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Research Article

Design and Fabrication of Multi Plant Stem Fiber Extraction Machine

Fitsum Etefa Ahmed, Mekasha Tilahun, Firew Gemeso

Ethiopian Institute of Textile and Fashion Technology (EiTEX), Bahir Dar University, Bahir Dar, Ethiopia.

*Corresponding author's e-mail: oneday790@gmail.com

Abstract

The interest of using natural plant fiber is increasing. Nowadays Natural fibers are preferable than synthetic fiber for their appropriate stiffness, mechanical properties and high disposability. There are two ways of plant stem fiber extraction adopted. These are stripping and decortications by a decorticator. Manual extraction of fibers by stripping method is tedious, time consuming and cannot be recommended for industrial application. There is a semi-automatic decorticator machine which used for extraction of fiber from the skin, bark, or rind off nuts, wood, plant stalks etc. It is used in the production of natural plant stem fiber extraction with high production rate, but it is expensive and not available in Ethiopia. The country had an agricultural lead economy, producing a variety of cereals, fruits, vegetables and cash crops. The Authors designed and fabricated multi plant stem fiber extraction machine. The machine has a horizontal drum whereby a drum has two different surfaces. The first half drum surface has closely welded small nails which used to extract fiber from plant stem which have a flat surface like, banana plant, sisal plant etc. The second half drum surface is grooved which used to extract fiber from plant stem which have a circular shape like papyrus plant. The fiber extraction could be performed simply by feeding a cleaned part of the stem through feeding unit of machine. Currently in the country there is no electromechanical plant fiber extraction machine. Some plant fiber extractor's in the country uses manual extraction of plant fiber. Authors fabricated plant stem fiber extraction machine have a higher production rate than manual extraction and the Authors planned to fabricate and distribute more machines for small scale enterprises participated in fiber extraction in the country.

Keywords: Textile; Plant Fiber; Fiber Extraction; Decorticator; Stripping.

Introduction

The interest in using natural fibers has increased significantly in the last few years. The abundance in nature combined with the ease of its processing was an attractive feature, which makes it an important substitute for synthetic fibers which were potentially toxic. Natural plant stem fibers possess many characteristics which make their use advantageous: low cost, low density, biological degradability, renewability, good mechanical properties and non-toxic. Now a day, Natural fibers are preferable for their appropriate stiffness, mechanical properties and high disposability [1-5].

There are two ways of fiber extraction adopted. These are stripping and decortications by a decorticator. Stripping is a manual extraction of plant fiber. Plant stem sections were cut from the main stem of the plant and then rolled lightly to remove manually by means of comb, and then the fibers were cleaned and dried. This manual extraction of fibers was tedious, time consuming and cannot be recommended for industrial application. Stripping is the most widely used and oldest method of removing fiber from the leaf sheaths consists of two basic operations: first, separating the fibrous outré layer from each leaf sheath, this outer layer being termed "tuxy" and the operation "tuxying"; and second removing pulpy material, thus freeing the fiber strands from the tuxy, the operation being termed stripping or cleaning. Both operations have to be performed as soon as possible after the stalk is felled. The tuxying operation is usually done in the field. The workman inserts a point of knife between the outer and middle layers of the leaf sheath, freeing an end of the outer layer 1 to 3 inch wide. This strip or tuxy is pulled off the entire length of the sheath. Each leaf sheath furnishes 2 to 3 tuxies. When all tuxies are removed from

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the leaf sheath, it is removed from the stalk and allowed to remain on the field for organic fertilizer. Usually another workman picks up the tuxies and carries them to the place where the stripping or cleaning operation is to be performed. This mechanical and manual extraction of banana fibers was tedious, time consuming, and caused damage to the fiber. Consequently, this type of technique cannot be recommended for industrial application. A special machine was designed and developed for the extraction of banana fibers in a mechanically automated manner.

A decorticator is a machine for stripping the skin, bark, or rind off nuts, wood, plant stalks, grain, etc., in preparation for further processing. Decorticating Machines were developed to separate the fibers mechanically after retting was complete. With the new machine, known as a decorticator, plant is cut with a slightly modified grain binder. It is delivered to the machine. The hurds are broken into fine pieces which drop into the hopper, from where they are delivered by blower to a baler or to truck or freight car for loose shipment. The fiber comes from the other end of the machine [6-12].

Decorticator machine used in the production of natural plant stem fiber extraction but it is expensive and currently not available in Ethiopia. The country had an agricultural lead economy, producing a variety of cereals, fruits, vegetables and cash crops. Besides the main agricultural products, different parts of the plants and fruits of many crops may be viable sources of raw material for industrial utilization [13-16]. In the country shortage of raw materials was a notable hindrance limiting the industrial growth. Besides the main agricultural products, different parts of the plants and fruits of many crops may be viable sources of raw material for industrial utilization, but only part of this material was exploited profitably because of lack of knowledge of the technology for its economic use and so much was returned to nature unused. In country textile industries there is shortage of raw materials especially the amount of cotton harvested cannot meet the great demand by Ethiopian Textile industry. In the country there is high amount of plant stem which have a fiber were dumped as waste, farmers often face the problem of disposal stems and these huge stocks were getting accumulated [17-24]. The present work aims at fabricating multi fiber extraction machine with less manufacturing cost with high production rate.

Methodology

Authors gathered data through observation, interview and relevant Literature review. Data is gathered from different organization like Bahir Dar Textile Share Company, Local machine work shop (Tornio work shop), Local Spare part suppliers, Small Scale Enterprises and Local Fiber Extractors.

Materials

Hollow Structural Sections of circular (CHS) pipe, Motor, Rectangular (RHS), Tubular steel, Sheet Metal, Bearing, Pulley, Belt, Nails, Socket, C- channel iron, Shaft, Angular iron etc., were used in fabrication work.

Methods

The main aim of this project is designing and fabricating multi fiber extraction machine. Currently in the market there are different single fiber type extracting machines, but the Authors machine can extract different types of fiber. As indicated in Fig. 1, the machine design has multi fiber extraction drum, motor and machine frame. The machine can work by Electric power and used to extract multi fiber.

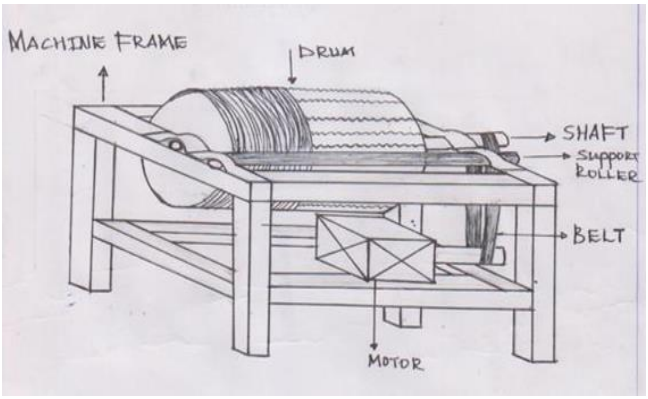

Fig. 1. Multi plants stem fiber extraction machine design

Multi fiber extraction machine parts description

Fiber extraction drum

Nowadays it is known that, different types of fiber extraction process are followed in different areas of world. Based on different types of plant stem fiber arrangement in their plant stem, the Authors fabricated extraction drum unit which used for the extraction of fiber from

different plant stem. The extraction drum has 70cm length and 65 cm circumference. As indicated in Fig. 2, the drum has two different surfaces. On the half length of drum surface, small nails are welded closely based on fiber arrangement of different plant stem which used to extract fiber from plant stem which have a flat surface like, banana plant, sisal plant etc. The other half length has grooved drum surface which used to extract fiber from plant stem which have a circular shape like papyrus plant. Nail welded drum surface have a length of 35 cm and the nails are welded on the drum by having 1.2 cm gap between nails at 90 degree to the drum length. Nail welded drum surface used to extract fiber from plant stem which have a flat surface like, banana plant, sisal plant etc. Grooved drum surface have a length of 35 cm and the grooved have a gap of 0.25 inch each other and each groove have a depth of 0.35 inch grooved drum surface used to extract fiber from plant stem which have a circular shape like papyrus plant.

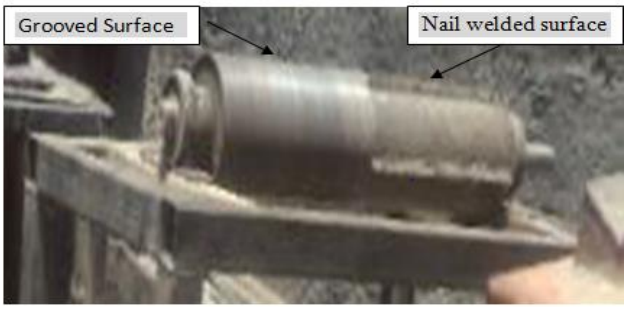

Fig. 2. Multi plants stem fiber extraction drum

Fiber extraction machine frame

As indicated in Fig. 3, the machine frame is made from 60x60x2 mm rectangular tubular iron steel which used to carry out machine parts. The machine frame has a dimension 110 cm height, 90 cm Length and 60 cm width.

Fig. 3. Fiber Extraction Machine frame

Machine motor

An electric motor is an electrical machine that converts electrical energy. As indicated in Fig. 4, the Authors used 2HP electrical motor with 900 rpm. The machine motor is connected with main shaft by using two v-belts.

Fig. 4. Machine motor

Plant stem feeding and machine protecting unit

As indicated in Fig. 5, the machine has two fixed plant stem feeding roller and the drum is covered with 0.75 mm thickness sheet metal. Sheet metal is used to protect machine operators from danger.

Fig. 5. Fiber stem feeding part

Result and discussion

Description of plant stem fiber extraction machine

Plant stem fiber decorticating machine used to extract fiber from different plant stem. The machine has a drum with two different surfaces which used to extract different fiber. The drum has a shaft holding extraction drum and at two edge of the shaft. The machine has two bearing with their bearing house used to hold extraction drum shaft. One edge of shaft has two pulleys and the motor under the drum also has two pulleys. Pulleys on the shaft and motor are connected by two V-belts. When the motor starts rotation, the extraction drum belt will drive the shaft. The drum which fixed on the shaft starts rotation and drum can start extraction of fiber from plant stem. The machine has a socket which used to connect with a power source. The drum is covered with a sheet metal for safety. During fiber extraction various plant stem fiber can pass through the machine feed rollers. As indicated in Fig. 6, fabricated plant stem fiber

extraction machine used to extract different plant stems, like banana plant, sisal plant, papyrus plant and etc.

Fig 6. Fiber extraction machine

Table 1. Machine specification

S.No.	Specification	Description
1	Type of machine	Multi plant stem fiber extraction machine
2	Uses	Extract fiber from plant stem
3	Working condition	Electrically
4	Number of operator	1 person/machine
5	Material input	Plant stem
7	Material output	Plant stem fiber
8	Maintenance system used	Oiling and cleaning
9	Power	2 HP
10	Length of machine	0.75 m
11	Width of machine	0.9 m
12	Height of machine	1.1 m
13	Driving type	Motor

Table 1 shows multi fiber extraction machine specification and description. The machine uses electric power and can be maintained easily by cleaning and oiling. The machine motor has a force 2 HP with 900 Rpm. The cost to fabricate this machine is very cheap compared to Automatic Electrical fiber extraction machine in the market. To fabricate this machine, it costs around 650$ as compared to 3500$ in case of an Automatic Electrical in the market.

Benefits of project

Higher Production rate

As shown in Fig. 7, the authors extracted plant stem fiber in order to know production rate of the machine. The Authors used sisal and papyrus plant stem sample for extraction. They tried 5 sample extractions for 10 min for each samples. They extracted an average of 2.5 kg of sisal fiber within 10 min and an average of 1.5 kg of Papyrus fiber within 10 minutes. Based on the machine can extract an Average of 15 kg of Sisal fiber within an hour and can extract an average of 9 kg of papyrus fiber within an hour. In case of Manual fiber extraction, a person participated in natural fiber extraction in the area can extract around 20 kg of fiber per day. If someone used the new machine for fiber extraction, he or she can extract more than 100 kg of fibers per shift or within 8 hours. This indicates that, the new machine has higher production rate than manual fiber extraction.

Fig. 7. Sisal fiber extraction by authors machine

Easy to operate

The machine can be operated easily. The machine has only On/Off Switch to operate and does not include any complicated electronic devices. This makes the machine quite easy to operate.

Less maintenance

The machine has only two rotating parts such as Motor and drum which requires simple cleaning and Oiling. Moreover, most of the components used have large working life span, which reduces the maintenance of the machine.

Increases human comfort

Manual Fiber Extraction is a tedious job to do and it depends completely on the skills of worker, but the machine can be used by any other person without much knowledge of the Extraction techniques. The worker can be engaged in plant part feeding and fiber collection. Thus increases human comfort.

Conclusions

In Ethiopia, textile sector plays a very important role in the Economic growth of the Country. Different domestic and foreign companies are investing their capital in this sector. This project aims at facilitating innovative eco-friendly extraction, product development activities and effective industrial utilization of fibrous wastes from plants stem. The aim to design multi plant stem fiber extraction machine is that to increase natural fiber extraction. Manual fiber extraction is very tedious. Also the time required for the fiber extraction varies largely from worker to worker, thus making process is time unpredictable. This work lead to develop easily controlled multi plant stem fiber Extraction Machine. This will make fiber extraction convenient for Textile production. The project was set up to promote the creation of jobs, economic development and to create entrepreneur skill in the society and will specialize in the production of extraction of fiber from different plant stem. It is planned to fabricate the extraction machine to distribute for community participated in natural fiber extraction in the area.

Conflict of interest

The authors declare that there is no competing interest.

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