DESIGN AND DEVELOPMENT OF “TINAGAK” KNOTTING

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Abstract

The study sought to bring a solution to the slow and tedious process of knotting abaca (Musa textiles Neé) which is still processed by hand by a large number of abaca weavers and farmers. “Tinagak” is the local term for knotted Manila hemp, and is the basic component in the production of “sinamay” or dyed and stiffened manila hemp. Reverse engineering was done on the Weavers Knotter (MESDAN Brand) to come up with a design applicable to “tinagak” knot. On-station testing however showed that the prototype failed to work properly than what was desired. Alternative designs were made; however, the prototypes have not been fabricated as the mechanisms and parts require specialized tools and materials as well as precision instruments. Baseline information and data obtained will serve as a guide to researchers and inventors who want to venture and conduct similar undertakings. Designs have been made which will serve also as a good basis and reference for further explorative undertakings in order to come up with a desired machine for knotting “tinagak” in the future.

Keywords: tinagak, knotting, Manila hemp

1.0 Introduction

Abaca (Musa textiles Neé), popularly known in the international market as Manila hemp, is one of the top foreign exchange earners of the Philippines. The abaca industry has considerably contributed to the country’s economy, not only in terms of the millions of dollars it has brought in but also of the massive employment it has generated for the Filipino people.

Eastern Visayas remains the leading producer of abaca in the Philippines, followed by Bicol and Southern Talgalog regions (Gonzal 1994). In 1977, abaca production in Northern Samar alone reached 2,300 tons representing five percent of the country’s production (NSIRDTP Terminal Report 1997). Southern Leyte is the province in the region which has the biggest land planted to abaca with the fiber plant having 2,732 farmers. The province also topped the list of sinamay weavers (127) used in the production of abaca handicrafts and novelty items. In the production of sinamay, “tinagak” (knotted manila hemp fiber) is the basic component. Southern Leyte alone has 340 “tinagak” makers (DTI 2003). The thriving fiber handicraft industry operating in the Philippines, is exporting on a worldwide basis.

The basic component used in handicraft production is the “tinagak,” a long continuous abaca fiber produced by manually knotting the tips of individual abaca fiber. The production of this basic component is time consuming and tedious. Recent feedback from abaca handicraft processors indicated the
bottleneck in the processing of “sinamay” from “tinagak” fiber. Production of 1 kg of “tingak” yarn requires five days. This work is very boring such that mostly old women are doing this kind of job.

There is existing equipment that is available in joining individual fiber using glue, but comments from sinamay processors indicate that the material produced is not as strong as that of “tinagak.” In Bantig, Maasin City, Southern Leyte, one of the processors use the filamenting machine developed by PTRI to join abaca fibers. However the machine could not produce a continuous single strand of fiber similar to that of “tinagak” but two or more strands fused together using a very fine synthetic filament. The PTRI also made use of the Weavers Knotter (MESDAN Brand) which is used to join threads and synthetic fibers, however, the machine does not work on abaca fibers.

There is no existing equipment yet that has solved the problem of “tinagak” knotting. Hence, this project will try to explore the possibility of designing and developing a “tinagak” knotting machine that will address the pressing problem on the low productivity of “tinagak” fiber.

2.0 Methodology

Baseline Information and Acquisition of Existing Knotting Machine

Actual visit to the SJPCCI-MABIP fiber processing site in Matalom, Leyte was conducted to observe the actual existing method of knotting “tinagak”. Detailed process of the existing method employed by “tinagak” knotters was documented including the time element for each process and the average capacity of the knotters. Previous research studies conducted by the National Abaca Research Center (NARC) as well as Metals Industry Research and Development Center (MIRDC) were also taken into consideration.

A Weavers Knotter for synthetic fiber (MESDAN Brand) was purchased from MESDAN S.P.A. in Italy through their agent, the Textile Machineries and Spare Parts Corporation in Paranaque City. The operation of the machine was studied and analyzed to serve as a basis in the development of the “tinagak” knotting machine through the process of reverse engineering.

Design Considerations

The following were considered as target features of “tinagak” knotting machine to be developed:

A machine that is easy to use/handle by any user.
A machine that has a capacity 3 times higher than the existing hand knotting method.
Quality of “tinagak” (strength of the knotted portion and tightness of the knot) that is comparable to that of manual knotted abaca fiber.
A machine that could produce
higher “tinagak” recovery (minimal wastage of fibers).

Designs were based from the existing hand method and the existing Weavers Knotter mechanism. Reverse engineering of the machine was done to come up with a mechanism that could knot fibers in a way that is comparable to “tinagak.” Working drawings were made using Autocad. Several designs were made and taken into consideration.

**Design and Fabrication of the Prototype**

Designs were conceptualized and drafted using Autocad. A prototype was then fabricated on-station to test and simulate its workability. The developed prototype was tested using abaca fiber obtained from SJPCCI-MABIP. Modifications and re-designing were made to come up with a workable prototype.

### 3.0 Results and Discussion

**Baseline Information**

A field survey was conducted in Matalom, Leyte particularly in SJPCCI-MABIP to gather data and study the existing manual knotting of “tinagak.” Five experienced knotters, all of them women, with an average age of 59 and an average of 30 years in “tinagak” knotting activity. Manual knotting process was observed including the step-by-step hand manipulation to produce a knotted fiber. It was observed that all knotters used the same techniques and gadgets in knotting the “tinagak.” Sheet bend (Fig. 2) is used to knot two fibers. According to the fibers processors, this type of bend is the most applicable to “tinagak” because aside from its strength, it produces only a small bulge or protrusion in the knotted part thus making the knotted fiber easier to pass through the weaving machine without having the knotted part clogged up. In addition, sheet bend is commonly used to tie two ropes of unequal thickness together. The thicker rope of the two is used to form a bight, and the thinner rope is passed up through the bight, around the bight and tucked under itself.

Result of measurements using a Vernier Caliper (Table 1) showed that the “tinagak” knot has an average thickness of 0.58 mm. The highest observed value is 0.8 mm while the lowest is 0.4 mm. Variations in knot thickness is brought about by varied thickness of both ends of abaca fiber. One end of the giber (thicker end) has an average thickness of 0.30 mm while the thinner end has an average thickness of 0.16 mm.

It was observed that existing hand knotting method of “tinagak” could be divided into four major steps. The first step involved the pulling of a single fiber from a bunch of fibers suspended just beside the knotters, then it is followed by knotting, trimming, and lastly,
Figure 2. Sheet bend used to knot two fibers.

Table 1. Variations in the thickness of “tinagak” knot and abaca fibers.

<table>
<thead>
<tr>
<th>Samples</th>
<th>“Tinagak” knot (mm)</th>
<th>Abaca fiber head (mm)</th>
<th>Abaca fiber tail (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.80</td>
<td>0.40</td>
<td>0.10</td>
</tr>
<tr>
<td>2</td>
<td>0.55</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>3</td>
<td>0.70</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>0.50</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>5</td>
<td>0.45</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>6</td>
<td>0.75</td>
<td>0.30</td>
<td>0.15</td>
</tr>
<tr>
<td>7</td>
<td>0.60</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>8</td>
<td>0.40</td>
<td>0.30</td>
<td>0.15</td>
</tr>
<tr>
<td>9</td>
<td>0.55</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.55</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>Total</td>
<td>5.85</td>
<td>2.95</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Pulling the knotted fiber to the container where the long and continuous knottter fiber is placed (Fig. 4). The time element for each step was recorded using a stopwatch. As shown in Table 2, the total average time spent by experienced knotters in doing the four major steps of knotting is 12.67 seconds. Pulling of single fiber from a bunch of suspended fibers consumed an average of 4.19 seconds (33.07% of the total knotting time), while the average time spent in the actual knotting using the sheet bend is 2.86 seconds (22.57% of total knotting time).
time), while pulling the knotted fibers to the containers consumed an average of 4.02 seconds (31.73% of the total knotting time). It was surprising to note that for experienced knotters, time spent in pulling the fibers before knotting (4.19 seconds) an after trimming (4.02 seconds) is much longer than the time spent in actual knotting and trimming of knot. This result may not hold true for unexperienced knotters. However, it is expected that total knotting time for unexperienced knotters will be much longer than that of the experienced knotters.

Figure 2. Major steps in hand knotting abaca fiber.
The first major step which is the pulling of fiber from a bunch of suspended fibers is quite difficult to mechanize since the process involves visual inspection and selection of the fiber to be knotted. Mechanizing the 3 major steps could greatly reduce the total knotting time.

Table 2. Time spent (seconds) in doing the four major steps in hand

| Description and Operation of the Weavers Knotter |

The Weavers Knotter (MESDAN Brand) was examined as to its mechanism, design and operation. It has a mass of 0.35 kg and is operated by fitting to the hand of the operator through its handle and hand-fitting belt to accommodate the four fingers. The Weavers Knotter is designed to knot synthetic fibers.

Figure 3. Flowchart of the proposed machine intervention in “tinagak”
The Weavers Knotter parts

Upon examination and familiarization of the above machine, five primary parts were identified as important components responsible for the knotter’s proper operation:

Frame – the frame holds all the other parts and mechanisms of the knotter. It includes the handle where the hand of the operator will be fitted through its belts.

Trigger – the trigger is located at the top of the handle. When actuated by the thumb of the operator, it will drive all the moving parts of the knotter.

Tying scissors – the tying scissors is responsible for winding the fiber to be knotted in order to form the overhand loop and at the same time trim the excess material from the knot formed.

Tensioners – the tensioners hold the fibers to be knotted and control the tension that will be applied to the knot.

Transmission mechanism – the transmission mechanism is responsible for transmitting and changing movement from the trigger to the tying scissors and tensioners. It is composed of gears, screw and return spring.

The Weavers Knotter operates by feeding both ends of the fibers to be knotted altogether across its front opening. The operator will then pull the trigger using his thumb to move the tying scissors and tensioners to knot the two fibers and at the same time trim the excess fibers that protrude from the knotted part. The knot formed is a hand knot, which is not applicable to “tinagak” due to its bigger bulge.

Several trials were conducted using abaca fibers. The fibers are cut as it passes through the scissors, however no knot is being formed. It was found out that the Weavers Knotter couldn’t knot abaca fiber which is somewhat stiff and brittle. Using a polyester thread which is soft and pliant, the Knotter could easily knot but though it has a trimming scissors, a 3.0 mm excess fiber still protrudes from the knotted part.

Based from the above observations, a careful study and analysis was conducted to modify the existing mechanism and to come up with one that will work with the abaca fiber and applicable to “tinagak” knot.

Designs and prototype of the “tinagak” knotting machine

Considering the result of the baseline survey, information
gathered, and preliminary analysis, it was initially decided to design a knotting machine with the following mechanisms:

1. Knotting mechanism that could knot the fiber in exactly the same way as the knot of the manual method (sheet bend),
2. Trimming mechanism to cut the protruding ends of the knotted fibers, and
3. Winding mechanism or rubber rollers to pull the knotted fibers.

However, upon the recommendation of the PCIERD Monitoring Team the researchers later on decided to just focus on the knotting mechanism as the main objective of the project. Reverse engineering was done on the Weavers Knotter with due consideration of the knot produced by the manual method which is sheet bend.

Several designs on mechanism were made based on the Weavers Knotter as well as some independent analysis on possible mechanisms that could make sheet bend’s loop in order to come up with the desired knot for “tinagak.” Initial prototypes were then fabricated to simulate and verify the workability of the designs. On-station testing was conducted using the abaca fiber secured from SJPCCI-MABIP, however several prototypes made failed to work properly as desired. A “tinagak” knot be made using the prototypes but with additional manual manipulation on the fiber thereby making the process much longer. However, with the use of Autocad, design simulation proved to difficult. With the limitation encountered by the researchers, designs were limited only to those that are not much complicated in terms of the mechanisms.

Fig. 5 shows one of the prototypes made and was tested using abaca fibers. The main feature of the prototype is a rotating hook that could make a loop of one fiber similar to that of sheet bend. The problem encountered by the researchers is the mechanism that

![Figure 5. Developed knotting machine prototype being tested by the researchers.](image-url)
A similar design using metals to move the fiber was being tested. The problem again is the design mechanism that could make a loop to form the sheet bend. Manual manipulation is again needed to complete the knotting process.

**Additional designs of “tinagak” knotting machine**

The researchers made other designs, however prototypes have not been fabricated as the mechanisms and parts require specialized tools and materials as well as precision instruments to fabricate them. Submitting the design to fabricators may not be possible because some dimensions are not yet fixed while the drawings of some mechanism are difficult to interpret unless there is direct supervision of the researchers during the fabrication.

Figure 6 shows a design which is based from the Weavers Knotter. It is composed of the following mechanisms/parts: lever, links, slider, rollers, rack gear, screw and cam. The lever will actuate all the mechanism once it is pushed down by the operator.

![Design based on the Weaver’s Knotter](image)

Figure 6. Design based on the Weaver’s Knotter

Figure 7 shows another design which was independently based on how the sheet bend loop is being made. There are no mechanisms involved but only two fixed plate hinged together on one side containing rectangular channels which will guide the abaca fiber as it is pushed inside the channels. The channels have a uniform width and depth of 1.5mm, respectively, enough to accommodate a single abaca fiber.
As the two fibers to be knotted are inserted and pushed inside the channels of the two plates, sheet bend loops will be formed. When both ends of the inserted fiber come out from the opposite sides of the plates, a sheet bend loop is already formed in between the plates. A pedal operated device which will control the opening of the two plates will then be triggered by the operator to open the two plates and release the sheet bend loop formed. The operator will then pull both fibers that are joined to tighten and complete the knot from the loop already formed. The plate that will be used should be a stainless steel or similar metal that will not corrode and that the channels should be very smooth to avoid blockage once the end of the fiber is pushed inside.

Figure 7. Design of tinagak knotter based on the loops of a sheet bend knot (plates in the drawing are in an open position)

On-station testing was conducted to verify the workability of the designs. However the prototypes made failed to work properly than what was desired. The researchers made other designs, however prototypes have not been fabricated as the mechanism and parts required specialized tools and materials and precision instrument. Submitting the design to fabricators may not be possible because some dimensions are not yet fixed while the drawings of some mechanism are difficult to interpret unless there is direct supervision of the researchers during the fabrication.
4.0 Conclusion

Much effort has been done by the researchers to come up with the desired output, however actual output fell short of what was expected. Reverse engineering of the Weavers Knotter for “tinagak” failed. However, the baseline information and data will serve as a guide to researchers and inventors who want to conduct similar undertakings. Since “tinagak” knotting is just one of the components of the whole abaca fiber craft process, research and development efforts that will focus on the enhancement and improvement of the output and quality of the other components involved in fiber craft production should also be undertaken.

5.0 References Cited

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