

# **Design and Fabrication of Pandan Slitter Machine**

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## **Abstract**

This study discusses the design and fabrication of a pandan slitter machine that will remove the thorns and cut the leaf into working strips that are set for air drying. The study includes the evaluation of the machine in terms of its capacity per unit time and the evaluation of the slit leaves in terms of quality such as straightness and consistency of width. The prototype was divided into three main mechanisms that govern the slitting of leaves, removal of the thorns and movement of the leaf. Evaluation of capacity and quality of output was based on 5 leaves producing 30 strips per process. The 3D design of the slitter machine was made using Autodesk Fusion 360 software, afterward, the prototype was fabricated to evaluate the actual performance of the slitter machine by installing instrumentations such as feed mechanism, sensors, and cutting mechanism. And finally, evaluation of machine performance was done by comparing the actual output produced by the prototype to the output produced by conventional or manual methods. It was observed that the average time for the manual stripping and removal of thorns is 1.798 minutes while the average time it takes for the machine slitting and removal of thorns is .5298 minutes. The result of the study proved that the slitter machine significantly improves the output by 239%.

## **Keywords**

Pandan leaves, slitter machine, design, fabrication

## **1. Introduction**

Pandanus, screw pine, or known simply as Pandan is a species of plant related to palm. The Pandan has a variety of uses particularly in industrial purposes. Although some of its smaller species are used commonly in culinary and medicinal purposes (Thompson, 2006), Pandanus is used in the textile industry here in the Philippines with products such as ropes, bags, mats, or "banig" as it is called in the Philippines. These leaves are cut, dried, and often dyed before weaving. The process in making these hand-woven "banig" varies in different areas.

The process of making a banig starts by removing the thorns of the leaves cutting them into strips, followed by air drying/ sun drying the leaves, flattening, dyeing, and lastly the actual weaving process. The raw materials used in making these handicrafts have evolved over the years, from the simple use of the leaves as roofing to the difficult weaving of mats and simple bags. This innovative thinking has allowed the weavers a chance to have a livelihood in which they can do in the comfort of their homes (Decena, 2009).

In most rural parts of the Philippines, where a species of Pandan grow, people still make use of weaving as their primary source of income. That being said, the weaving of Pandan leaves can be a long and intricate process that often starts with the removal of thorns, cutting them into strips, followed by air drying/ sun drying the leaves, flattening, dyeing and lastly

the actual weaving process. The removal of thorns, the cutting process, and flattening are the most difficult processes which require time and must be done manually. Most often than not, farmers end up being cut or splintered by the very leaves they are tasked to prepare. Also, the tools they use for cutting are susceptible to inconsistencies when it comes to the gap between blades which then often lead to varying widths of the strips and by extension uneven weaving patterns. Furthermore, the tools used by each farmer have different dimensions which are quite troublesome since the varying widths in the strips greatly affect the quality of the finished product. The flattening on the other hand requires less precision and more effort. This is because the tensile strength of a Pandan leaf when dried is very high which thereby requires great effort to press or flat. Flattening the strips makes it easy for the weavers to weave since the leaves are much easy to handle when they are soft and flat. Also, the flattening process not only flattens and softens the leaves, but it also gives the strips a shining look which seems to attract more buyers. It is therefore very timely for studies such as this to be conducted since the demand for handicrafts made from Pandan leaves is yet to reach its peak (PCW, 2013).

For this reason, it became the research interest of authors to design and fabricate a slitter machine for pandan leaves. This study would help Filipino Pandan farmers increase their production of Pandan strips used as raw material for creating hand-woven crafts. Furthermore, this study will offer a safer and efficient way of producing raw materials. The study will also help ensure that the width of each strip is consistent as well as the production rate which would be beneficial to the Pandan weavers and handicraft manufacturers in the particular community. Moreover, this study will help spread awareness to fellow students about the importance of promoting the country's cultural heritage by incorporating engineering and technology to traditional arts and crafts.

## **2. Methodology**

A walkthrough was done in Brgy. Plaridel Baybay City, Leyte to determine the necessary information that is useful for the study such as the actual processes done in preparing the leaves. Furthermore, an interview was conducted together with the manager of a cooperative which is one of the primary beneficiaries of the machine. The process of preparing the Pandan strips is divided into two parts: the removal of thorns; and the stripping. The makers of the strips use a knife in removing the thorns from both sides of the leaf and the midrib, while the stripping process is done with the use of a tool called "Lilasan". The tool resembles a shark's fin embedded in wood. With this conventional method, it usually takes 1 to 1 ½ minutes for a single worker to finish a single leaf.

The design and fabrication of the slitter machine were inspired by the Metal Industry Research and Development Center (MIRDC) Pandan leaf slitter machine whose design revolves around a manually controlled crank and is used to slit the processed leaf (Limson and Luces, 2015). However, the study seeks to improve the said machine by converting it from manual operation to fully motorized one. Furthermore, the leaves subjected to the proposed slitter machine are raw which in turn makes other processes before weaving the strips easier. The design and motion of the Pandan slitting machine are vital in the construction of this machine to avoid mistakes, errors and conflicts regarding the components and their corresponding motion individually, and as a whole, whose goal is to obtain the strips of raw Pandan leaves to be used for weaving.

### **2.1. Design of Slitter Machine**

The design of the Pandan slitter machine was made using Autodesk Fusion 360 with the actual dimension scales for an easy fabrication with each component made individually. The design shown in the figure 1 is the whole setup of the Pandan slitter machine. The machine is composed of three major assemblies that will function systematically to obtain the desired output. First, the roller assembly will cover the entrance and exit of the leaf from the machine. This assembly holds the frame that will hold the rollers and the rollers itself which will be in contact with the leaves throughout the process. These rollers are powered by a 30RPM 12V-DC motor. Next, the primary blade assembly is responsible for removing the thorns attached to the leaves via rotary blades that are powered by a 300RPM 12V-DC motor. And lastly, the secondary blades will deliver the final cut made to the leaves that will complete the slitting process.

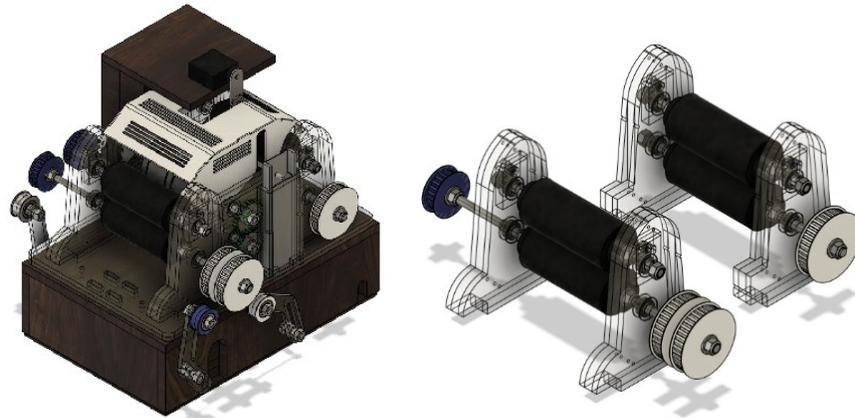


Fig. 1. 3D Design of Slitter Machine using Fusion 360

## 2.2. Design of Roller Cutting Mechanism

The Roller mechanism is an essential component of the machine. It is responsible for the movement of the feed or the leaf within the machine from the point of entry up to the exit. This machine utilizes 4 rollers of the same diameter where both the bottom rollers are connected by belts. The entry roller houses another pulley of the same diameter which is then connected to the drive pulley via a belt. This is designed in such a way that the direction of rotation of both rollers is the same. The lower set of rollers however are driven by their upper counterpart through means of gears since the rotation of the lower rollers should be in the opposite direction. The gear ratios are 1:1 on both since all rollers should have the same angular velocity.

The roller cutting mechanism is made to remove the midrib and the edge of the leaf which holds the thorns. This is also called the primary cutting process. The roller cutting mechanism consists of the upper and bottom primary roller. The upper primary roller cutter consists of four circular saw blades housed inside spacers to maintain a fixed distance between each other and the lower primary roller cutter consists of spacers that overlaps between the blades of the upper primary roller cutter to provide a cutting action to the leaf under process. The gap between the rollers is 1.5mm, which is ideal to flatten the leaf yet not break it. The lower roller is driven by a belt connected to the lower entry roller pulley. The upper primary slitter shaft is then driven by the lower shaft by gears with a ratio of 1:1 to maintain a constant speed to avoid buckling. The figure 2 shows the 3D design of the roller cutting mechanism.

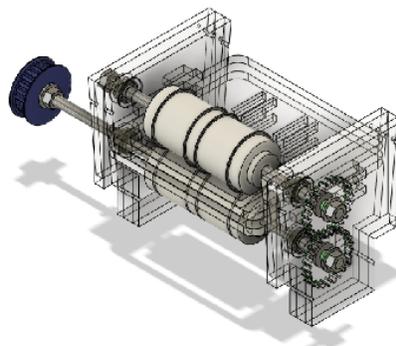


Fig. 2. 3D Design of Roller Cutting Mechanism

## 2.3. Design of Razor Slitting Mechanism

The razor slitting mechanism is made so that the blades used for slitting the strips, punch through the leaf. The design for strip slitting is different compared to the roller cutting mechanism since in this type, once the blade penetrates the leaf, the blades stay stationary and slit through the leaf as it constantly passes through. The slider-crank is driven by a servo motor that rotates in two positions that are 90 degrees apart depending on its corresponding action determined

by the proximity sensor. The slider-crank is connected to the shafting of the secondary blades such that it can be lowered or raised depending on the current orientation of the crank arm connected to the servo. The sensor detects the leaf right after the exit rollers which then indicates that the length of the handle has been achieved and may now proceed to strip slitting. The servo then rotates such that the crank arm, along with the slider attached to the secondary blade shaft, is lowered downward by its weight and by the force of the servo to punch through the leaf. The figure 3 shows the 3D design of the razor slitting mechanism.

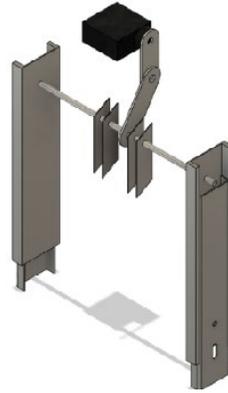


Fig. 3. 3D Design of Razor Slitting Mechanism

#### 2.4. Design of Control Panel

The control panel is where all the major control components are placed. It is further sub-divided into two parts, the microcontroller system, and the motor. The microcontroller is connected to the servo motor and can be controlled via switch in the control box. Also, the microcontroller-based mechanism was made with the use of the microcontroller software to see how the servo motor (RDS3115mg) and the sensors (Photoresistor) function as a whole. Also, the code was designed specifically for this machine which utilizes the use of a Servo motor and LDR. The motor functions separately from the microcontroller and can be controlled using a switch. The switch is responsible for the rotational direction of the motor. Shown in figure 4 is the schematic diagram for the electrical components of the slitter machine.

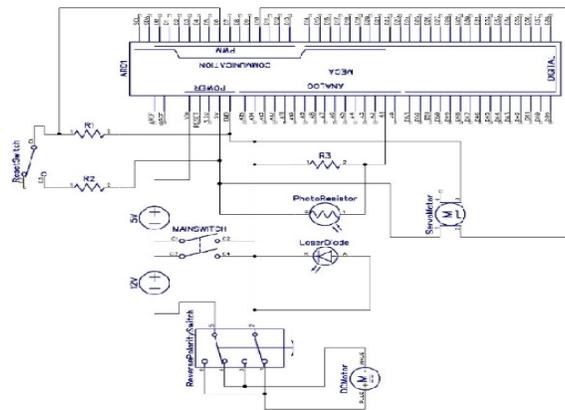


Fig.4. Schematic Diagram for Electrical Components

### 3. Results and Discussion

The Pandan leaves that were used for testing the prototype slitter machine were harvested from Brgy. Plaridel, Baybay City, Leyte. The leaves were carefully chosen by the farmers according to their standards. The factors that are considered in selecting the leaves were the age and length of each leaf. The leaves may be classified into two categories, old and young. Old leaves tend to be longer and thicker, while the young ones were relatively shorter but

are easy to handle. It can be said that the older the leaves get, the thicker they become. Making it hard for the farmers to cut. Overall, the leaves sent were young leaves that are 100 cm in length and 10 cm in width. The leaves were pre-cut to remove the base and the tip of the leaf. The leaves were cut 30 cm from the tip and 30 cm from the base. This is because the tip of the leaf tends to curve and thus will be inconsistent and the base of the leaf will be too hard to process.

### 3.1. Result of Capacity Testing

The manual production of the leaves starts with the removal of thorns in the midrib as well as the side of the leaves. Then the handler proceeds to the stripping process. They usually do this one process at a time. For a specific number of leaves, they first remove all the thorns of all the leaves then proceed to the next process. But for the sake of comparison, the researcher asked them to perform both processes one leaf at a time.

The researchers asked the handlers to record the amount of time it takes to finish each leaf taking the average of 5 leaves. The data shows that it takes an average of 1.798 minutes for a manually cut leaf to complete both processes. Also, the time it takes to remove the thorns of each leaf is an average of 1.25 minutes, while an average of 0.548 minutes for doing the strips. An estimate of 33 leaves may be processed for an hour when all of the processes are done manually.

On the other hand, for the use of a prototype slitter machine, 5 pre-cut leaves were used, measured to be at an average of 100 cm in length and 10 cm in width. The leaves were individually fed to the machine to measure the amount of time it takes for the machine to complete one leaf. It can be observed from the table that the average time it took for the machine to produce the strips was 0.5298 minutes. Both the removal of thorns and the stripping process were done simultaneously. The machine can process roughly 113 meter-length of leaves per hour. The table 1 shows the time to perform the removal of thorns and stripping process for each leaf manually versus using the slitter machine.

Table 1. Processing Time of Slitting using Manual Process and Slitter Machine

	MANUAL PROCESS			SLITTER MACHINE	
	Removal of thorns (mins)	Stripping (mins)	Total time (mins)	Removal of thorns and stripping (mins)	Total time (mins)
Leaf 1	1.3	0.57	1.87	0.485	0.485
Leaf 2	1.2	0.53	1.73	0.536	0.536
Leaf 3	1.3	0.57	1.87	0.583	0.583
Leaf 4	1.25	0.53	1.78	0.501	0.501
Leaf 5	1.2	0.54	1.74	0.544	0.544
	<b>Total Average</b>		<b>1.798</b>	<b>Total Average</b>	<b>0.5298</b>

### 3.2. Result of Quality Testing

After comparing the output of the manual slitting process to the output of the slitter machine, the researchers also tested the quality of leaves the machine has produced in terms of their width measurements and straightness.

For the width measurement, the target is to produce 10 mm strips having  $\pm 1$  mm tolerance. One leaf has two separate handles, and each handle has three strips. Therefore, each leaf can produce 6 strips. The researchers used the following data to determine the mean, mode, median, and standard deviation of the strips produced manually and those produced by the machine. The table 2 shows the comparison of the width dimensions of both manual and machine produced strips.

Table 2. Comparison of Strips Width in mm (Manual versus Machine)

	MANUALLY PRODUCED						MACHINE PRODUCED					
	Handle 1			Handle 2			Handle 1			Handle 2		
	Strip 1	Strip 2	Strip 3	Strip 1	Strip 2	Strip 3	Strip 1	Strip 2	Strip 3	Strip 1	Strip 2	Strip 3
Leaf 1	8	10	11	11	10	9	10	10	8	10	10	8

Leaf 2	11	11	10	10	11	9	Leaf 2	10	10	8	10	10	8
Leaf 3	9	10	9	10	11	10	Leaf 3	9	11	8	10	10	8
Leaf 4	9	11	11	10	11	9	Leaf 4	11	10	8	10	9	8
Leaf 5	8	11	9	8	11	10	Leaf 5	10	10	9	10	10	9
<b>Mean</b>	<b>9.9</b>						<b>Mean</b>	<b>9.4</b>					
<b>Mode</b>	<b>11</b>						<b>Mode</b>	<b>10</b>					
<b>Median</b>	<b>10</b>						<b>Median</b>	<b>10</b>					
<b>Std. Dev.</b>	<b>1.01</b>						<b>Std. Dev.</b>	<b>0.96</b>					

The results showed that the majority of the strips produced by a machine have better quality in terms of width dimension consistency compared to those produced manually as reflected in their mode (11 vs 10) and standard deviation (1.01 vs 0.96).

Similarly, the straightness of strips was also analyzed to compare the quality of strips produced manually and by the machine. The evaluation for straightness in the strips will either be a pass or a fail, the criteria for this evaluation will be more of visual inspection. Two tests were done, one for the manually produced and the other is for the machine produced.

Table 3. Comparison of Strips Straightness (Manual versus Machine)

MANUAL			MACHINE		
	Handle 1	Handle 2		Handle 1	Handle 2
Leaf 1	3 out of 3	1 out of 3	Leaf 1	3 out of 3	3 out of 3
Leaf 2	2 out of 3	3 out of 3	Leaf 2	1 out of 3	1 out of 3
Leaf 3	1 out of 3	2 out of 3	Leaf 3	3 out of 3	2 out of 3
Leaf 4	3 out of 3	2 out of 3	Leaf 4	3 out of 3	3 out of 3
Leaf 5	3 out of 3	3 out of 3	Leaf 5	3 out of 3	3 out of 3
<b>Mean</b>	<b>23 out of 30</b>		<b>Mean</b>	<b>25 out of 30</b>	

As shown on table 3, there is no significant difference between the two processes. However, there is a slight difference when it comes to the quality of the cut. The ones done by the machine tend to have a straighter output compared to the manually produced leaves (25 vs 23).

#### 4. Conclusion

The authors were able to design and fabricate a pandan slitter machine that will remove the thorns and cut the leaf into working strips that are set for air drying. The slitter machine involves the design of 3 major components such as roller cutter mechanism, razor slitting mechanism, and a control panel. The performance of the slitter machine was evaluated in terms of capacity per unit time and quality of slitting output in terms of width dimension consistency and straightness. The results of the study revealed that in terms of capacity, the slitter machine can produce an average of 0.5298 minutes per leaf (6 strips) while the manual or conventional process is 1.798 minutes. This proves that the slitter machine significantly improves the output by 239%. Also, the strips produced by slitter machine has better quality in terms of width dimension consistency compared to those produced manually as reflected in their mode (11 vs 10) and standard deviation (1.01 vs 0.96) as well as in terms of quality of straightness, wherein the ones done by the machine tend to have a straighter output compared to the manually produced leaves (25 vs 23).

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