed rather than driving by their leg.

Main parts of the machine are easily available in local market and can be manufactured and assembled by local micro and small enterprise (MSEs) with in cheap price i.e. 3446.15 Eth birr. And the machine requires relatively less space compared to the manual one by more than half percent because it eliminates the main wheel with its stand. This modification helps every individual (women, young children and partially disabled peoples) to operate the machine at their home with in limited space with higher production rate and ease of operation so it is indispensable for job opportunity for spinning machine manufacturer and spinners/operators/ majority of the society. Mass manufacturing also possible because nowadays Ethiopian government give more attention to TVET colleges and MSEs to transfer technologies by adjusting lone, machine lease and the like.

Since textile sector is a necessary tool for stimulating economic growth and employment opportunities in all societies, universities EiTEX, textile institutes, TVET colleges, can utilize this machine as source of research imputes and deliver training on it. So it can be conclude that this project has a great role and improves the drawbacks of the imported and locally manufactured spinning wheels.

5.2 Recommendations

Finally I would like to forward the possible recommendations to the concerned body. The Modified motor power driven spinning wheel with modified slider has been recommended for local spinners who work at their home, TVET training colleges and for those who graduates from TVET colleges, MSE enterprise engaged in spinning and traditional weavers, partial disabled persons, women and children because it is productive, cheap, ease to operate, portable from place to place via bag and require less space, can be maintain locally.

- University and TVET colleges and institutions have an organized technology teams. so I recommended they have to approve and fascinate such technologies periodically by transferring it to society through MSE and TVET.
- All other disciplines should work with textile researchers and experts, textile institutes should take the lion share in this regards.
- This project shows that our competence how can we manufactured and improve imported technologies locally so academic and research institutes has to perform more jobs in order to transfer such cottage industry technologies.
- Ethiopian government establishes different institute including Ethiopian Textiles Industry Development Institute (ETIDI) such institute should focus on traditionally way of making crafts alongside to modern technologies since cottage industries are the bases for recently developed sophisticated technologies.
- Government and nongovernment organizations have to provide the training for such new technology both how to manufacture it and how to operate it for MSE TVET and private spinners.

- Attitude towards the sector should be improved still there is poor attitude on the society
- Reviving and restructuring the spinners servicing centers (SSCs) to act as R&D centers which can be provided solutions in spinning wheel for product innovation as well as process innovation to the spinners.

What we discussed in the above issues can be implemented completely with proper government policy interventions. proper integration of co-operation and co-ordination from all government agencies, co-operative societies, NGOs, local spinners and weavers, traders and retailers of local spun yarn products should give due attention on Textile technology sector specially for cottage industry.

5.3 Future Scope

1. This modified motor power driven spinning wheel can be easily converted into solar operated spinning wheel
2. The part of flyer i.e package building mechanism can be modified to be self package building mechanism.
3. Incorporate drafting system

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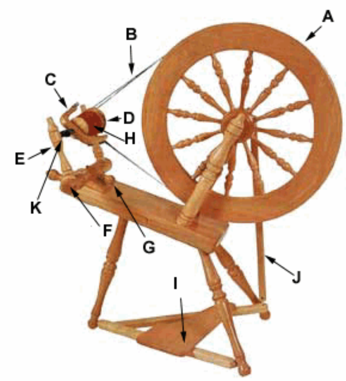
The Paris Book of Job, created in the Peloponnesus in 1361–62,

APPENDICES

Appendix A

Pictures modified Power Driven Spinning Wheel during Prototype Fabrication i.e. Assembly, Checking prototype, Testing and sample yarn production.



Picture of spinning wheels which are available in TVET colleges, Federal MSEs and local spinners and prototype of my power driven spinning wheel

Picture while I am fabricating and producing parts, size and shape and assembling some parts of power driven spinning wheel in Gondar polytechnic college

Fully assembled power driven spinning wheel with and without pedal driven wheel in as optional in case of electric power interruption

Appendix B

Checking the power driven spinning wheel and producing weft yarn

Testing the functionality of the prototype

Sample weft yarn Product

Appendix C

Work plan

No	Activities	June				July				August				September **		
		Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3
	First Quarter															
1	Undertaking literature review on design and fabrication of electrically operated spinning wheel															
2	Design preparation															
	Second Quarter															
1	Material selection and preparing specification															
2	Buying															
	Third quarter															
1	Providing the required shape, length, width, thickness and number															
2	Assembly, Finishing ,Testing and sample production															

** week 1 is considered 13th month of Ethiopia "Pagume"