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JUDUL: DESIGN AND FABRICATE NEW PELTON WHEEL BLADE

SESI PENGAJIAN: 2008/2009

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DESIGN AND FABRICATE OF NEW PELTON WHEEL BLADE

MOHD QAYYUUM BIN MOHD RIDZUAN

A report submitted in fulfillment of the

requirements for the award of

Diploma of Mechanical Engineering

Faculty of Mechanical Engineering

Universiti Malaysia Pahang

NOVEMBER 2008

SUPERVISOR'S DECLARATION

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Diploma of Mechanical Engineering"

Signature	: ………………………………………
Supervisor	: En. Muhamad Imran Bin Mohmad Sairaji
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STUDENT'S DECLARATION

I declare that this thesis entitled "Design and Fabricate of New Pelton Wheel Blade" is the result of my own research except as cited in the reference. The thesis has not been accepted for any diploma concurrently submitted in candidature for any other diploma.

Signature : …………………………………….....

Name : Mohd Qayyuum Bin Mohd Ridzuan

Date : …………………………………….

To my beloved father, mother, sister and brother

Mohd Ridzuan B Abdul Manaf, Nor Balquis Binti Simon,

Noor Qursyaaien and Mohd Qhaa'liq

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Last but not least, I am also indebt to Faculty of Mechanical Engineering for the usage of workstation computer, CNC Milling machine, sand casting and fluid lab equipments for fabrication and analysis of Final Year Project. My Sincere appreciation to who has involved directly and indirectly in succession of the project and thesis. Their views and tips are useful indeed. I am grateful to all of them. Thank You.

ABSTRACT

Design and fabricating New Pelton Wheel Blade is a conceptual understanding of turbine engineering and water flow engineering which is not provided in daily lectures room due to the fact that it is advance knowledge in this field. It is one of the industry that needs necessary knowledge in Malaysia, this is because in our country has many dam but they did not use Pelton concept turbine. Theoretically, it uses the same concept and field of engineering. As such, it is vital to attain this basic knowledge through this project. The design is taken from the existing Pelton wheel and it is vital because the new Pelton wheel needs to fit inside the existing hub. Material that is strong and considerably light is was used to fabricate the Pelton wheel blade using various methods. Evaluation of the test is based on the data obtained in which its range is identical between the existing and new Pelton wheel blade. The findings suggest that a lighter Pelton are an ideal selection, but we compensate the weight with a much more resistant and strong material. All of the work that been done in this project prove to be vital ta the performance of the Pelton wheel blade.

ABSTRAK

Rekabentuk dan binaan turbin Pelton memerlukan pemahaman tentang konsep bidang kejuruteraan turbin dan kejuruteraan aliran di mana pengajaran tentang ilmu ini tidak diberikan di dalam kuliah harian kerana bidand ini adalah bidang pakar. Ini adalah salah satu ilmu yang perlu dikenali dan difahami kerana di Malaysia terdapat banyak empangan-empangan hidroelektrik. Walaupun ia tidak menggunakan Turbin Pelton, secara teorinya, idea dan kosep sama digunakan di dalam bidang kejuruteraan ini. Oleh itu, penguasaan tentang ilmu ini adalah penting di dalam projek ini. Reka bentuk turbin Pelton baru diperolehi daripada turbin Pelton sedia ada, ini penting kerana turbin Pelton yang baru perlu muat didalam tapak yang sedia ada. Jenis bahan yang kuat dan agak ringan dipilih didalam pembinaan turbin Pelton menggunakan pelbagai cara pembuatan. Pemeriksaan terhadap eksperimen adalah menjurus kepada julat data yang serupa di antara turbon Pelton yang sedia ada dan yang baru. Hasil menunjukkan bahawa turbin Peltron yang ringan adalah ideal tetapi, projek ini mengorbankan ciri berat dengan material yang kuat dan ketahanan yang mantap. Segala kerja yang telah di buat semasa projek ini membuktikan ia penting dalam membuktikan prestasi turbin Pelton baru ini.

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%	**-**	percentage
Ø	-	diameter

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Pelton Wheel Blade is commonly used today in calculating water flow experimentation. But around the 1870's it is used as a turbine. Water turbine to be exact. Thus this project purpose is to understand how the Pelton Wheel Blade works when jetted with high pressure water and then fabricate a new Pelton wheel blade that are easier in repairing, higher durability and longer life span compare to the existing Pelton wheel blade.

1.2 Objective of the Final Year Project

1.2.1 General Objective

This final year project is part of the required subjects to be taken during the Diploma of Mechanical engineering course. This is done during the final semester before advancing into the industrial training program. Therefore, it is vital to complete this project in order to receive a final grade depending on the effort put in.

The final year project is also to give students the individual ability and confidence to complete a task with under less supervision of lecturers. With this, students can learn problem solving skill in areas of designing, analysis, fabrication, and testing as well as to learn to do a complete formatted report which is important for future thesis writing.

1.2.2 Specific Objectives

a) Fabricate a new Pelton wheel blade that is more durable, resistant to force and have much longer life span compare to the existing Pelton wheel blade.

b) To make the Pelton wheel blade scoop easily detachable. The purpose of this feature is for the ease of replacement if any one of the fourteen scoops has any defects.

1.3 Problem Statement

Existing Pelton wheel blade is made of plastic. Therefore it has less resistant to force even if it is accidentally dropped. If one of the scoop of the Pelton wheel blade is broken or break, in the condition of the existing Pelton wheel blade now, we must replace the whole wheel blade. It is not cheap and the time consumes for ordering and delivery is long, so, experimentation is halted for the time being. As a result, the maintenance of using Pelton wheel blade is quite high.

1.4 Scope of Project

In order to accomplish the project objectives, the following scopes are identified:

a) Understand the usage and function of Pelton wheel blade.

b) Measure the existing Pelton wheel blade.

c) With the measurement, draw a three-dimensional (3D) in Solidworks. But it is now separated into two parts, the centre plate and scoops.

d) Fabrication of the new Pelton wheel blade. The material used is now changed from plastic to aluminum.

e) Conduct experimentation on both existing and new Pelton wheel blade. The result should be identical or somewhere near the range of existing Pelton wheel data.

1.5 Flow Chart

First of all is the title selection. Here, the title is selected from a list of other final year project titles. Three main titles are selected according to the preferences. The topics are submitted to the Faculty of Mechanical Engineering. The title then are allocated by the subject coordinator and after confirmation, the title are then announced with the supervisor and the students that are selected. After receiving the title, the students are allowed to switch titles with the permission of the supervisor. A declaration is then sign to be under the new supervisor and weekly meetings are scheduled.

Once the title has been confirmed, the supervisor request that for the understanding by the students about the project. Thus, literature review on the title is done thoroughly covering all aspect of the projects. The medium for this research are via internet and books. Essential information related to the project is gathered for referencing.

After the understanding of the project and literature review are done for the project background, comes the measurement of the existing Pelton wheel blade. This is because in this project, the dimension must be identical because the new one will be placed onto the existing Pelton wheel housing for experimentation. So, this is the critical part of the project because, if the measurements are incorrect, the new Pelton wheel will not fit in the existing housing. The measurements are done with basic measurement tool such as vernier caliper and ruler.

Then, with the measurement obtained, comes the fabrication process. In this process, the types of material are also chosen. This is based in the availability of material and process that are available for uses that match the material chosen. After a while of studying and researching, aluminum are chosen because of it higher density, lighter than any other metal available and higher resistance to force than plastic, that is the material for the existing Pelton wheel. During fabrication, the Pelton wheel is separated into two parts, the centre plate and scoops. The centre plate is fabricated using CNC milling machine and the scoops are fabricated using sand casting.

After that, we arrive at test and experimentation process. This process is done using the actual lab experimentation that is done by students for their fluid subjects. But, the experimentation is not 100% following the entire experiment lab sheet. The actual experiment is done to check more detail such as braking speed, rotational speed of shaft. This is not necessary for test to see if the new Pelton wheel blade is functional. So, the only tests that are conducted are test to see the flow rate of water. If the flow range are identical between the existing and new Pelton wheel blade. Then, it is deemed functional.

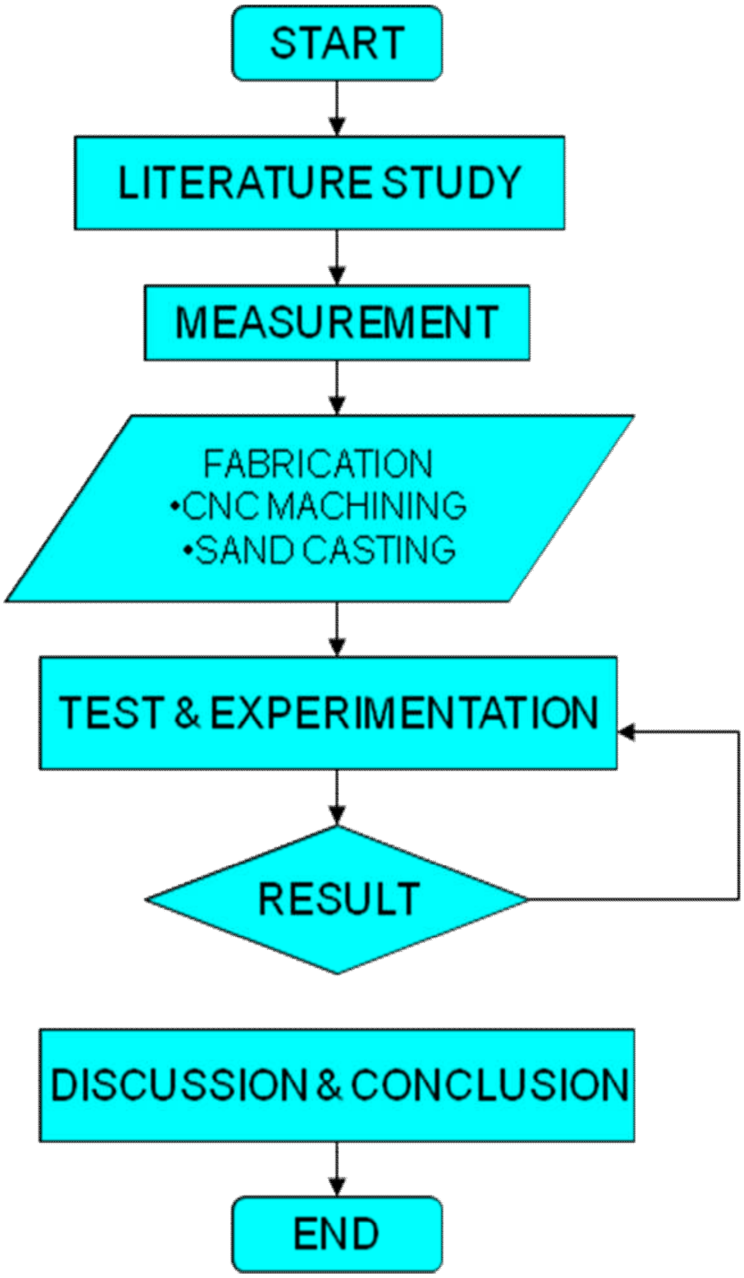


Figure 1.5: Flow Chart

1.6 Gantt Chart

Week 1, the confirmation of the product title was done. With the hectic schedule of clashes classes, there is little time to see the supervisor. Sadly, in week 1 there is no progress. But initiative have been taken, that is learn what is it Pelton wheel blade.

Week 2, first time meeting the supervisor and immediately start off the meeting with meeting another lecturer that have knowledge about Pelton wheel, Mr. Devarajan Ramasamy. He explained in detail about Pelton wheel and its characteristic and the flaw of the existing Pelton wheel blade. He recommended the use of aluminum as the new material. Literature review is still on-going to find information about the method of choice for fabrication.

Week 3, findings are discussed with supervisor. Method of choice for the centre plate is CNC milling machine because this part need precision cutting. But, for the scoops are agreed to be sand casting but needs more analyzation about what method of sand casting to be use. Literature study about sand casting process start-off.

Week 4, unfortunately, the method that is most suitable for the scoop is investment casting. But, investment casting cannot be done in our laboratory. But the method is still sand casting but needs more processing after it had hardened. In this week also, the measurement of the existing Pelton wheel blade are taken because one of the aim of this project is to replicate the exact size.

Week 5, the measurement is presented to supervisor for additional tweaking. Discussion about the limitation of sand casting continues and what is the risk. After the measurement are confirmed, drawing with Solidworks begun.

Week 6, CAD drawing are presented to supervisor. Unfortunately, there is a little repairing need to be done. Discussion for the key point in mid-project presentation is also in this time.

Week 7, the repaired CAD drawing are presented. Draft slides for the mid-project presentation are also presented. There is a repairing need to be done here and there.

Week 8, the repaired slides are presented. The mid-project presentation is also done in this week and it went smoothly but had a little hiccup about a few questions.

Week 9 till week 14 is the fabrication period. The expected difficulties of sand casting came to realization. The scoops fabrication period takes up a lot of time in the fabrication period. In week 14 also the testing are done for the confirmation of functionality of the Pelton wheel blade.

Report writing begins in week 13 and completed in week 15 before the final presentation. Final presentation also is done in week 15.

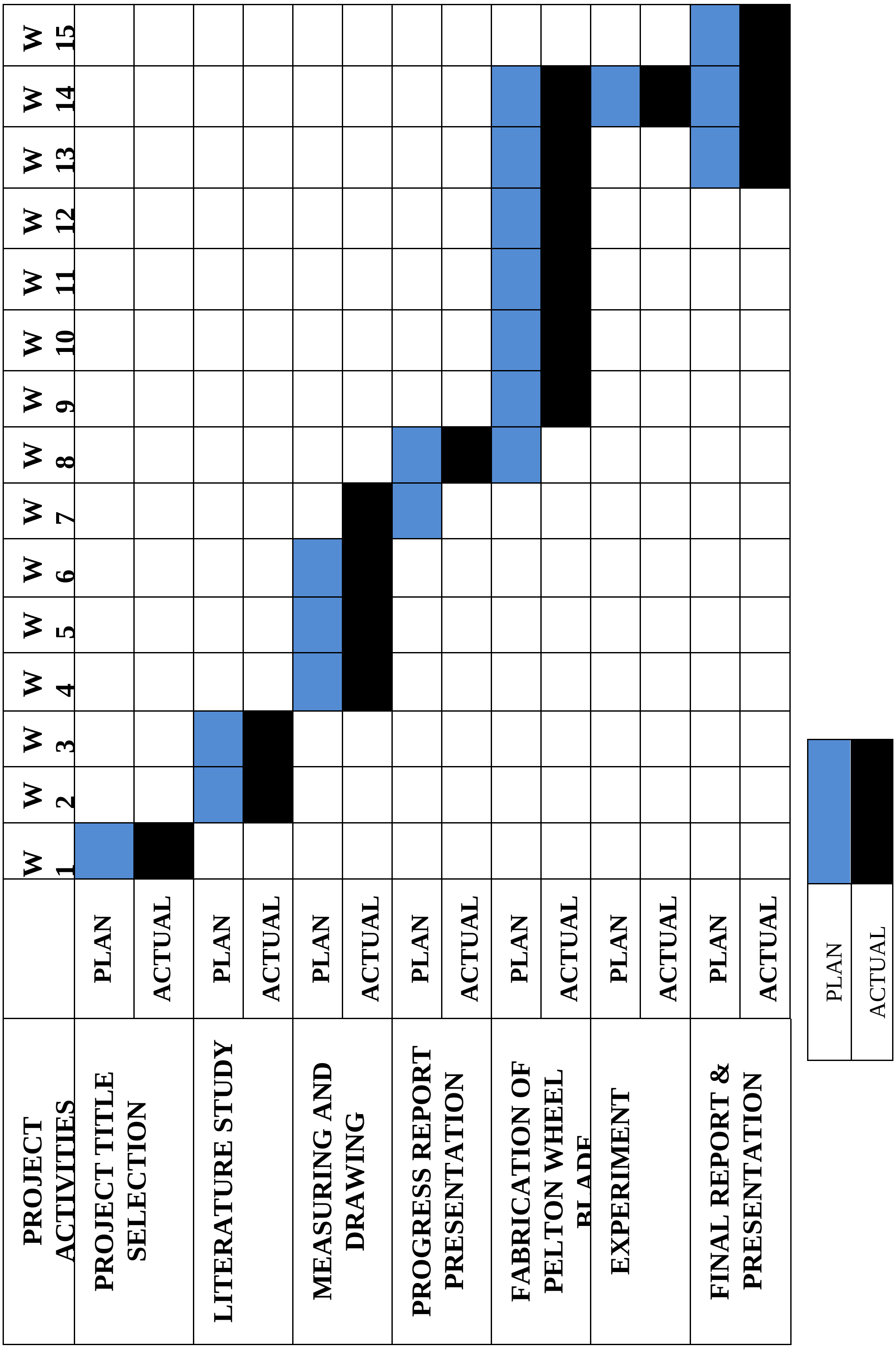


Figure 1.6: Gantt chart

CHAPTER 2

LITERATURE REVIEW

The title design and fabrication of a Pelton wheel blade requires an amount of good understanding on the knowledge of this science. Therefore, executing a research is necessary to obtain all the information available and related to this topic. The information or literature reviews obtained are essentially valuable to assist in the construction and specification of this final year project. With this ground established, the project can proceed with guidance and assertiveness in achieving the target mark.

2.1 Introduction

Figure 2.1: Pelton wheel blade

The Pelton wheel (Figure 2.1) is among the most efficient types of water turbines. It was invented by Lester Allan Pelton (1829-1908) in the 1870's and is an impulse machine, meaning it uses Newton's second law to extract energy from a jet of fluid. Its characteristic is easily notice by the shape of the scoops. Although the one-piece cast impulses water turbine was invented by Samuel Knight, Pelton modified the design to create his more efficient turbine, which is the characteristic of the scoops. Pelton wheels are the preferred turbine for hydro-power, when the water source has relatively high hydraulic heads at low flow rates. [1]

2.2 History

A primitive water turbine, which had water wheels and curved blades onto which water flow was directed axially, use in watermill, was first described in Arabic text written in 9th century. [2]

Jan Andrej Segner developed a reactive water turbine in mid-1700s. It had horizontal axis and was a precursor to modern water turbine. In 1820, Jean Victor Poncelet developed an inward-flow turbine and in 1826, Benoit Fourneyron developed an outward-flow turbine with efficiency of ~80%

In 1844, Uriah A. Boyden developed an outward flow turbine that is improvement to Fourneyron turbine. Then in 1849, James B. Francis improved the inward flow turbine to over 90% efficiency, Francis turbine was the name of the turbine.

But in 1866, Samuel knight invented a turbine with a new concept. He invented a bucketed wheel that captures the jetted water. Lastly in 1879, Lester Allan

Pelton improves the Samuel Knight design with a double bucketed wheel. William Doble improved the Pelton design with an elliptical bucket that has a cut in it to allow jetted water a cleaner entry. This is the modern Pelton wheel that is used today that achieved 92% efficiency. Although Doble took over the company but he did not change the name of the turbine because it had brand recognition.

2.3 Material Selection

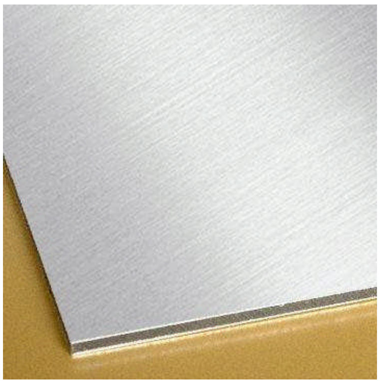


Figure 2.3: Aluminum

In Pelton wheel blade, the material depends on the usage of the Pelton wheel. In this case I use aluminum (Figure 2.3). Because this project Pelton wheel blade is use in fluid lab, in other words for experimentation usage only. The existing Pelton wheel blade uses plastic, but it has many negative factor such as less resistant to force and quite fragile. So, the selection of aluminum is considered best because it has higher resistant to force and longer life span than plastic. In weight aspect, plastic is more light, but aluminum is also in competitive in weight, in other words it is also light.

2.4 Process Solution

In fabricating this Pelton wheel blade, we use CNC Milling and sand casting. This two processes is the ideal process after a period of time searching for the right method.

CNC Milling is used in fabricating the Centre Plate. The reason for this method is because the centre plate needs precision drilling. What better machine can be used other than CNC Milling that has a high accuracy mechanism.

For the Scoops, we use sand casting. Although the true way to cast it is not available, that is investment casting; we still prefer sand casting to be used but it is just only a basic sand casting. But in addition, we have to spend more time in finishing processes.

CHAPTER 3

METHODOLOGY

In the designing and fabricating this Pelton wheel blade, a flow of method had to be used to design and successfully use the Pelton wheel blade. First of all, planning had to be charted out. This acts as a guideline to be followed so that, the final piece of Pelton wheel blade meets the requirements and time could be managed. This would determine the efficiency of the project to be done. Regulating and analyzing these steps are very important as each of it has its own criteria to be followed. The designing process that includes the study of the existing Pelton wheel blade is the backbone of the final piece, therefore using appropriate precise method is imperative for this project. Only with this determination on the designing phase can be successful and the fabrication phase of the project can be carried out. The fabrication phase has to follow once the designing is done. Once this has been established, modification can be made to triumph during testing of the Pelton wheel blade. During testing, the experiment criteria are validated so that the testing is done with shorter time but with the result needed obtained. Finally, the analysis of the whole project can be concluded in the next chapter.

3.1 Steps by Step Fabrication Process

3.1.1 Centre plate

The centre plate is the part that holds together all of the fourteen scoops. It is made using CNC milling machine because it need precision cutting. Its material is solid aluminum cylinder rod that has Ø100mm. Firstly, the Ø100mm are cut into a relatively small thickness that is 15 mm. using Bench saw like as shown on figure 3.1.1.c.

Figure 3.1.1.a & 3.1.1.b: Raw material used

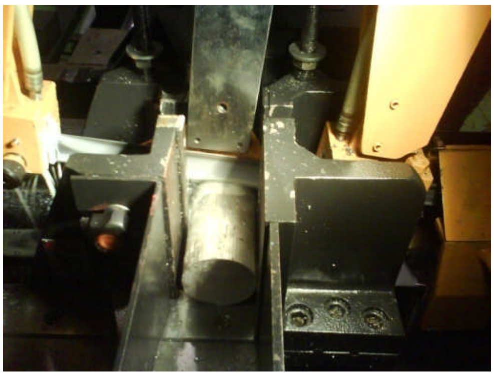


Figure 3.1.1.c: Cutting process using Bench saw

Then comes the part where the face of the cutter workpiece is smoothed using facing method at the lathe machine.

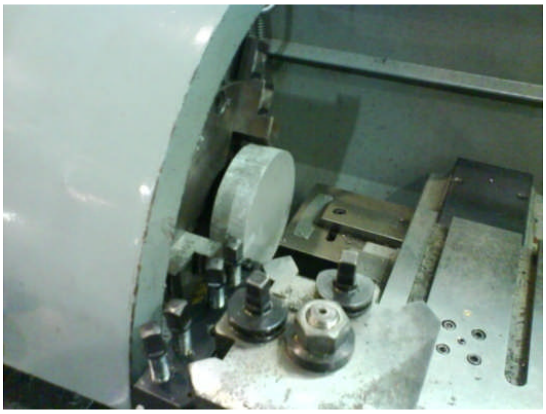


Figure 3.1.1.d: Facing process

After that the workpiece is put in CNC milling machine for the actual part to be fabricated. But, firstly, it needs the program and this is generated by Mastercam software.

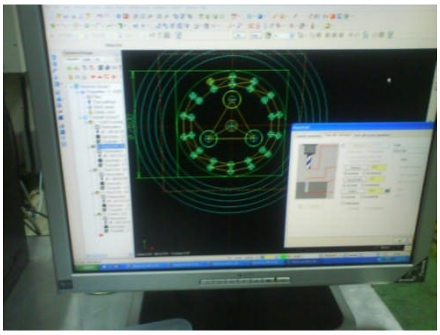


Figure 3.1.1.e: Program generation using Mastercam

With the program already generated and simulation has been run to see if any glitch happens. The CNC machine is ready to run with the insertion of tool that needs to be used. The tool used are Ø3mm centre drill, Ø3.2mm drill bit, Ø8mm drill bit, and Ø12mm drill bit.

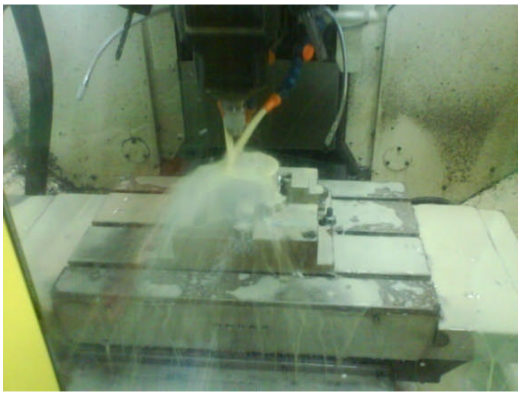


Figure 3.1.1.f: Running in CNC Milling machine

After that, the unused part of the work piece is milled off. The actual dimension for the thickness is 5mm. Like as shown on figure below.

Figure 3.1.1.g: Conventional milling process

Lastly, the finish product is tapped for the threading using M4 x 0.7 hand tap. This is for the scoop placement using bolts.

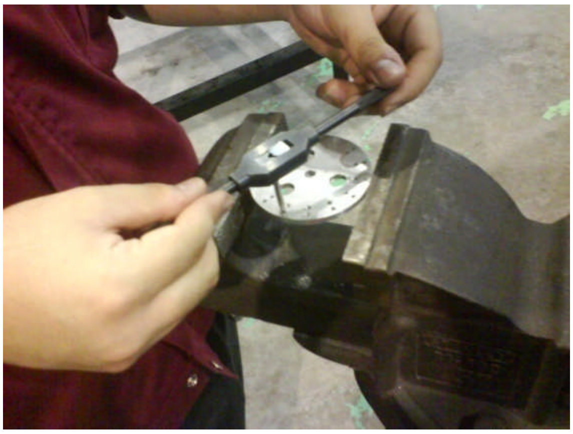


Figure 3.1.1.f: Tapping process

All of the processes above accumulated and the final piece is completed and ready for assembly with the scoops.

Figure 3.1.1.g: Final piece

3.1.2 Scoops

The scoops are the completion part for this project. Without its true way of casting that is investment casting that can’t be done at laboratory. But sand casting is still the most appropriate method. So, the project precedes with basic sand casting processes. Firstly, the mold to make the pattern is retrieve from the existing Pelton wheel blade using paper clay.

Figure 3.1.2.a & 3.1.2.b: Retrieving shape from existing Pelton

Then the paper clay is scooped out of the Pelton wheel and is left for it to harden for 6 hours.

Figure 3.1.2.c: The hardened clay

After it has hardened, plaster of Paris is mix together with water with ratio of 2:1. The mixture is then poured into the mold and left to harden for 12 hours.

Figure 3.1.2.d: Pattern making in process

After the pattern has hardened, the mold for the pattern is break apart to retrieve the pattern. By doing this, the pattern is completed. These three steps are repeated for 14 times to make 14 patterns.

Figure 3.1.2.e: Finished pattern

Then, the pattern is paste on a 450mm x 300mm sheet metal.

Figure 3.1.2.f: Pattern assembled on the sheet metal.

The sheet metal is put on the floor and the sand are fill in the box shaped mold. Then it is compressed to let no air trapped in the sand. Then holes are made and the holes are filled with CO2. This is to fasten the harden of the sand.

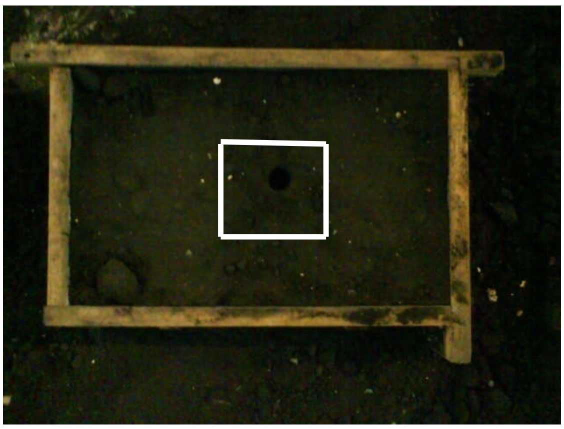


Figure 3.1.2.g: Mold in the making

After that the box are open and that left us with the hardened mold.

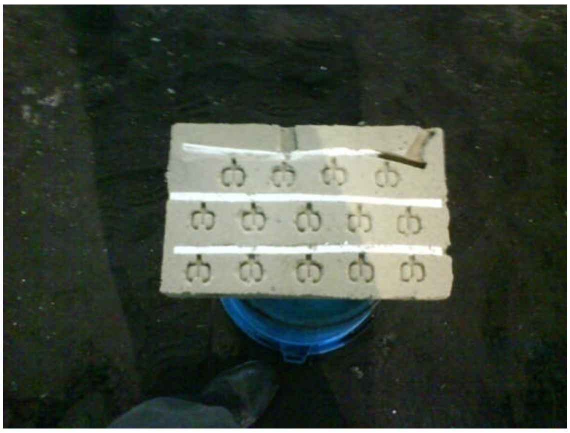


Figure 3.1.2.h: Hardened mold

The molten aluminum are poured into the mold and left for about 15 minutes for it to harden.

Figure 3.1.2.i: Aluminum poured

The mold is broken apart and the scoops are scooped out. Process for making the mold is repeated once. But the second mold is only capable of making 10 scoops because of broken pattern. The perfect and near perfect scoops are chosen, the rejects scoops are gathered and put in a specified place for it to be melt again.

The aluminum scoops are grind to cut off any extra aluminum that is not needed that the scoops. The below process is repeated for 14 times, that is the number of scoops pieces needed.

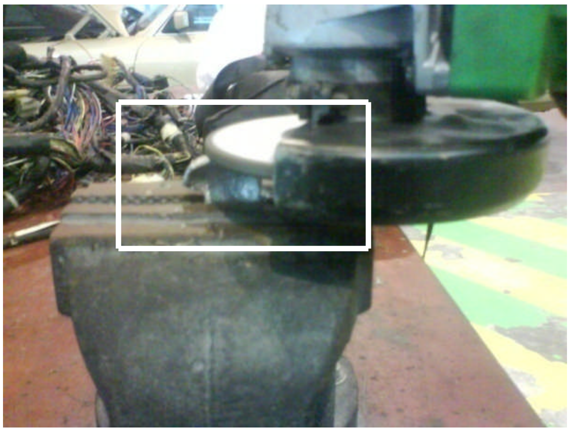


Figure 3.1.2.j: Grinding in progress

The grinded scoops are punch to make a reference for the Ø3.2mm drill bit to drill through.

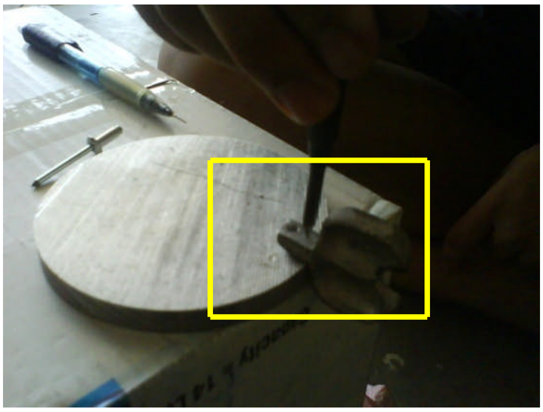


Figure 3.1.2.k: Punch for drill reference

After that, comes the drilling process according to the reference point that is earlier punched.

Figure 3.1.2.l: Drilling process

After all of the 14 scoops are drilled, then it has to undergo tapping process to make threading for the purpose of combining with the centre plate.

Figure 3.1.2.m: Tapping process

Then the 14 scoops are filed and polishing with vertical air grinder for the final finishing process.

Figure 3.1.2.n: File in progress

Figure 3.1.2.o: Polishing process

Figure 3.1.2.p: Finish Scoops

3.2 Tool used and pattern making material

This tools are all involved in making this project a successful. Material for making the pattern is also shown.

Figure 3.2.1: Various tools

3.2.2: Vertical air grinder

Figure 3.2.3: Paper clay

Figure 3.2.4: Plaster of Paris

3.3 Assembly

After the two main components has completed fabrication. Now comes the time for the assembly phase. For the attachment of the two parts, bolt are uses with the size of M4 x 0.7. There are two type of blots is used. That is

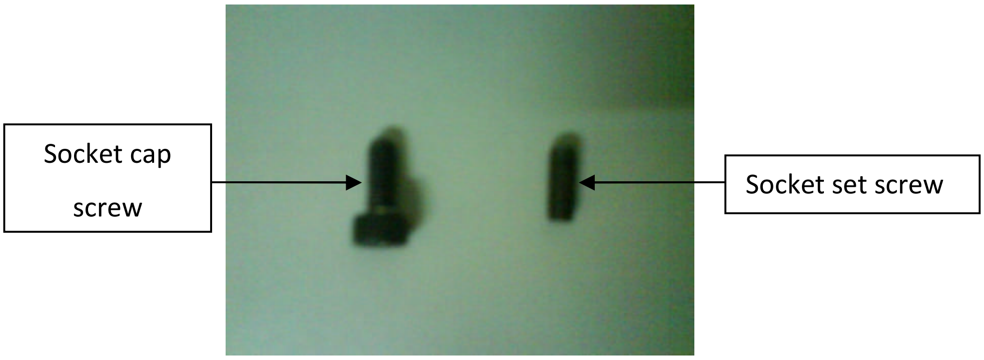


Figure 3.3.1: Bolts

The process of attachment for the first bolt and second bolt on the plate through to the scoops.

Figure 3.3.2: Attachment in progress

Finally, the finish project has been assembled.

Figure 3.3.3: New Pelton Wheel Blade

CHAPTER 4

RESULTS AND DISCUSSION

The result and discussion function as the achieving target of the final year project. However if the target is not met, it means there were problem faced during the process and will be discussed. If the result proves that the objective is accomplished, the process is discussed too. This part of the project is about understanding the outcome of the testing process. The outcome resolves in the performance of the Pelton wheel blade in lab experimentation. The Rotation per Minute (RPM) and its volume flow rate is comprehended to see how well the Pelton wheel blade performed. Basically, this analysis is a must for the project because it shows how well the Pelton wheel blade turned out to be. The focus of this chapter is solely on the product of this project. Once the target of this chapter is met, then only the whole project process and outcome can be concluded in the next chapter.

4.1 Assembly for experimentation

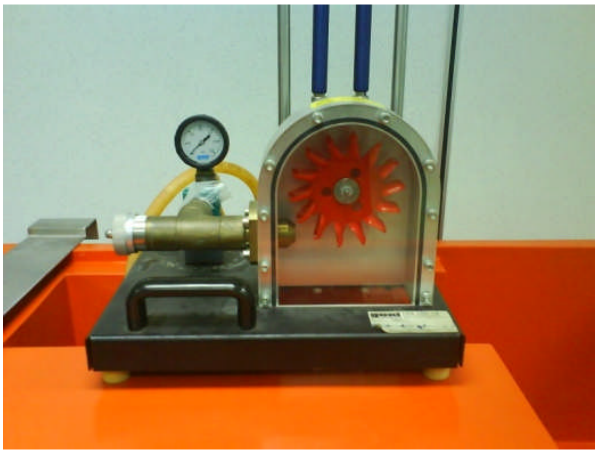


Figure 4.1.1: Experiment hub

Picture above shows that the hub for the experimentation that will be conducted. The existing Pelton wheel blade will be taken out and the new one will be inserted in its place. Before inserting, there will be an additional 2 x 1mm and 1 x 2mm thickness washer that will be added compare to the existing one that has 2 x 2.5mm washer thickness because the new Pelton wheel centre of the scoops that will be hit by the water jet is different from the existing Pelton wheel. This is because the placement of the scoop is in the back compare to the existing that is right in the centre.

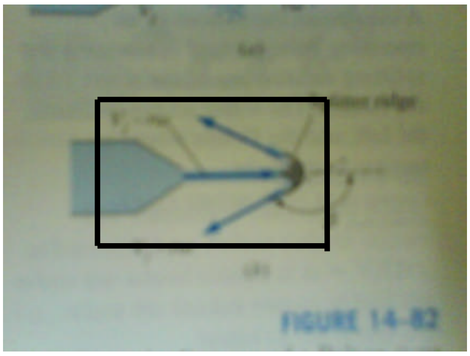


Figure 4.1.2: Theoretical position of the centre of scoop and water jet. [3]

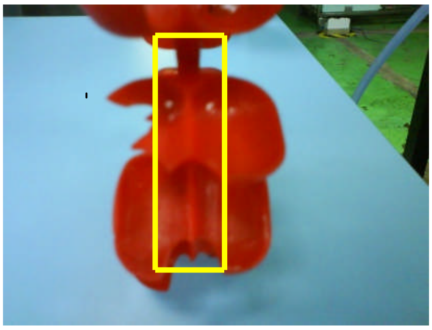


Figure 4.1.3: The original offset of the scoop position relative to the centre plate.

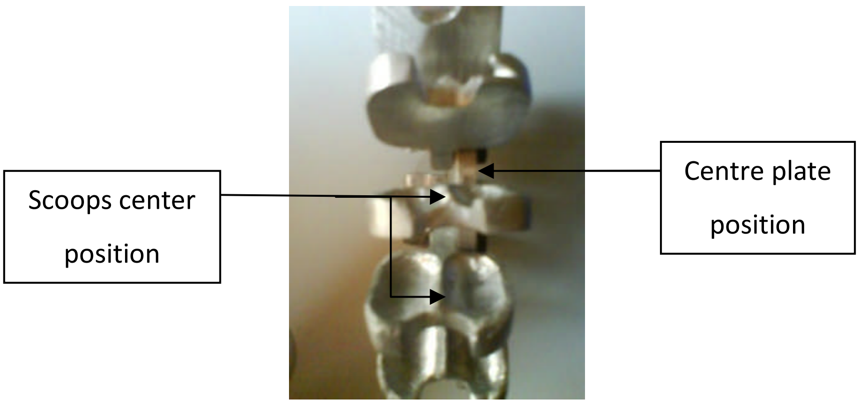


Figure 4.1.4: The new Pelton wheel blade altered position.

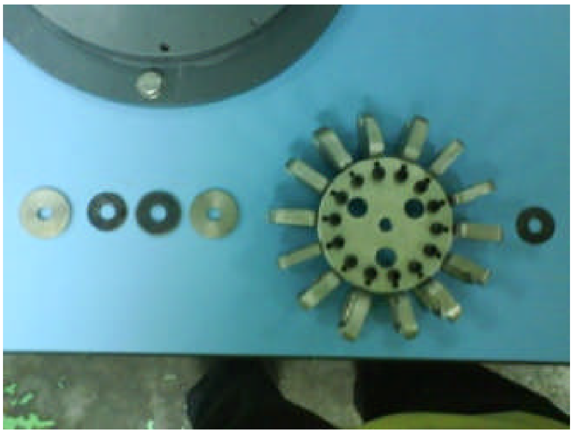


Figure 4.1.5: The position in the shaft in order from left to right with washer.

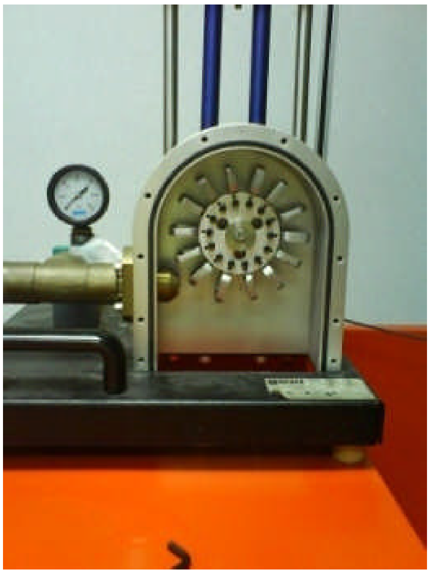


Figure 4.1.6: The new Pelton wheel blade after installation into hub.

4.2 Experimentation

The experiment conducted is based on the actual experimentation that is done by students with the existing Pelton wheel blade. Its lab experimentation entitled ‘Pelton Turbine’. But, based on the experimentation compared to the objectives needed, that is to prove the functionality of the New Pelton wheel blade by getting similar data. There are some of the data that need calculation well not be done. Instead the data collected are volume and time for calculating volume flow rate. Then Rotation per Minute (RPM) collected after added braking force of 0.5N, 1.0N, 1.5N, 2.0N and 2.5N.

The difference in weight is the existing Pelton wheel weights about 50.688g and the new Pelton wheel weights about 273.729g.

4.2.1 Calculating Volume Flow Rate

Firstly, the pump are turned on and the stop watch are set to zero. Then close the valve at the bottom of the volumetric tank, wait until the liquid reaches a value of 10 liters and at the same time start the watch. After the liquid reaches value of 15 liters, stop the watch. The time measurement and the high value of water are noted and filled in a table. Lastly, calculate the volume flow rate. This experiment is repeated twice using the existing Pelton wheel and new Pelton wheel. For each Pelton the data collection are repeated six times. The Rotation per Minute (RPM) for both Pelton wheel blades is set to 114 RPM.

The equation for Volume Flow rate is

Volume Flow Rate = Volume / Time

Volume [l]	Time [s]		Volume Flow Rate [l/min]	
	Existing	New	Existing	New
5	32.45	31.32	9.24	9.58
5	32.47	31.37	9.24	9.56
5	32.38	31.32	9.26	9.58
5	32.41	31.35	9.26	9.57
5	32.45	31.33	9.24	9.58
5	32.39	31.34	9.26	9.57

Table 4.2.1: Data for volume, time and volume flow rate

Table 4.2.1 describes the Volume flow rate collected from calculating with suitable equation using the time and volume obtained from experimentation.

4.2.2 Obtaining Rotation per Minute (RPM) with effect of braking (N).

Firstly, the pump is turned on. The RPM for 0N is set to 229. Then the braking on the shaft is added to 0.5N and the data of the RPM is collected. This continues to 1.0N, 1.5N, 2.0N and 2.5N of braking. This experimentation is repeated twice using the existing and new Pelton wheel blade.

Braking Force (F) in Newton (N)	Rotation Per Minute (RPM)	
	Existing	New
0	229	229
0.5	175	170
1.0	125	122
1.5	82	62
2.0	30	26
2.5	0	0

Table 4.2.2: Data for braking force and RPM

Table 4.2.2 describes the Rotation per Minute (RPM) obtained after there is an added weight on the shaft of the Pelton Wheel Blade.

4.3 Discussion

Based on graph 4.3.1 and 4.3.2, the result of the Volume Flow Rate experimentation is adequate to say that the new Pelton wheel blade is a success based on the almost identical data obtained, that is the gap for the time taken for each Pelton are near to the result taken from previous data collection. Although there is a range of below 0.3 seconds for time and below 0.1 l/min for volume flow rate between the 6 data collection.

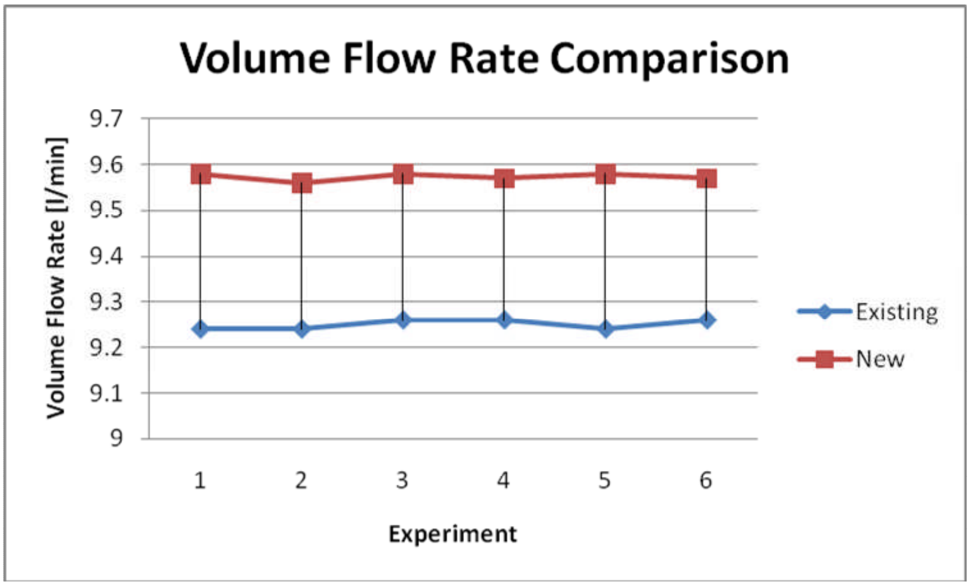


Figure 4.3.1: Volume Flow Rate Comparison Result

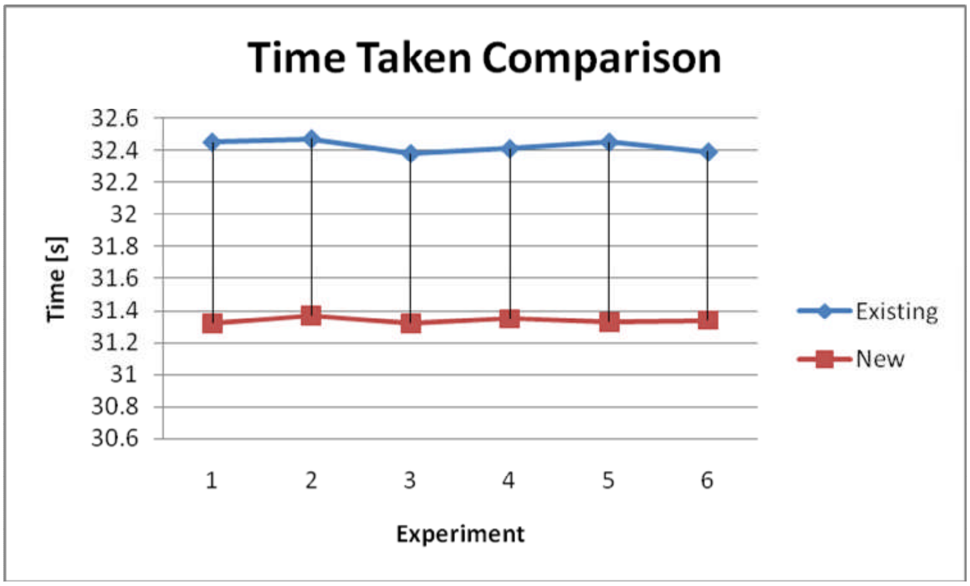


Figure 4.3.2: Time Taken Comparison

Based on graph 4.3.3, the result of RPM with involvement of braking experimentation is enough to support the Volume Flow Rate experimentation in stating that the new Pelton wheel blade is a success. Even though there is a gap of RPM, this is considered accepted. This is because the existing Pelton wheel blade has 3 broken scoops. So, in other words, there is only 11 working scoops and water will hit fewer scoops that originally intended. Thus, making the speed RPM much faster that the new Pelton wheel blade that has the full scoops of 14 working. Another reason is that the new Pelton wheel blade is slightly heavy than the existing ones. This is because the new ones are made of aluminum and the existing ones are made of plastic. This project compensates the added weight with a more heavy duty material for longer life span.

Below is the picture showing the three scoops in the existing Pelton wheel blade that have been broken.

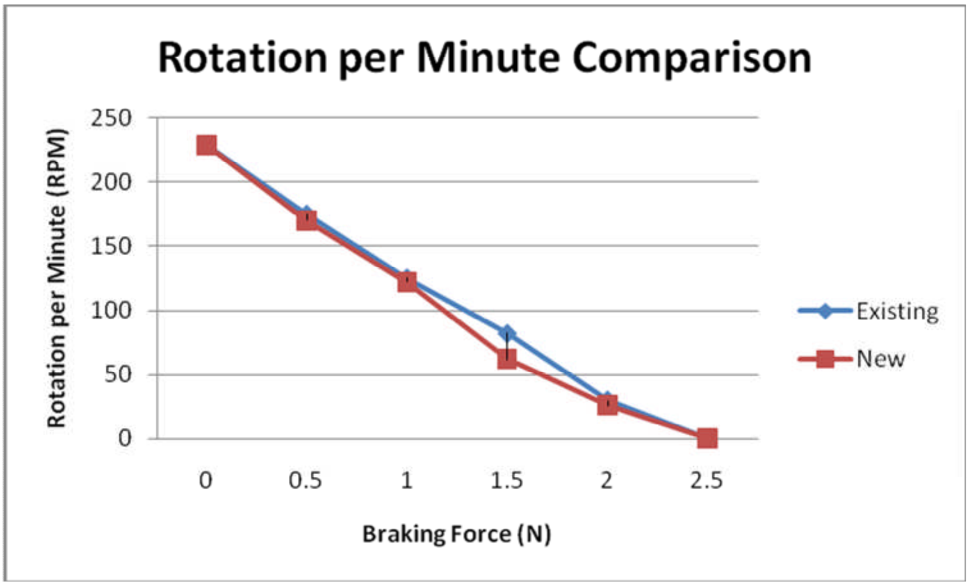


Figure 4.3.3: Rotation Per Minute Comparison

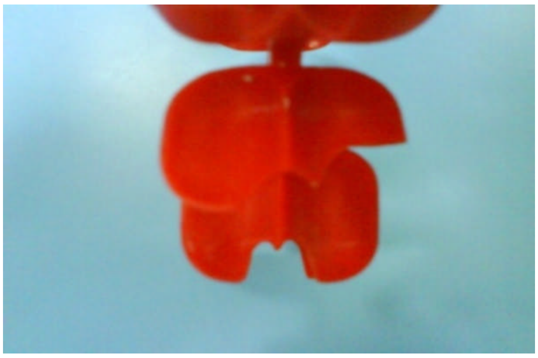


Figure 4.3.4, 4.3.5, 4.3.6: Broken scoops

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

In this chapter, a summary is established to conclude the whole final year project. However there were problems faced during the course of this project. The measures taken to rectify these problems have been identified and applied. There will be the recommendations for future project of the same kind to improve it. Therefore, a more complete understanding and enhanced application steps can be attained. In addition, the interest on the knowledge of turbine can be spread wide to the population not just the specialist but also the public.

5.1 Problems faced throughout the project

During the process of this Pelton wheel blade, many problems and small glitches were faced. The first was obtaining details knowledge about the CNC Programming. The subject is taught in the same semester as the final year project, so, there is a must to learn about the CNC Milling and programming earlier than the subject taught. The learning of the Mastercam program. It takes about 2-3 days to learn about it. This program is the coding generator for the CNC Milling.

Then there is a must of in-depth learning of sand casting. Even thought it has been taught in Manufacturing Technology subjects, there is no application of it, only theoretically. But the most affected problem to this project is that there is no process to make the scoops. The right process should be Investment casting but in UMP laboratory, it cannot be made. So, we have to make do with what we have to make the scoops. We chosen the basic sand casting process as the method, but it have its consequences that are there will be more time consumes in finishing processes. This is because the surface is not smooth, there were many rejected scoops and the thickness varies. Although this has been solved, comes new problem, that is the furnace to melt the aluminum, the only one in UMP is broken down. So, there is a setback in the project.

5.2 Conclusion

In conclusion, the project objectives were achieved. The first objectives, fabricate a new Pelton wheel blade that is more durable, resistant to force and have much longer life span compare to the existing Pelton wheel blade was completed when the Pelton wheel blade has finished fabricating. The usage of aluminum ensures the objective has been conquered but with a cost also, that is added weight. The second objective is that to make the Pelton wheel blade scoop easily detachable. The purpose of this feature is for the ease of replacement if any one of the fourteen scoops has any defects. This is accomplished by using 2 different nuts for each scoop, one is for positioning and one is for ensuring it is stick to the centre plate tightly. Lastly, achieving the scope also is a success. Many of the scope have been accomplished during the measuring and fabricating processes. The last scope that is also important is the experimentation on both existing and new Pelton wheel blade. The result should be identical or somewhere near the existing Pelton wheel data. Although there is a different in the data that is roughly 0.3 seconds and below and also 0.1 l/min for volume flow rate. Therefore, the overall project is a success.

5.3 Recommendation

My recommendation related to this project is divided into the knowledge of sand casting manufacturing and application, fabrication process and equipment availability and recommendation for future works.

The knowledge of sand casting manufacturing must be applied also in hands-on, not only theory. Because in hands-on, students can feel and take experience first-hand and knows what to do when they have step into working environment if any problems occurred. By doing so, hopefully, sand casting knowledge will be enhanced to each and every mechanical student.

The fabrication process should be available in our mechanical laboratory. This will fasten the fabrication process and the product also is improved in appearance and shape. The equipment availability, the furnace should at least have two sets, in case of a breakdown; the second one can be used.

The weight of the Pelton wheel fabricated with aluminum can be reduce. One of the methods is reducing the thickness, but not too thin that will result in a non-sturdy Pelton wheel blade. The scoops weight also can be reduce by removing unnecessary thickness.

Lastly, in the future project, the method of fabrication can be improve by using 3D laser scanner for occupying measurement scoops and also CNC Milling for a more accurate, higher surface finish and thin scoops.

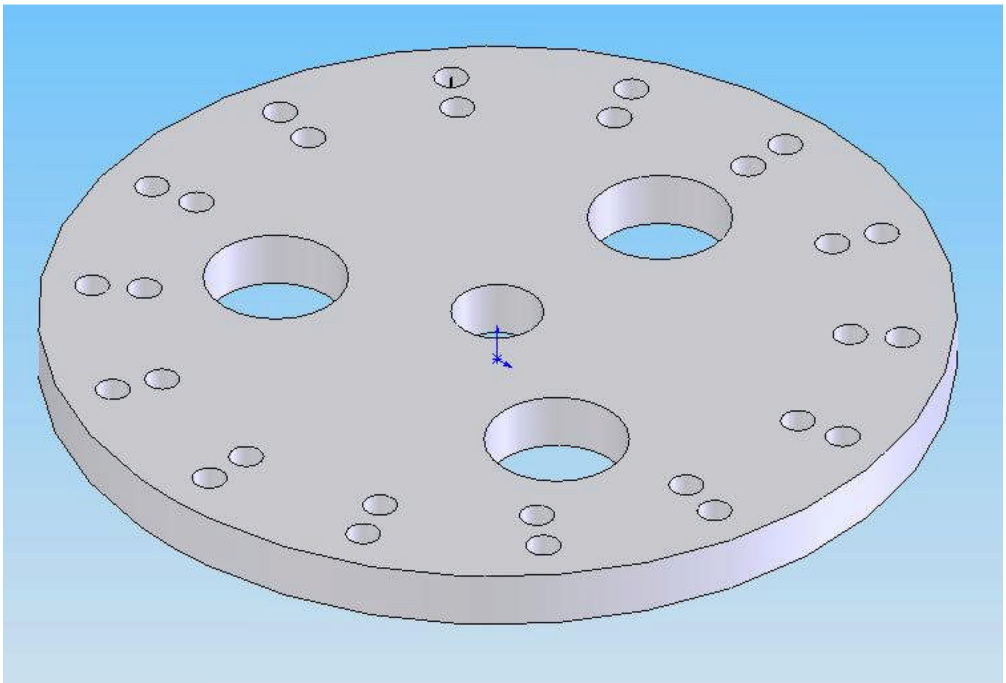
REFERENCE

1. [1] [3] Yunus A. çengel., John M.Cimbala. 2006. *Fluid Mechanics Fundamentals and Applications.* New York: McGraw-Hill.

2. [2] Donald Routledge Hill. 1991. "Mechanical Engineering in the Medieval Near East", *Scientific American*.

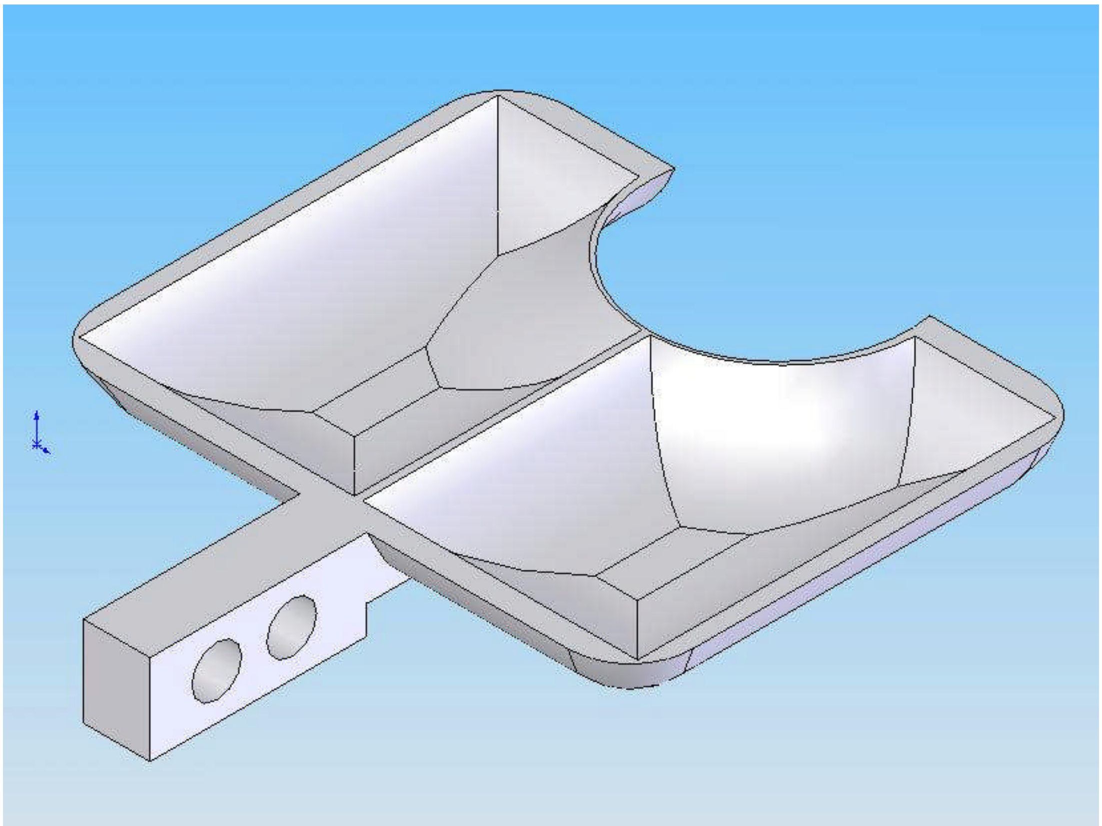
APPENDIX A1

Cad Drawing of Centre Plate



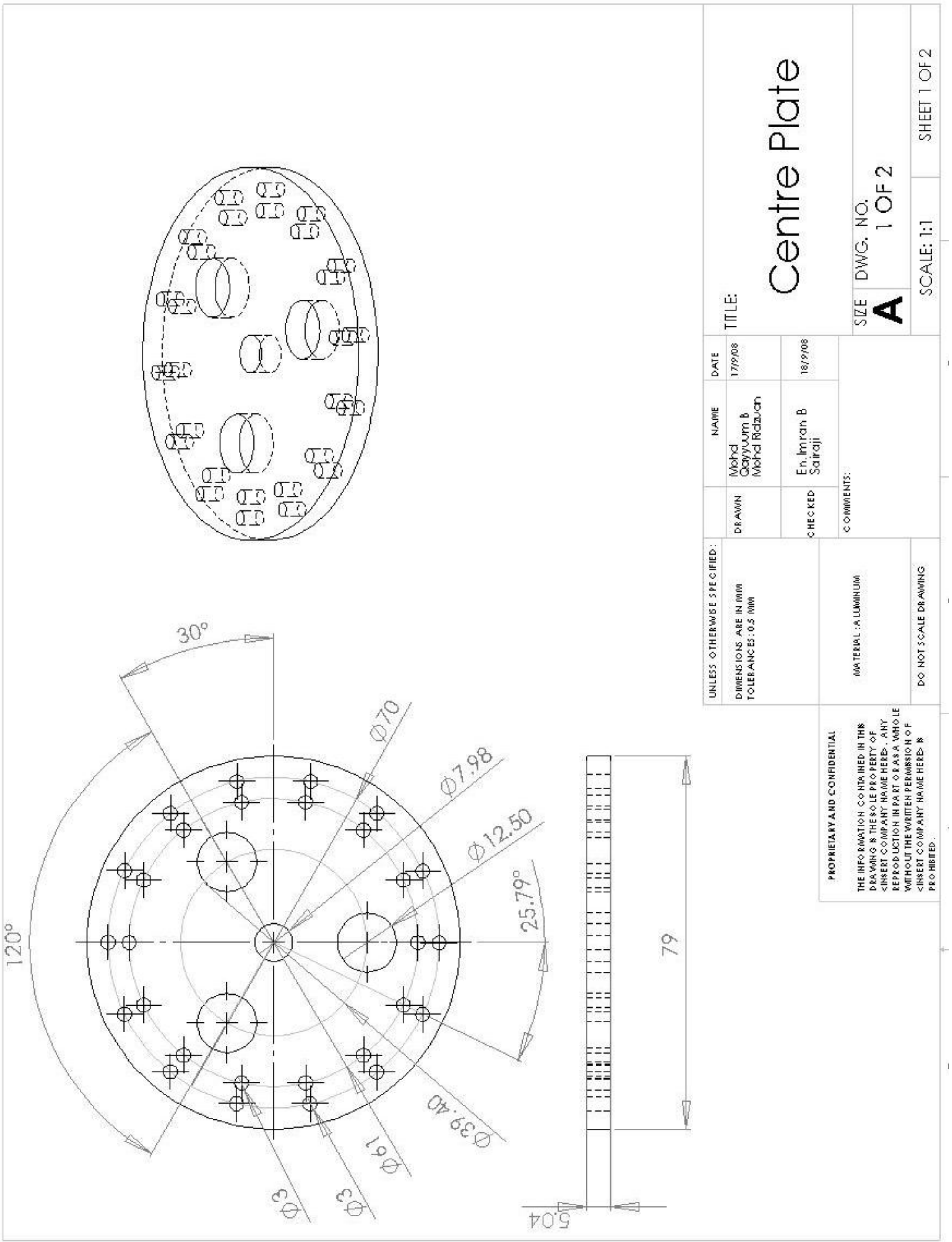
APPENDIX A2

CAD Drawing of Scoops



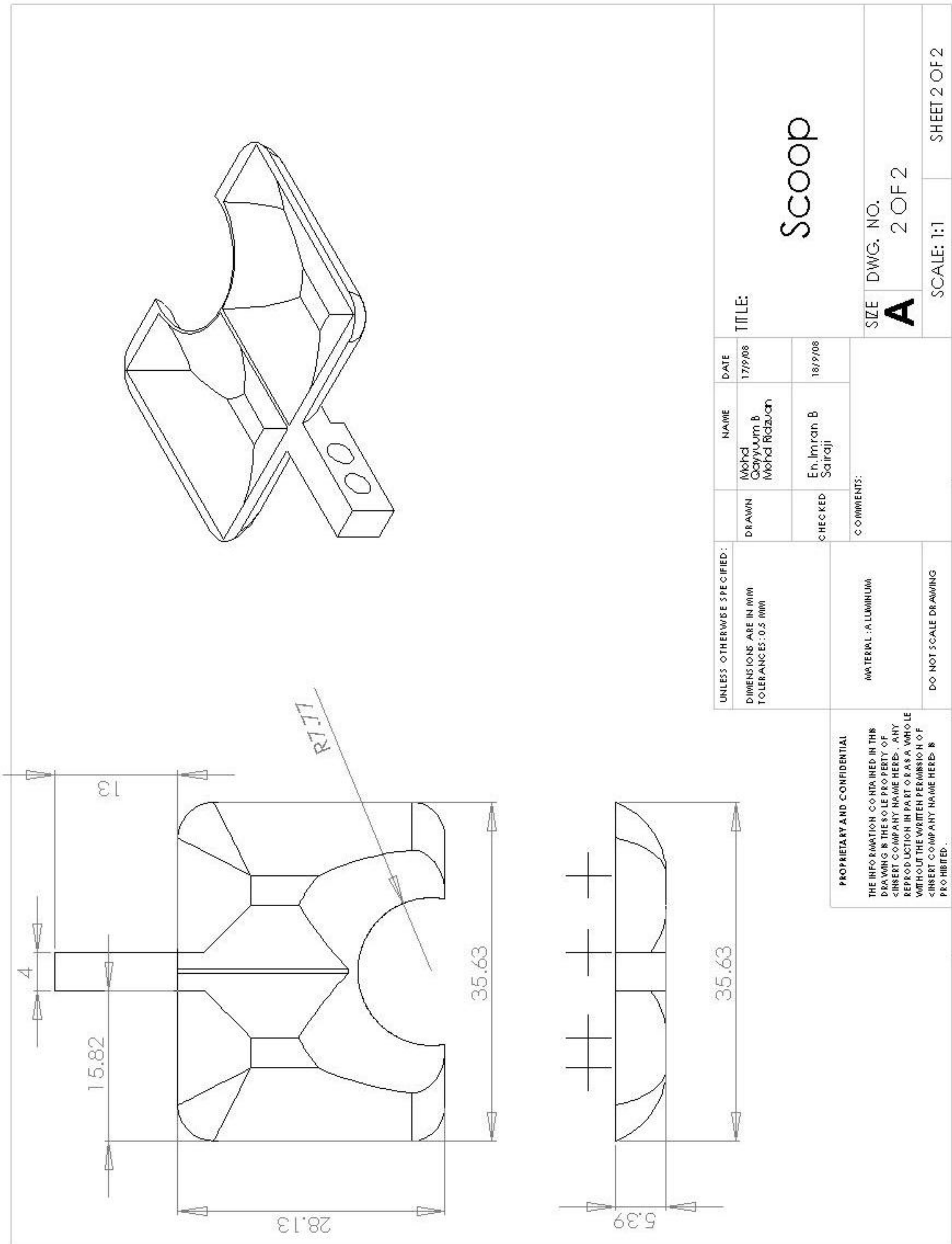
APPENDIX B1

Technical Drawing of Centre Plate



APPENDIX B2

Technical Drawing of Scoop



APPENDIX C

NC Coding for Centre Plate

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%
O0000(T)
(MCX FILE - E:\NEW FOLDER\T.EMCX)
( T1 |    5. CENTER DRILL | H1 )
( T2 |    12. DRILL | H2 )
( T3 |    8. DRILL | H3 )
( T4 |    3. DRILL | H4 )
N100 G0 G17 G40 G49 G80 G90
N110 T1 M6
N120 G0 G90 G54 X-15.184 Y31.535 S1200 M3
N130 G43 H1 Z10.
N140 G99 G81 Z-5. R10. F50.
N150 X0. Y35.
N160 X15.217 Y31.519
N170 X27.384 Y21.798
N180 X34.129 Y7.76
N190 X34.117 Y-7.814
N200 X27.349 Y-21.841
N210 X15.167 Y-31.543
N220 X-.018 Y-35.
N230 X-15.2 Y-31.527
N240 X-27.372 Y-21.812
N250 X-34.125 Y-7.778
N260 X-34.121 Y7.796
N270 X-27.361 Y21.826
N280 X-23.061 Y18.396
N290 X-12.798 Y26.58
N300 X0. Y29.5
N310 X12.825 Y26.566
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N330 X28.766 Y6.541
N340 X28.755 Y-6.586
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N360 X12.784 Y-26.586
N370 X-.015 Y-29.5
N380 X-12.811 Y-26.573
N390 X-23.071 Y-18.384
N400 X-28.762 Y-6.556
N410 X-28.759 Y6.571
N420 X-16.454 Y-9.5
N430 X0. Y0.
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N490 M01
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N530 G99 G83 Z-10. R10. Q2. F80.
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N550 X16.454
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N770 X27.384 Y21.798
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N810 X34.117 Y-7.814
N820 X28.755 Y-6.586
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