

**AMM018**

# **Study on Manufacturing of Small Wind Turbine Wood Blade by using CNC Milling Machine**

Jinnawat Sawadduang and Soemsak Yooyen \*

Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang  
1 Chalongkrung Rd., Ladkrabang, Bangkok, 10520, THAILAND

\* Corresponding Author: soemsak.yo@kmitl.ac.th, Tel. 66 2 329 8350, Fax. 66 2 329 8352

## **Abstract**

This research was to study the production of wind turbine wood blades. The smaller than 3 kilowatts wind turbine blades have been made of exotic pine because it was lightweight, durable and cheap to produce. It was, however required highly skilled craftsmanship and high wages. If one of the blades failed, all off the blades must have to be replaced. This study reported the production of small wind turbine wood blades by using CNC milling machine. The process was starting from drawing isometric and determining the size of the rotor. After all, the process started with a CNC milling machine by using the command code based on engineering principle to get the blades in desired size.

**Keywords:** wind turbine blades, milling machine CNC, pine

## **1. Introduction**

In the present day, there are many great inventions that are essential to human as well as to help increase everyday productivities. These inventions need energy in order to run and operate. From here it can be seen that energy is in fact a very essential part of human life. Energy can be in many forms such as oil and natural gas. Human depends very much on oil and gas energy and as a result, this energy will slowly be depleted. This issue can be resolved very easily by using renewable energy such as wind and solar energy instead of fossil fuel.

Wind energy is a great solution and one of the most used methods of renewable energy. The windmills are used to create electricity by converting wind energy. The important factors for this method are speed of the wind and location of the windmill. By considering these two important factors, one can easily utilize the concept of renewable wind energy.

In the past, a very specialized and highly skilled technician was required to produce and manufacture a windmill. Also, it took a long period of time to produce the windmill. This was due to a greatly precise shape and dimensions of the windmill as well as there did not have a tool or applications to speed up the process. The more skilled and experience worker, the more precise the produced windmill. Nowadays, computerized numerical control method is used to aid the production of the windmill. This will result in more precise shape and dimension as well as shorter period of time to complete manufacturing the windmill.

## **2. Research Methodology**

The manufacturing process of small windmill by using CNC machines can be defined by four steps as discuss below. The steps are specifying a shape and dimensions of the windmill, computer aid design of

the windmill, computer aid manufacturing of the windmill, and CNC controls.

### **2.1 Computer aid design**

The computer aid design step is to sketch and draft a 3D shape and dimensions of the windmill. The design program can also sketch each parts and components separately for ease of reviewing and inspecting the appropriateness of the model. Moreover, the design program can define a name to components and can determine the properties of the model such as material and hardness as well as the tolerances of the windmill. The detailed shape and dimensions are also required for designing the fixtures to mount the model for CNC process, for determining the location of the fixture on the model. In general, the CAD design program is divided into two parts, hardware and software. Hardware consists of components such as high performance computers and monitors. On the other hand, software consists of a program for designing a model. The CAD design program uses its build-in functions to create the model and represent the model on the pc monitor. The picture model information is stored in the storage of the computer in term of bulk files for further use. The first step of create a windmill model is to sketch six equal windmill blade and each blade having the width dimension as specified in table 1 This can be done using Plane command of the design program as show in figure 1.

**AMM018**

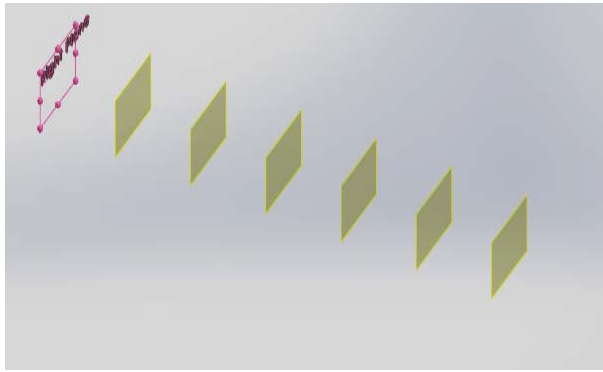


Fig. 1 Creation of the taper shape

The blade can be marked out the stations by measuring from the root of the work piece, drawing a line around the work piece at each station by using a square. After that, marking the correct width at each station by measuring from the leading edge, and join the marks up with a series of lines. Finally, the shape can be cutting along these lines.

Table. 1 The width of blade at each station

Section	Width	
1	6"	150 mm
2	4 3/4"	120 mm
3	3 15/16"	100 mm
4	3 1/8"	80 mm
5	2 3/4"	70 mm
6(tip)	2 3/8"	60 mm

Each section of the blade has different drop dimension as shown in table 1. This was done by using sketch command by starting from the side of the blade.

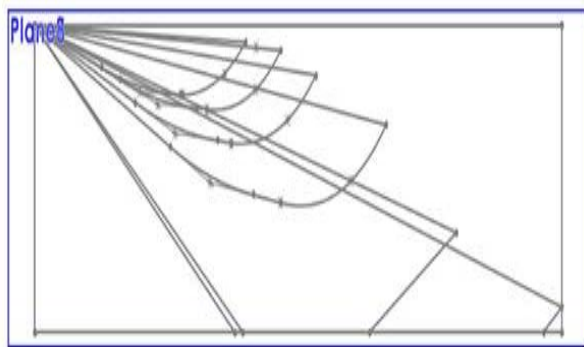


Fig. 2 Creation of the taper shape



Fig. 3 Dropping dimension on cutting side

Table. 2 The carving of the twisted windward face

section	Drop	
1	1 1/2"	37 mm
2	1"	25 mm
3	7/16"	12 mm
4	1/4"	6 mm
5	1/8"	3 mm
6(tip)	1/16"	2 mm

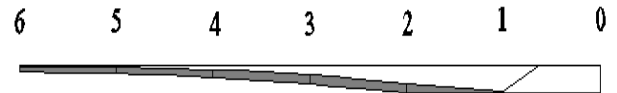


Fig. 4 Dropping of windward face dimension

The windward face of the blade to be angled, even somewhat flat, like the underside of an aircraft wing, the angle to be steeper at the root rather than at its tip. The reason why blade-angle should change is because the blade-speed becomes slower as it approaches the center. This affects the angle of the apparent air velocity striking the each blade.

The process can be starting by marking the stations (with a square) on the cutting in Step 1. Then mark the 'drop' on each of these new lines, measuring from the face of the wood as shown below and marking the position of the trailing edge at each station. After that joining these marks to form the line of the trailing edge. The leading edge is the other corner of the work piece.

Table. 3 The thickness of the blade section

section	Thickness	
2	15/16"	25 mm
3	1/2"	13 mm
4	3/8"	10 mm
5	5/16"	8 mm
6(tip)	1/4"	7 mm

At each station, the blade can be measured the appropriate thickness from the windward face, and marking. The line can be connected by joining these marks. After sketching the blade, the command boss/base can be used as shown in figure 5 and can be saved as .STL file.

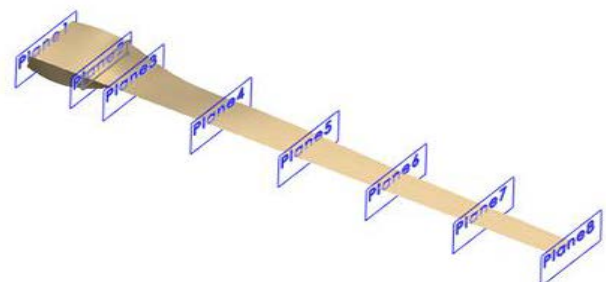


Fig. 5 Turbine blade sketching

## AMM018

### 2.2 Computer Aided Manufacturing (CAM)

In order to precisely produce the windmill, the CAD sketch and drawing is used to determine various coordinates and cutting paths of the CNC machine. CAM is incorporated with the production of the windmill in order to create continuous production system. Whenever there is a need to manufacture the windmill, CAM code will be written and then the code will be send to the CAM control system. The production plan starts by entering the important parameters for the new model, height of 1200 mm and width of 150 mm as shown in figure 6.

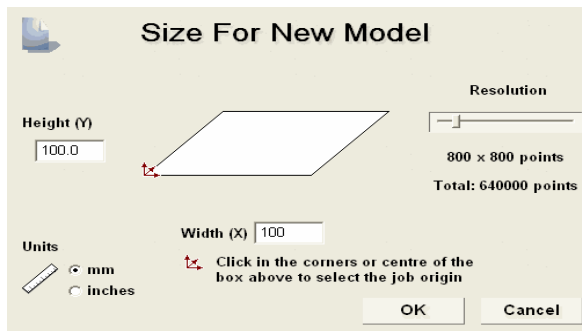


Fig. 6 Size for new model

After entering all the parameters, the cutting path of the cutter must be defined. Then, the simulation is performed prior to actual machining of the windmill. From simulation, G-code is generated and is used for CNC stage.

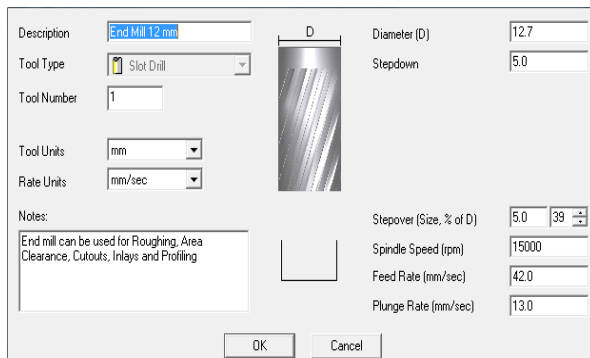


Fig. 7 Parameters of milling

### 2.3 CNC control system

CNC machine is controlled using the program called NC studio. The program received the command from the working file and then used it to control the operation of the CNC machine based on speed and distance. Version 5.4 of this program has a special function to support all 3 axis of operation, hence this will in turn improve windmill blade cutting especially with uneven surface area.

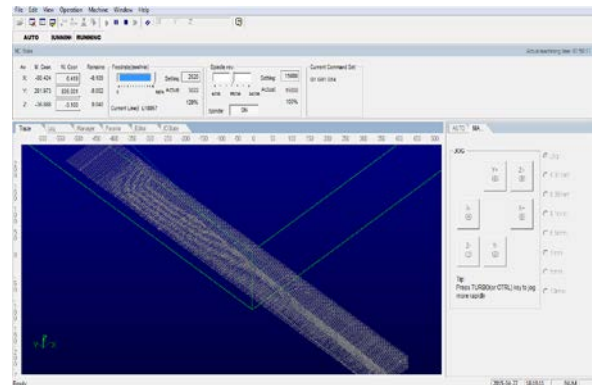


Fig. 8 NC Studio Version 5.4



Fig. 9 CNC machine during operation



Fig. 10 CNC machine

## 3. Discussion

### 3.1 Results based on computer generated 3D model

After sketching the blade model according to 1200 mm length and 150 mm height, the model can be seen in figure 11.

## AMM018

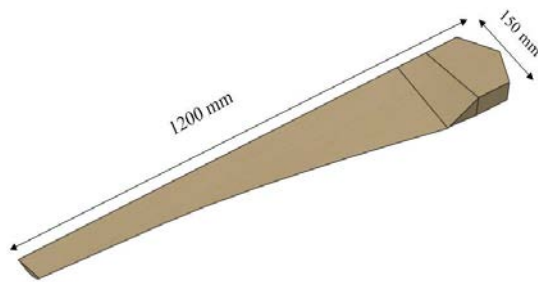


Fig. 11 3D model of wind turbine blade

### 3.2 Results based on computer aided manufacturing

G-code generated from CAM simulation is used as a working file for NC studio CNC control program. The procedure for cutting path of the cutter head is very critical because too fast or too slow feed rate and spindle speed will compromise the accuracy of the blade as well as decrease the useful life of the cutter head. The parameters for CNC machine can be seen below Tool Type Router Blade, Diameter: 12.70 mm Height 32 mm, Step down 5.00 mm, Spindle Speed 15000 rpm, Feed Rate 42.00 mm/sec.



Fig. 12 Router blade

### 3.3 Results based on CNC control system

As seen on the parameters used for CNC machine, the spindle speed for the cutter head is quite fast. As a result, the CNC machine must be stopping every 3 hours of operation because the temperatures rise of the machine. If the machine overheats, the cutter head and the machine will be severely damage. An operator must be station at the machine in case of emergency.

### 4. Conclusion and discussion

(1) CNC machine is very powerful and precise machine and can produce a low error and very accurate product. This is because the machine operates in 3 axes and is driven by servo and step motor as well as is programed by a computerized code. As a result, the machine can produce the product up to 0.00X mm precision.

(2) The product is produced much faster because the advancement of the automated CNC machine reduced the time to manufacture a model.

(3) Cost is based on economic of scale.

(4) Reduction in extra clamping systems of the machining piece because in general the CNC machine provide more than enough clamping system to safely secure the machining piece.

(5) An operator doesn't have to be experience in order to control the CNC machine due to its programmable control system.

(6) CNC machine is very versatile and flexible. The program which is used to control the machine can be edit anytime in order to produce different type or dimensions or parameters of the windmill blade.

(7) Model with high complexity can be done with ease because of the existence of CAD and CAM, which will then be used as part of the program for CNC control system.

The windmill blade of the length 1.2 m produced by CNC machine took too long to manufacture because the CNC machine was stop every 3 hours due to concern of high temperature rise from fast spindle speed. Also, the blade dimensions were not very accurate due to lack of experience of the CAD programmer, size of the cutter head as well as the knowledge of the CNC machine operator. Three windmill blades were produced in total and the time of production was 6 hours.

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