DESIGN OF IMPELLER WHEEL AND IDLER PULLEY WITH CNC MACHINING PROCESS AND TOOLING DESIGN

Arranged as a requirement to complete Undergraduate Study Program in Mechanical Engineering, Engineering Faculty

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APPROVAL SHEET

This Final Report has been corrected, accepted and legalized by supervisor, knowing by Head of Mechanical Engineering Department Wuxi Institute of Technology and Head of Mechanical Engineering department Universitas Muhammadiyah Surakarta.

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Day : Saturday

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DECLARATION

Hereby, I declare that in this publication no works have ever been submitted to earn a bachelor's degree at a college and as far as I know there is no work or opinions once written or published by others, except in writing referred to in the manuscript and mentioned in the bibliography.

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Surakarta, 1 Juli 2017

Writter

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DESIGN OF IMPELLER WHEEL AND IDLER PULLEY WITH CNC MACHINING PROCESS AND TOOLING DESIGN

ABSTRACT

Design of three-axis and four-axis part is one of important process before machining process. To begin the machining process for three-axis part and four-axis part, the process has must begin from design the product so can produce the product which can be accepted by many people's. There are many software who provide the processing aplication for design the product. One of the software aplication for design is UG Siemens NX. The latest of UG NX is NX 10.0. Moreover, The type of tools also have the important role in the process of machining. Many types of tool like as cutting tool, milling tools (ball mill, 5 parameters) and drilling tool. So the process will produce the product which the data of process will be processed in the production parameters as the final conclusion.
Key words : Three-axis part, Four-axis part, UG Siemens NX 10.0, Cutting tool, Milling tool, Drilling tool.

ABSTRAK

Desain sumbu tiga dan sumbu empat merupakan salah satu proses penting sebelum proses pemesinan. Untuk memulai proses pemesinan untuk bagian tiga sumbu dan bagian empat sumbu, prosesnya harus dimulai dari desain produk sehingga bisa menghasilkan produk yang bisa diterima oleh banyak orang. Ada banyak perangkat lunak yang menyediakan aplikasi pengolahan untuk desain produk. Salah satu aplikasi perangkat lunak untuk desain adalah UG Siemens NX. Yang terbaru dari UG NX adalah NX 10.0. Selain itu, jenis alat juga memiliki peran penting dalam proses permesinan. Banyak jenis alat seperti alat pemotong, alat penggilingan (ball mill, 5 parameter) dan alat pengeboran. Sehingga proses akan menghasilkan produk yang data prosesnya akan diproses dalam parameter produksi sebagai kesimpulan akhir.
Kata kunci : Bagian tiga sumbu, bagian empat sumbu, UG Siemens NX 10.0, Alat pemotong, Alat pengggilingan, Alat pengeboran.

1. INTRODUCTION

In the modern era, development in the life like as industry, technology, and human need is progressing very rapid. Every manufacture has must adapt customer demands who always increasing every day. The customer sometimes feel less satisfied to the products offered by producer. Therefore, the producer has must innovation to make the product of best quality and can be accept by customer.

Besides that, to make a product, the producer has must devise the design by the product where it product have must multifunction and can be used in the long time. Therefore, in the design the product also there the procedure and the step of design the product.

Production and manufacturing process in many kind of fields required to solve the problem above without put aside the health and safety, it's mean a user or operator does not harm himself while interacting and work with the machine. According the safety operational standard of user in this day only operate the machine with computerized machine without directly touching and interacting with the machine. So that operator's safety is assured.

In the devise the design, there are many software program have used to design the product. The product realization process can be roughly divided into two phases; design and manufacturing. The engineer usually use the computing program to design the product.

In the procedural of design product, there are some step who must known and also how to implementation the design product to the turning machine for make the machining process.

A product is something sold byan enterprise to its customers. Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product.

Not only that, in the design the product producers also notice the precition of product and also the suitability the product in the design so the engineer has must notice the suitability of product.

The engineer also notice the two main aspect in the production. First, Design, the design function plays the lead role in defining the physical form of the product to best meet customer needs. In this context, the design function includes engineering design (mechanical, electrical, software, etc.) and industrial design (aestherics, ergonomics, user interfaces). Second, Manufacturing, the manufacturing function is primarily responsible for designing, operating, and/or coordinating the production system in order to produce the produce the product. Broadly defined, the manufacturing function also often includes purchasing, distribution, and installation. This collection of activities is sometimes called the supply chain.

In the experiment, there are some part who used in the everyday life. In terms of the axis type, there are some type of axis like as three axis part, four axis part, five axis part and six axis part. In the experiment, we will use of three axis part and four axis part.

Moreover, the CNC program also have the important roles. If the CNC program has mistaken, then the result will be not satisfactory and the product will be defective.

Therefore, the engineer has must prepare the something to begin the design the product and make the product in the CNC machine who known is turning machine.

The product can be called good if the product has designed right and also notice the quality and the suitability of CNC program in the make of product.

2. ANALYZE METHOD

To begin the design of product, the engineer has must prepare the tools to begin the design of product. One of them is a software design. To choose the best of software design, make sure choose the software which can be apilcated on the CNC machine. One of most software design is UG Siemens NX. This time, we use UG NX 10.0 to design the product.

2.1. Design of Three Axis Part

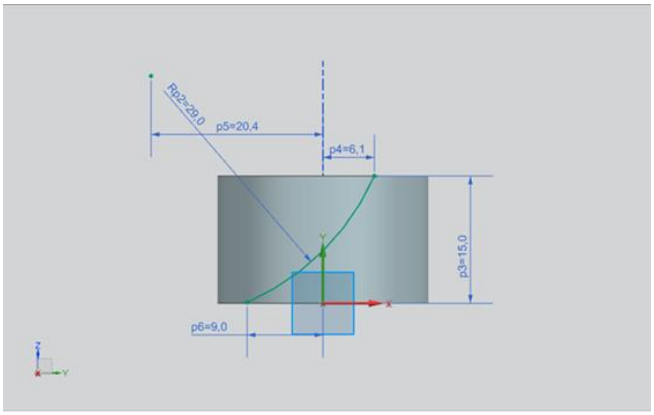
Before make the product of three axis part, we will design the part. To three axis part has called name impeller wheel. The function of impeller wheel is converted into kinetic energy and the exhaust gas at the wheel circumference is directed at constant velocity to the turbine wheel. How to design the impeller wheel, follow the steps below:

1. Determine the Datum Coordinate System. To type, choose the Dynamic then for Reference CSYS click Absolute – Displayed Part and click the object who will click then OK.
2. Make sketch the body with size like as table.

Table 1 Table for Sketch Body

	Length (mm)	Width (mm)	Diameter (mm)	Curve (mm)	Range (mm)	Angle (degree)
SKETCH_000	-	-	25	-	-	-
SKETCH_001	20.4	-	--	29	-	-
	6.1					
	9					
SKETCH_002	-	-	78	-	-	
SKETCH_003	32.4	23.5	-	-	-	102
SKETCH_004	-	-	30	-	-	--
SKETCH_005	-	-	30	-	-	-
SKETCH_006	-	--	25	-	-	-
SKETCH_007	27	12	-	-	-	-
SKETCH_008	-	-	8	-	8.5	-
SKETCH_009	97.6	80.3	-	-	-	-
SKETCH_010	38.5	16	-	-	-	-
	19					
SKETCH_011	10	12.7	-	-	-	-
		12.8				

Figure 1 Example for Sketch Body

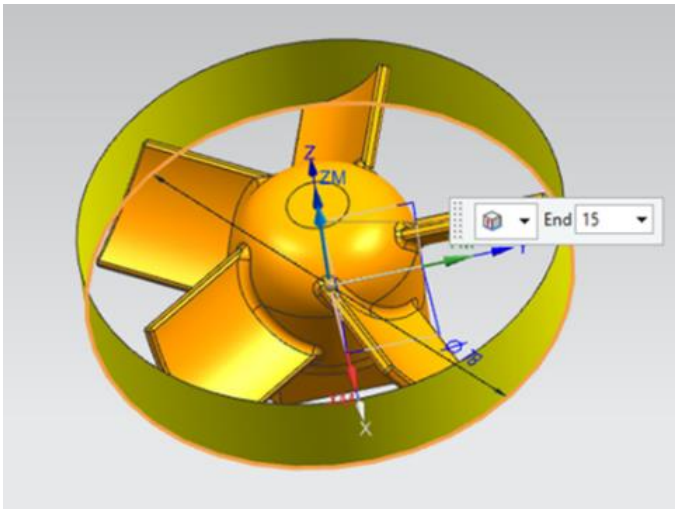


3. Make the Extrude with size like as table.

Table 2 Table for Extrude Body

	Start Distance (mm)	End Distance (mm)	Tolerance
Extrude (2)	0	15	0,001
Extrude (5)	0	15	0,001
Extrude (11)	-	15	0,001
Extrude (14)	-1	17,5	0,001
Extrude (19)	0	3	0,001
Extrude (33)	-30,3	50	0,001
Extrude (36)	-	20	0,001
Extrude (37)	0	12	0,001
Extrude (38)	0	10	0,001

Figure 2 Example for Extrude Body

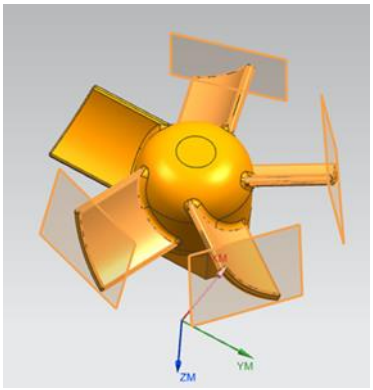


4. Design the leaf blade with the following steps. To make the sketch of curve use the Projected Curve and Through Curve to find the direction of axis. To make the thickness

of leaf blade, use the Thicken with offset 1 has 1 mm and offset 2 has -1 mm. To make the body and cutting the sketch use Trim Body and Unite.

5. To make the many items, use the Pattern Features. Because the design of body has circular, use the Circular mode. The Pattern Features also can be used to cutting the sketch of body in large quantities.

Figure 3 The Pattern Features function

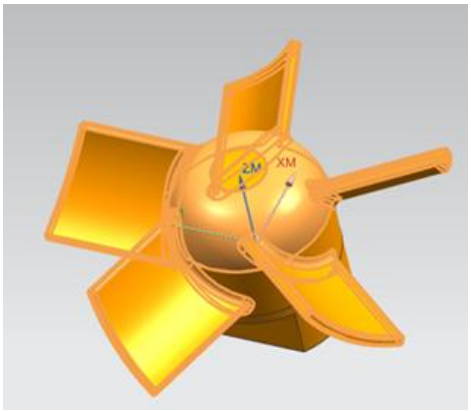


6. To make the curve in the edge of body, use the Edge Blend with the certainty G1 (Tangent) and total select edge and radius like the table.

Table 3 Table of Edge Blend

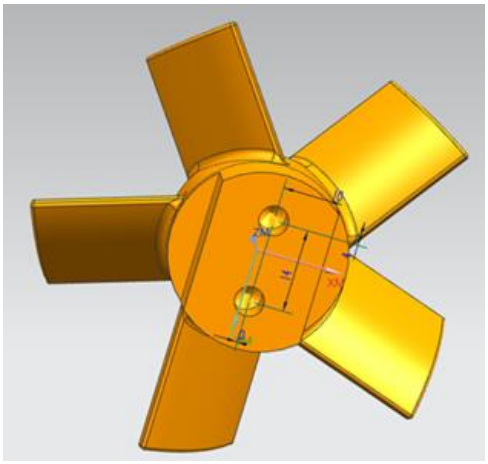
	Total Select Edge	Radius (mm)
Edge Blend (20)	1	10
Edge Blend (27)	50	0,5
Edge Blend (28)	13	1,5
Edge Blend (29)	52	1,5

Figure 4 Example for Edge Blend



7. Make the two hole on the under the body with the size diameter 5 mm, depth 8 mm and tip angle 118^0.

Figure 5 Two hole on the under body

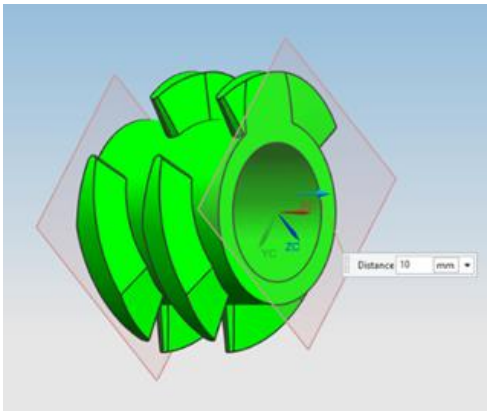


2.2. Design of Four Axis Part

Before make the product of four axis part, we will design the part. The name of part is idler pulley. The function of idler pulley is regulates the belts that connect to the crankshaft and are used to produce movement in numerous engine accessories, such as the alternator, steering pump and air-conditioner compressor. Any steps which is conducted to design the four axis part, follow the steps below :

1. Make the Body, then click Extrude with the certainty for Limits Start, the distance has 0 mm and for Limits End, the distance has 60 mm, tolerance 0,0254.
2. Make the Datum Plane on the top and bottom body with distance 10 mm.

Figure 6 Datum Plane



3. Cut the body with Trim Body and to cut the sheet body use Trim Sheet.
4. Click the Offset in Face with certainty like the table.

Table 4 Offset in Face

	Total Select Curve	Offset (mm)
Offset in Face (18)	10	11
Offset in Face (19)	10	11
Offset in Face (20)	12	11
Offset in Face (21)	12	11
Offset in Face (22)	10	11
Offset in Face (23)	10	11

5. Make the Bridge Curve on the top and bottom body with value 0% and 100%.

3. DISCUSSION ANALYZE

3.1 Machining Process

After design the part in the UG Siemens NX, next step the engineers has prepare the tools to begin the machining part in the CNC machine. There are various the procedure in starting the process of machining part. One of most important is availability of tools, CNC machine works fine, and the program design on the UG NX has right. If the requirements are readily available, then the machining process will be begin. How to steps the begin of machining process, follow the steps.

3.2. Machining the Impeller Wheel

1. Workpiece
   →To make the Impeller Wheel, use the workpiece with size length 80,2 mm, width 80,5 mm, and height 82 mm.

Figure 7 Workpiece for Impeller Wheel

2. CNC Machine

→Use the Fanuc VMC 650 E to make the part of impeller wheel.

Figure 8 Fanuc VMC 650 E

3.3. Geometry 1

→ To make the part, there are some stage in the process of machining. In the project, there are two stage in the process of machining. The process it is Geometry 1 and Geometry 2. To Geometry 1, there are some steps which must be done that is :

1. Find the X, Y value

   → To begin the machining process must determine the X, Y value on the workpiece in order to not happen mistake in the cutting the workpiece. To determine the X, Y value used to tool like as figure.

Figure 9 Tool for find X,Y value

After determine the X, Y value then input the X, Y value at the machine. To determine the X value, touch the side of workpiece then input the X = 0 and the result will be inputed in the machine. To determine the X value, use the formula like below.

$$x = \frac{x_1 + x_2}{2}$$

So are determine the Y value, touch the side of workpiece then input the Y = 0 and the result will be inputed in the machine. To determine the Y value, use the formula like below.

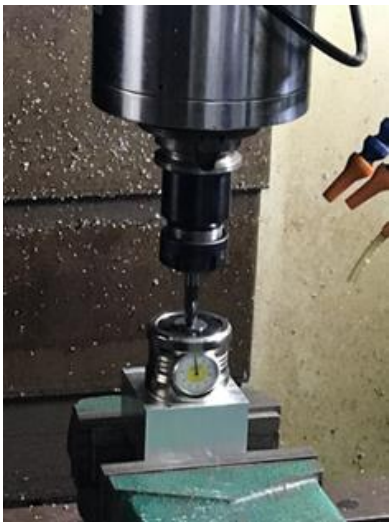
$$y = \frac{y_1 + y_2}{2}$$

To geometry 1, obtained that X = 260,956 and Y = -252,618

2. Find the Z value

→ To find the Z value, have depends the tool which be used. To determine the Z value, use the tool like figure below.

Figure 10 Tool for find Z value



How to determine the Z value? Put it down the knife block like as picture above then touch on the workpiece then touch the drill on the knife block until has showed the zero (0) number then input the Z value with Z = 0, then the result will be inputed in the machine.

Table 5 The X,Y, and Z value for Geometry 1

X	Y	Z
260,956	-252,618	N/A
260,956	-252,618	-270,19
260,956	-252,618	-225,06
260,956	-252,618	-225,06
260,956	-252,618	-225,06
260,956	-252,618	-225,06
260,956	-252,618	-225,06
260,956	-252,618	-270,19
260,956	-252,618	-270,19
260,956	-252,618	-221,46
260,956	-252,618	-245,6
260,956	-252,618	-283,18
260,956	-252,618	-283,18
260,956	-252,618	-283,18
260,956	-252,618	-283,18
260,956	-252,618	-283,18
260,956	-252,618	-253,82
260,956	-252,618	-253,82
260,956	-252,618	-253,82
260,956	-252,618	-253,82
260,956	-252,618	-253,82
260,956	-252,618	-253,72

3. Cutting the Workpiece

→ In the cutting the workpiece have use the tools with different diameter of drill so the research must right in selecting tools of drill. In the UG NX simulation, determine depth per cut, spindle speed, feed rate and feed per tooth. After determine the depth per cut, feed per tooth, feed rate and spindle speed, the data will be inputed in the UG NX simulation and implementation in the CNC Machine.

Figure 11 The graphic feed rate and spindle speed for Geometry 1

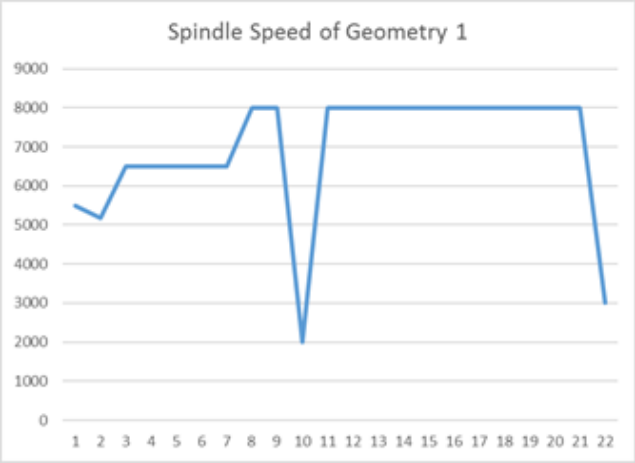


Table 6 Table feed rate and spindle for Geometry 1

Spindle Speed (rpm)	Feed Rate (mmpm)
5500	4500
5188	5500
6500	3000
6500	3000
6500	3000
6500	3000
6500	3000
8000	1500
8000	1500
2000	150
8000	3000
8000	2500
8000	2500
8000	2500
8000	2500
8000	2500
8000	1989,5
8000	1989,5
8000	1989,5
8000	1989,5
8000	1989,5
3000	1000

Figure 12 The drill tools and result of Geometry 1

3.4. Geometry 2

→ To step for Geometry 2 same as Geometry 1. But there are simplification in the use of tools. How to step for start the Geometry 2 follow the steps below :

1. Find the X, Y value

→ To find the X, Y value same as Geometry 1. To determine the X value, touch the side of workpiece then input the X = 0 and the result will be inputed in the machine. And to

determine the Y value, touch the side of workpiece then input the Y = 0 and the result will be inputed in the machine.

For example, obtained X1 = 262,699 and X2 = 350,849 so to find the X value has used

$$x = \frac{262.699 + 350.849}{2}$$
$$= 306.774$$

So, the X value is 306,774.

To formula Y, for example obtained Y1 = -135,530 and Y2 = - 223,485 so to find the Y value has used

$$y = \frac{(-135.530) + (-223.485)}{2}$$
$$= -179.4175$$

So, the Y value is -179,4175.

2. Find the Z value
   → Same as Geometry 1, have depends the tool which be used. To determine the Z value, use the tool like make the Geometry 1. How to determine the Z value?Take the tool like as picture above then touch on the workpiece then touch the drill on the tool until the tool has showed the zero (0) number then input the Z value with Z = 0, then the result will be inputed in the machine.

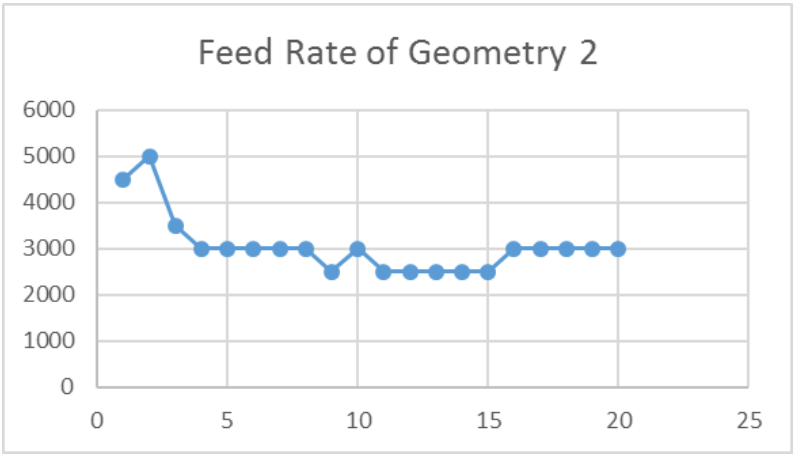
Table 7 The X,Y, and Z value for Geometry 2

X	Y	Z
306,774	-179,4175	N/A
306,774	-179,4175	-270,73
306,774	-179,4175	-235
306,774	-179,4175	-235
306,774	-179,4175	-235
306,774	-179,4175	-235
306,774	-179,4175	-235
306,774	-179,4175	-235
306,774	-179,4175	-283,73
306,774	-179,4175	-246,12
306,774	-179,4175	-283,73
306,774	-179,4175	-283,73
306,774	-179,4175	-283,73
306,774	-179,4175	-283,73
306,774	-179,4175	-283,73
306,774	-179,4175	-254,32
306,774	-179,4175	-254,32
306,774	-179,4175	-254,32
306,774	-179,4175	-254,32
306,774	-179,4175	-254,32

3. Cutting the Workpiece

→ In the cutting the workpiece have use the tools with different diameter of drill so the research must right in selecting tools of drill. In the UG NX simulation, determine depth per cut, spindle speed, feed rate and feed per tooth. After determine the depth per cut, feed per tooth, feed rate and spindle speed, the data will be inputed in the UG NX simulation and implementation in the CNC Machine.

Figure 13 The graphic feed rate and spindle speed for Geometry 2



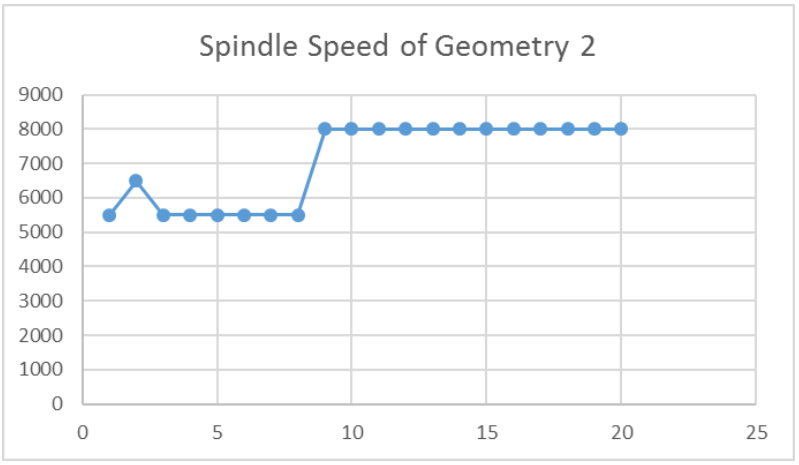
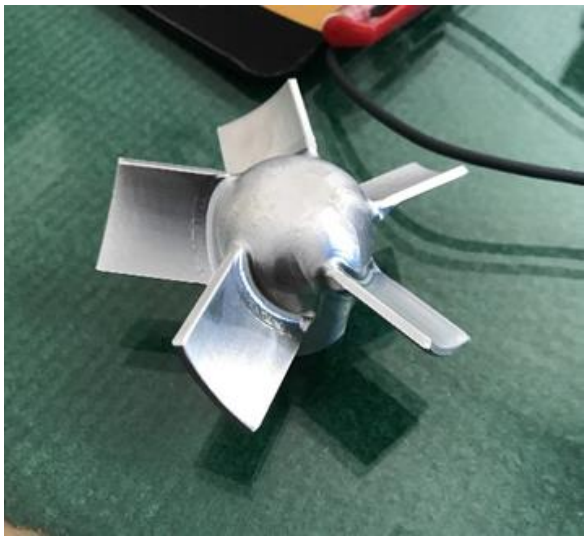


Table 8 Table feed rate and spindle speed for Geometry 2

Spindle Speed (rpm)	Feed Rate (mmpm)
5500	4500
6500	5000
5500	3500
5500	3000
5500	3000
5500	3000
5500	3000
5500	3000
8000	2500
8000	3000
8000	2500
8000	2500
8000	2500
8000	2500
8000	2500
8000	2500
8000	3000
8000	3000
8000	3000
8000	3000
8000	3000

Figure 14 The drill tools and result of Geometry 2

Figure 15 The result of Impeller Wheel



3.5. Machining the Idler Pulley

→ The second step of machining process is make the four axis part. To make the four axis part is not easy. Certainly, in addition to different machines with three axis part also the design of four axis part are complex and need the long time to make the four axis part so must be careful in the design of four axis part. Not only that, in the make of four axis part, there are two type of CNC Machine like as CNC Lathe and CNC Milling. To four axis part, the name is idler pulley. The tools are need to begin the machining process. What the tools are needed to begin the machining process, follow the steps below :

1. Workpiece

   →To make the idler pulley, use the workpiece with size length 150 mm and diameter 80 mm.

Figure 16 Workpiece to make idler pulley

2. CNC Machine

→Use the FANUC CHEVALIER QP 2033-L to make idler pulley

Figure 17 Fanuc Chevalier QP 2033-L

3. Cutting the part

→ To knowing the process for cutting a workpiece has used the UG NX simulation and also the VERICUT CNC Machine. In the cutting the workpiece have use the tools with different diameter of drill so the research must right in selecting tools of drill. In the UG NX simulation, determine depth per cut, spindle speed, feed rate and feed per tooth. Next the depth per cut, feed per tooth, feed rate and spindle speed data will be inputed in the UG NX simulation and implementation in the CNC Machine. How to steps the machining process simulation for four axis part, follow the steps below :

a. Determine the size of part.
b. Determine the feed rate and spindle speed.
c. Determine the X and Y value.

   → To find the X and Y value same as the three axis part. To determine it use the tool like as figure below.

Figure 18 The tool to find X, Y value

To determine the X value, touch the upside of workpiece then input the X and the result will be inputed in the machine. To determine the Y value, So are determine the Y value, touch the side of workpiece then input the Y and the result will be inputed in the machine.

The result is X = 427,793 and Y = -267,299.

d. Determine the Z value

→ To find the Z value same as the three axis part. To find the Z value has depend the tool which be used. How to determine the Z value? Put it down the knife block then touch the drill tool until the knife block has showed the zero (0) number then input the Z value then the result will be inputed in the machine. The result is Z = -394,950.

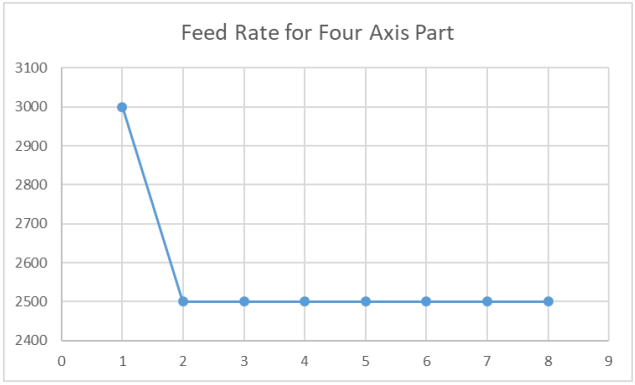
e. Cutting the Workpiece

→ In the cutting the workpiece have use the D12 (Milling Tool 5 Parameters) like as figure below.

Figure 19 D12 - Milling Tool 5 Parameter

In the UG NX simulation, determine spindle speed, and feed rate. After determine the feed rate and spindle speed, the data will be inputed in the UG NX simulation and implementation in the CNC Machine.

Figure 20 The graphic feed rate and spindle speed for idler pulley



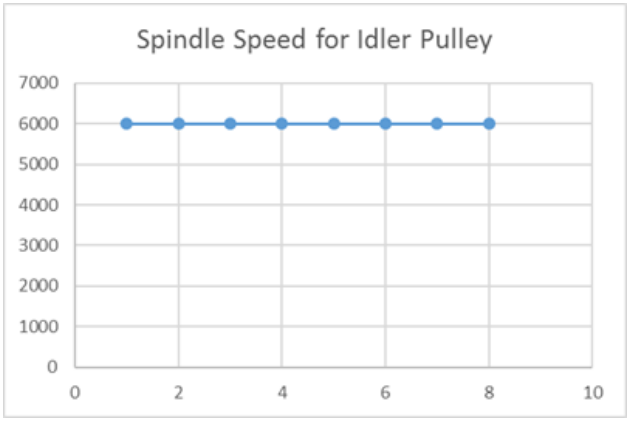
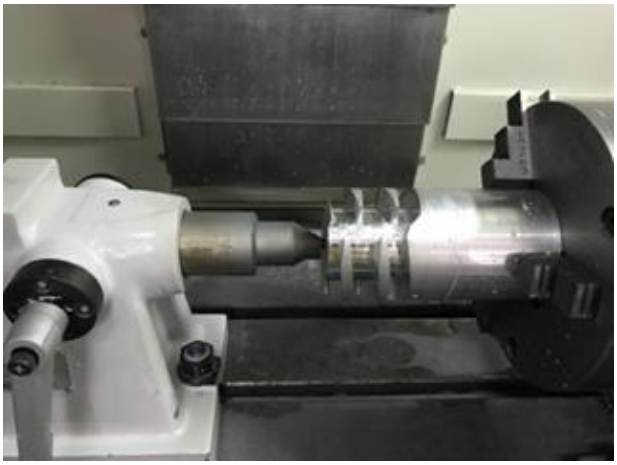


Table 9 Table for idler pulley

	Tool	Feed Rate (mmpm)	Spindle Speed (rpm)
VC_SURF_AREA_ZZ_LEAD_LAG	D12 (Milling Tool 5 Parameters)	3000	6000
VARIABLE_CONTOUR_COPY	D12 (Milling Tool 5 Parameters)	2500	6000
VARIABLE_CONTOUR_COPY_INSTANCE_1_INSTANCE	D12 (Milling Tool 5 Parameters)	2500	6000
VARIABLE_CONTOUR_COPY_INSTANCE_INSTANCE	D12 (Milling Tool 5 Parameters)	2500	6000
VARIABLE_CONTOUR_COPY_INSTANCE	D12 (Milling Tool 5 Parameters)	2500	6000
VARIABLE_CONTOUR_COPY_INSTANCE_1_INSTANCE_INSTANCE	D12 (Milling Tool 5 Parameters)	2500	6000
VARIABLE_CONTOUR_COPY_INSTANCE_INSTANCE_INSTANCE	D12 (Milling Tool 5 Parameters)	2500	6000
VC_SURF_AREA_ZZ_LEAD_LAG_COPY	D12 (Milling Tool 5 Parameters)	2500	6000

Figure 21 The result of CNC Milling for idler pulley

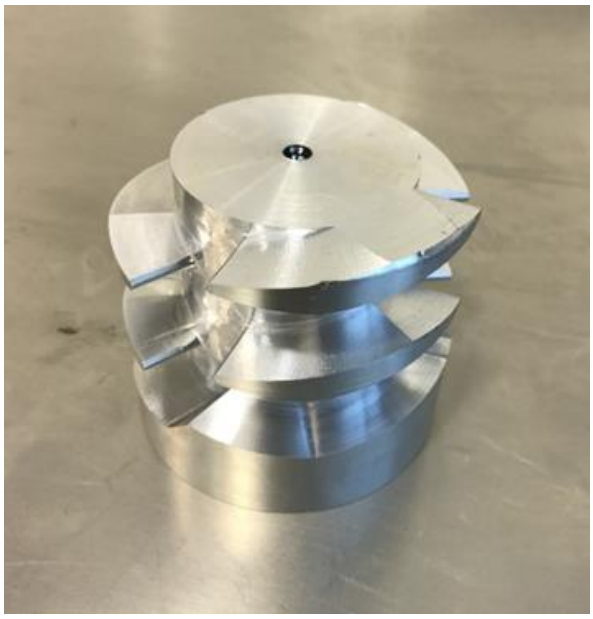


f. Cutting the Workpiece use CNC Lathe

→ After finishing the CNC Milling part of four axis part, the next step is cutting the workpiece. To cutting the workpiece has use the CNC Lathe machine. To machine use the CA 6136 machine like as figure below.

Figure 22 CA 6136 CNC Lathe

Figure 23 The result of Idler Pulley



4. CONCLUSION

After following the design and making the product with 3-axis part and 4-axis part and also analyze the various type of tool, the research has get the conclusion. The conclusions are :

1. When design the part, look at the sizes and the model will be makes.
2. When choose the workpiece, choose it with a size that suitable and reliable.
3. Determine the X, Y, and Z value during the compensation before start the machining process.
4. To determine the X and Y value, touch the tool on the side of workpiece then input the X value and Y value with X = 0 and Y = 0 To determine the Z value, depends the tool which be used then touch the drill tools with the tool until shows the zero value then input the Z value with Z = 0.
5. When the begin the machining process, determine the tools who have used in the CNC machine and measure the diameter of drill tools.
6. To process the machining process, use UG Siemens NX to processing data to the CNC machine and simulation for make the product and also as the ilustration to process the machining process in the CNC machine.
7. Determine the spindle speed, depth of cut and feed per tooth to determine the speed of spindle and the speed of cutting tool.

8. For four axis part, determine the diameter of drill tool use the software which name is VERICUT CNC Machine.
9. For four axis part, there are A axis. A axis to show the rotation of workpiece which be cutting.
10. To find the X and Y value has not same to three axis part where for four axis part no need to input the zero number in the machine. As well as with the Z value.
11. To make the four axis part not only use the one type of CNC but two type. Like as CNC Milling and CNC Lathe. CNC Milling used to make the design the part thereas CNC Lathe used to cutting the workpiece.

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