Development of Paper Twining Machine

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Abstract

Twined product or rope was used in early times even during the prehistoric era where there is evidence that ropes were made from grasses and vines twisted together by hand. Ropes were used for moving heavy objects like stones and logs. The ancient Egyptians were probably the first civilization to develop special tools to make rope and as modernization continued, more rope machines were developed and produced. Common materials for rope include natural fibres such as manila hemp, hemp, linen, cotton, coir, jute, straw and sisal, as well as synthetic fibres such as polypropylene, nylon, polyesters, polyethylene, aramids, and acrylics. Rope is of paramount importance in diverse fields such as construction, seafaring, exploration, sports, and communications. Nowadays, it is also used in making handicrafts and as decorative materials. Twined paper is used in handicrafts or as decorative material but is more popular as paper bag handle. Rope can be made using the traditional method or with the use of machines. Traditional or manual method is done by rubbing the said material in between both palms, or between the palm and leg. Large rope making machines are commercially available, but only large companies meeting huge demands are able to use them due to high equipment cost and high energy consumption. For small and medium enterprises some machines are available but the capability of large machine is either split into series of processes and machine or is limited to only one rope diameter. This study opted to develop a prototype of the Paper Twining Machine. A prototype that is portable, low cost, yet consumes low energy and still produce high quality rope or twine. Eventually the working prototype will be tested and evaluated to twine different materials such as dried and slithered hyacinth, coir, fibres, hemp and any imaginable material that is twinable. This was subsequently tested using a working model to ensure that the device performs satisfactorily during service. The prototype unit should successfully pass the functional testing and evaluation conducted at the MIRDC.

1. Introduction

The use of ropes for hunting, pulling, fastening, attaching, carrying, lifting, and climbing dates back to prehistoric times. It is likely that the earliest "ropes" were naturally occurring lengths of plant fibre, such as vines, followed soon by the first attempts at twisting and braiding these strands together to form the first proper ropes in the modern sense of the word. The ancient Egyptians were probably the first civilization to develop special tools to make rope. Egyptian rope dates back to 4000 to 3500 B.C. and was generally made of water reed fibres. Starting from approximately 2800 B.C., rope made of hemp fibres was in use in China. Rope and the craft of rope making spread throughout Asia, India, and Europe over the next several thousand years.

Some rope continues to be made from natural fibres such as coir and sisal, despite the dominance of synthetic fibres such as nylon and polypropylene which have become popular since the 1950s. This is because demand for eco-friendly product become more and more popular thus products such as handicrafts and dec-

Fig.1. One strand paper rope

Products made from twined paper rope.

Fig.2. Paper bag handicrafts using paper rope as base material

Fig.3. Paper bag using paper rope as handle

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orative materials made from natural fibres are widely accepted.

1.1 Significance

The project was made due to demand in twining mechanism for twinable materials such as hemp, jute, fibres and paper. But more particularly, due to the demand for a twining machine for paper, that is mostly used in handicrafts and paper bag handle.

This is to produce quality twined two strand rope, which will be used in many livelihood program such as basket weaving, paper bag making and many more.

The project will provide employment to individuals in the barangay who are skilled in making handicraft products from such materials.

1.2 Objectives

To design and develop a locally manufactured twining machine capable of twining a two strand paper twine.
To design and develop a portable twining machine which combine the function of the slivering machine and twining machine used in coco coir.

1.3 Time

The development of the prototype initially took six (6) months, followed by another six (6) months to fully refine and synchronize the twining operation of the machine.

1.4 Place of Study

The development of the prototype was done at the Metals Industry Research and Development Center (DOST-MIRDC) where design and fabrication facilities are present including the testing facility.

The facilities are composed mainly of the machine shop, welding shop, assembly area and painting area for finishing of parts and components.

Fig.4. Manual twining in between both palm

Fig.5. Manual twining in between palm and leg

2. Review of Literature

2.1 Manual Twining

The following images are just some of the similar and probable models that could be considered in designing the prototype of the twining machine.

Manual twining is done by rubbing/twisting a small amount of materials in between both palms as shown in Fig. 4 or between the palm and leg as shown on Fig. 5. This creates a single strand rope which is then combined to make a two or more strand rope using the same method. This traditional method has many disadvantages like inferior quality, short length produced and low strength worthiness due to uneven twist and diameter of said material. Manual twining is a labor-intensive method thus the rate of production is slow.

2.2 Conventional Twining Machine

The conventional type twining machine shown in Fig. 6 is consisted of several sub-assembly such as conveyor, carding, twining, spool, transfer mechanism and prime mover. The current condition of mechanized twining process is not only fast than the manual, it also results in more uni-

Fig. 6. A conventional twining machine

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form and with better quality twined rope. It has a higher tensile strength due to added carrying thread in each single strand yarn.

This machine produces two-ply rope of 4-6 mm diameter by intertwining the loose and twisted coco coir fiber coming from the belt conveyor and it goes to carding process to remove impurities, dust and short fibers. Then it passes thru the two crumpets to twist each strand and after twisting it will intertwine the two single strand to produce two-ply fiber rope. The rope will then be wound and spanned by a revolving spooler in the spindle assembly. The machine capacity can produce twined rope of about 18-20 kg/day. However, this type of twining machine demands highly skilled operator, upon whom the quality and productivity of the end-product is largely depend. Frequent problem encountered is the breakage of fiber rope due to uneven distribution of fallen fibers along certain portion of carrying cotton thread which cause disruption on the production.

2.3 Three Strand Gear Type Hook Rope Machine

In this method the yarns or fibres were attached to hooks. The hook was rotated, twisting the strands into a rope. The rope stayed together because the twist went in opposite directions. Fig. 10 a rope tool was placed between the strands as they were twisting to keep the twist tight and even.

Fig. 7. Portable three strand gear type hook rope machine

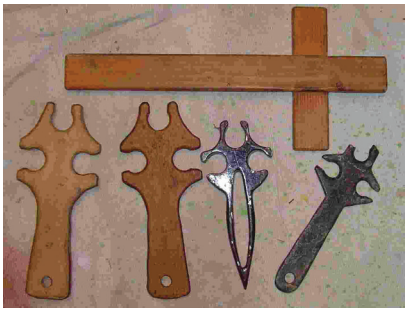


Fig. 8. Single strand paper rope making machine

2.4 Twining Machine with Spooler

Conventional twining machine uses a conveyor to transfer fibers into the crumpet prior to twining. This results to frequent breakage of twined ropes because of inconsistency of fiber lengths.

Instead of using a conveyor, slivered fiber rope from MIRDC developed slivering machine is used in twining. The twining machine will produce 2 ply rope of 6-10 mm diameter by intertwining slivered ropes from the slivering machine. The slivered rope and yarn will then be twined in the spindle assembly. This twining machine is better and simpler in operation since it eliminates the common problems in conventional twining machine i.e. disruption in twining operation due to breakage of fiber rope, high skill requirement, etc.

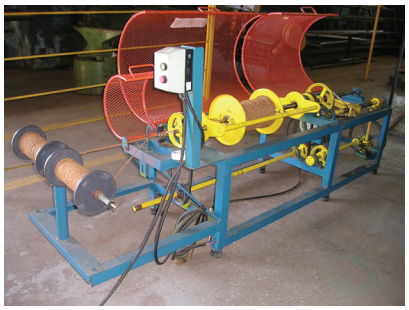


Figure 9. Twining machine with spooler

2.5 Paper Rope Making Machine

This machine uses kraft paper as it raw material producing a single strand paper rope. Paper rope is commonly used as paper bag handles, and or as a decorative material, or in making handicrafts.

Figure 10. A rope tool / separator

2.6 Global Handicrafts Trends

Handicraft products are not identified separately in H.S. Codes and therefore no reliable trade data is available on an international level. According to an extensive study done by US AID in 2006 on the "Global Market Assessment for Handicrafts" it specified that handicrafts are part of a much larger home accessory market, which includes handcrafted, semihandcrafted, and machine-made goods. The study also examined the global demand of handicraft as part of the home accessory market in the U.S. as an indicator of the size of demand.

The global market for home accessories was estimated to be at least $100 billion in 2006 according to the study. The U.S. is the largest importer of the home accessories and was valued at $67 billion, the second largest market is the E.U. collectively followed by Japan and Hong Kong.

The study segments the home accessory market in the U.S. in 2004 according to market share as follows: Accessories and Gifts 22%, Accent furniture 21%, Portable lamps 11%, Area rugs 9%, Wall décor 9%, Lighting fixtures 7%, Tabletop and tabletop accessories 7%, Collectibles 6%, Soft goods 5% and Permanent botanicals 4%.

The study highlighted the potential buyers of handicrafts in the U.S. as follows: (1) Specialty and lifestyle stores; (2) Catalog and internet retailers; and (3) Independent retailers.

The study lists most common raw materials used by handicraft producers as classified by ITC as follows: Basket, wicker and vegetable fibers, Metal, Leather, Paper, Pottery, Wood, Soap, Textiles, Stone, Glass, Bone, Horn, Shells and a combination of different materials and techniques.

The major exporters of handicrafts are China, India and Vietnam. China is the largest exporter of home accessories globally and in April 2005, China produced an estimated 70% of all home accessory products sold in the U.S. India total exports of handicrafts amounted to $3.5 billion in 2007 and 30% is exported to the U.S. Vietnam Handicraft exports in 2007 stood at US$824 million.

In terms of main trends in hand-

icrafts, it is growing commoditization of handicrafts production, shorter product lifecycles and an emphasis on creating new designs, the move from indigenous designs towards contemporary minimalism designs, the push to differentiate by focusing on luxury items and a significant growth in online sales.

(Source: USAID Handicraft Market Analysis)

2.7 Demand for Handicrafts in the Philippines

By far, exportation and tourists are one of the largest buyers of segment of handicrafts here in the Philippines. Tourism is affected by many economic and political factors and therefore the number of arrivals fluctuates from year to year as seen in Table 1.

As seen on the Fig. 4 visitors arriving here in the Philippines increase every year. 2010 to 2011 records shows a 12.71% growth rate of visitors arriving here in the Philippines. These means that demands for handicrafts made by locals is increasing every year. Handicrafts that were made by locals were mainly from indigenous material such as hemp, and natural fibres.

3. Scientific Basis/Framework

The basic concepts that have been considered to design the new type twining machine are as follows:

1. Simplicity at all stages. The prototype machine should be simple enough FOR that could install, operate and maintain easily.
2. Raw materials are readily available in the local market.
3. Reduction in weight, machine and power cost.
4. Portability of the machine

Based on the design consideration, the existing twining machine concept was revised in order to achieve portability without sacrificing the quality output; a concept of combining the slivering and twining process was made. Slivering is a process which twist raw material into a single strand. Twining is the process of combining the single strand rope into a two strand intertwines product rope. Below are the process diagrams for both conventional and conceptualized twining process, Fig. 16 is the conventional twining process developed while Fig. 17 is the conceptualized twining process.

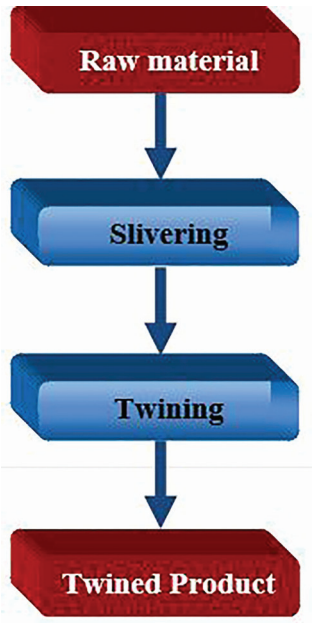


Figure 11. Conventional Twining process

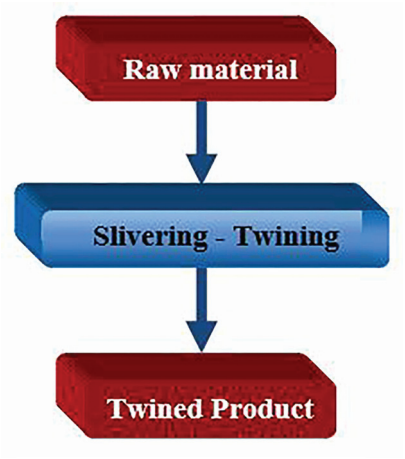
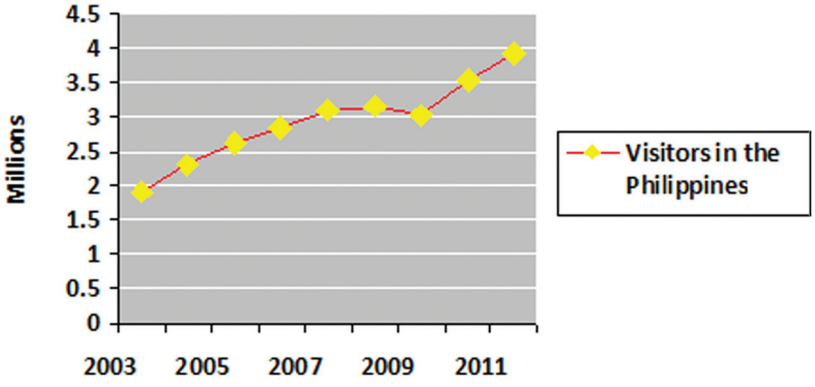


Figure 12. Concept twining process

Table 1. Tourism Arrivals in Philippines 2003 – 2011



Indicators	2003	2004	2005	2006
Visitors Arrival	1907226	2291352	2623084	2843345

2007	2008	2009	2010	2011
3091993	3139422	3017099	3520471	3917454

(Source: Department of Tourism from A/D Cards & Shipping Manifests)

4. Methodology

4.1 Project Development

The prototype design will have slivering, twining and spooling mechanisms. The tool bit for the slivering is interchangeable to allow change in rope diameter output.

The spooling speed may be modified by adjusting or changing the gear ratio of the spooling mechanisms.

The bobbin of the spooler is also interchangeable to allow replacement of empty bobbin when current bobbin is full.

4.2 Procedure

Having decided the concept, the activities that will be performed are as follows: finalization of concept; completion of the design; sourcing of materials; fabrication; assembly; initial testing; debugging; final testing; and terminal report writing.

4.3 Materials

Materials used in the base platform are mild steel angle bar and flat bar. For the slivering and twining subassembly, engineering plastic is used for the twining bit for low friction twisting, mild steel sheet for body and housing. For the spooling sub-assembly engineering plastic is also used for weight reduction to avoid excess vibration when in operation.

Discussion of Results and Findings

This machine is created primarily to twine a Japanese paper and make it into a two-strand string. Two Japanese paper strips were twisted simultaneously using a series of twisting process. The strips will be twisted initially in a pre-twisting mechanism and into the main mechanism, which twist and combine each strand to form the finished product. The finished product then goes to the spooling mechanism to spool the twined paper into desired volume.

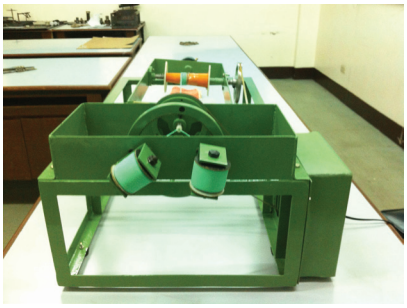
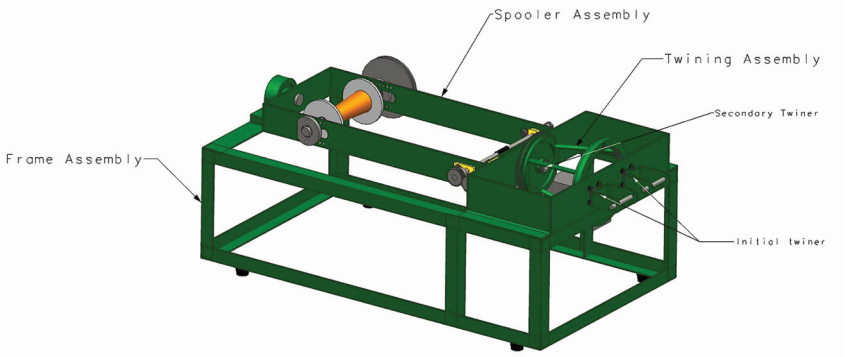


Fig. 13. Actual Twining Machine Front View

Fig. 14. Actual Twining Machine Side View

Major Parts of Paper twining machine



The whole assembly consists of twining subassembly, spooling subassembly and the machine housing and motor.

Main Technical parameters:

- Speed of Winding and Twining: 10 - 20m/min
- Twined paper diameter: 2 – 9 mm
- Total Power: 120W
- Dimensions of Machine: 690mm x 400mm x 310 mm

Description of Major Parts

1) Twining Assembly– this is where the raw material, from a strip of paper is twisted to produce the first strand, then to the secondary mechanism combining them forming a two strand rope or twine. The twining assembly consists of a set of planetary gear that is coupled to a pulley, which is driven the motor.

Initial twiner – the initial twiner under the twining assembly is the first stage of twisting. In this part of the machine the strip of paper will undergo rapid twisting to form the initial twine required for the final rope diameter.

Secondary twiner – In this part of the machine the initially twisted small diameter strand undergo slow twisting to perform the twining or combination of the strand forming a two strand rope.

2) Spooler Assembly– the spooler assembly spools the finish product into a spool of rope. The spooler assembly consists of a set of gears and pulley and a bobbin where the spooling of the rope is being made. The whole spooler assembly goes into a circular motion with exact same speed with the secondary twiner. The circular motion is the essential component of the spooler assembly to address the counter twisting when creating the rope / twine which if neglected results in loosening of the rope creating an inferior quality rope or twine.

3) Frame assembly – the frame assembly holds both the twining assembly and the spooler assembly. The frame assembly comes with four rubber feat which is responsible to damp any vibration created by the machine.

4) Motor and speed controller – this part of the machine is the prime mover of the machine, coupled with a speed controller operator can reduce or increase the speed of the twining process.

Testing Japanese Paper

Random samples were taken from the paper rope totaling 6 ropes. That is, three ropes for rope diameter 2mm, and three ropes for rope diameter 3mm. Using a calibrated digital-type Vernier caliper, each rope was measured for its initial parameters length and width (before & after twining) at five strategic points in the entire rope length. *(See illustration on next page)*

Summary and Conclusion

A portable paper twining machine that is less expensive, portable, easy to operate and is eco-friendly due to small energy consumption was developed through this study. The machine is made up of locally-developed parts

and simple components. Being low cost, it can be afforded by small and medium enterprises. Its portability is attributed to tabletop machine's overall dimensions of 690mm x 400mm x 310mm. The machine's portability and simplicity render it eco-friendly as it consumes only 12W of power.

The paper twining machine which comprises of combined slivering and twining operation up to the spooling operation was an effective machine for rural and small organization. Due to its simplicity, portability, low energy consumption, and locally available parts, this machine can be a competitive machine that can be deployed around the country.

This machine that is primarily created for twining paper can also be used in any twinable material such as hemp, jute, fibres and other related material.

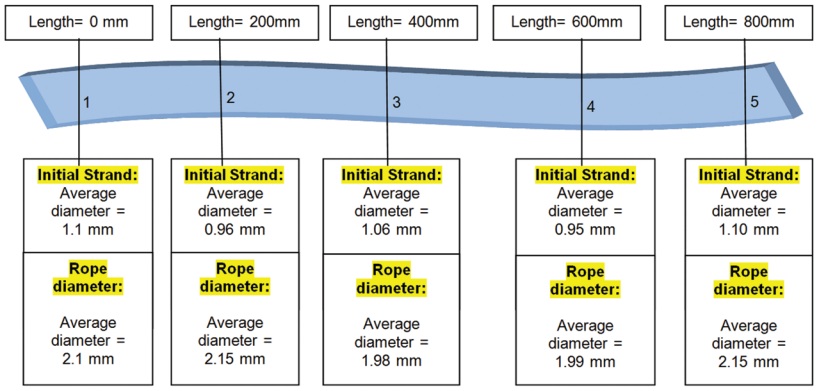
Recommendation for Future R&D Work

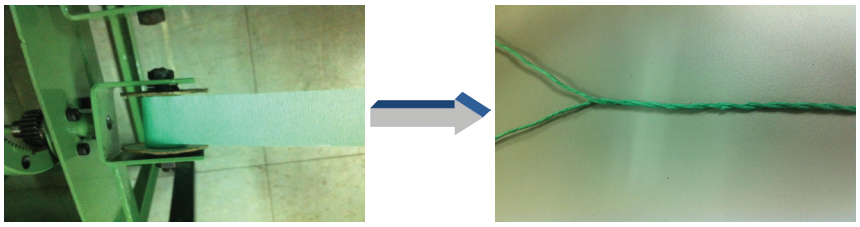
It is recommended that the acceptability of finished product be standardized based on every application, which is in need when the machine is in operation. In this manner the machine can be accurately configured to the exact speed and rate. To be able to produce high quality product at a maximum or allowable speed and rate.

Modifying the speed ratio of the gears especially in the spooler part of the assembly will allow the operator to adjust the quality of rope pitch produced. Also modifying parts such as the bobbin and the twining bit can greatly improve the durability of the machine thus allowing the machine to increase its performance and working hours.

To further improve the quality of the product being produced by the machine a synchronize twining and spooler assembly should be consider. Thus either having a gear ratio of 10:1 for the twiner or a gear ratio of 1:5 for the spur gear in the spooler assembly.

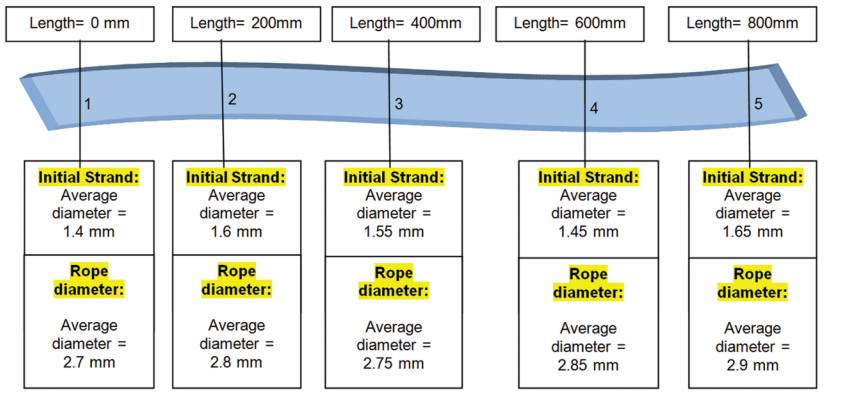
TEST PARAMETER No.1: paper width = 30mm

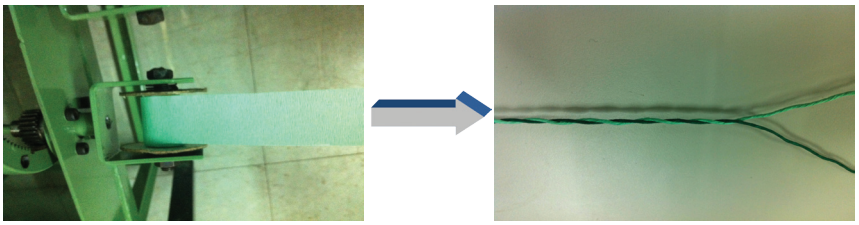




Before After

TEST PARAMETER No.2: paper width = 40mm





Before After