SIMULATION OF MICRO HYDRO POWER BASED ON RIVER CONFIGURATION AT RIVER DOWNSTREAM

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FACULTY OF MECHANICAL ENGINEERING

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I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has been accepted for any degree and is not concurrently submitted for award of other degree.

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DEDICATION

Dedicated to My Family

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ABSTRACT

Micro hydro power convert potential energy of water into electricity and it a clean source. The project present about Simulation of Micro Hydro Power based on river configuration at river downstream. The objectives of this project to simulate flow of downstream river for different Micro hydro power, to determine the performance and efficiency of micro hydro power in downstream river and to determine the availability of hydroelectric in rural areas. This project is focused on downstream river where the velocity, pressure and topology data is to be determined. The place that used for this project is Sungai Pahang. In this project just used two software, it is SolidWorks 2012 and ANSYS (CFX). Simulations have been done with two different turbine of micro hydro power, the first turbine is Propeller and the second is Tidal turbine. Between the two turbines the performance of Propeller turbine are good compared to the tidal turbine. It is because the toque of Propeller is higher compared to the tidal. The torque is 17.295Nm and 11.901Nm. As the conclusion propeller turbine are beater compare to the tidal turbine.

ABSTRAK

Kuasa mikro hidro mengubah tenaga keupayaan air kepada elektrik dan ia merupakan sumber yang bersih. Projek ini adalah mengenai simualsi kuasa mikro hidro berdasarkan konfigurasi di hilir sungai. Projek ini bertujuan untuk mensimulasikan aliran sungai hilir dengan perbezaan mikro hidro, ia juga bertujuan untuk menentukn kecekapan dan prestasi kuasa mikro hidro di hilir sungai dan ia juga bertujuan untuk kesesuaian diguankan di kawasan luarbandar. Projek ini dikhususkan dihilir sungai dimana kelajuan, tekanan perlu ditentukan. Tempat yang digunakan untuk projek ini ialah Sungai Pahang. Projek ini mengunakan dua jenis perisisan iaitu SolidWorks 2012 dan ANSYS (CFX). Simulasi ini telah dilakukan kepada dua jenis turbin yang berbeza. turbin pertama adalah Propeller dan kedua adalah Tidal.berdasarkan kedua-dua jenis turbin, turbine Propeller lebih baik berbanding turbin Tidal. Ini kerana daya kilas untuk turbin propeller lebih tinggi jika dibandingkan dengan turbin tidal. Daya kilas itu ialah 17.295 Nm dan 11.901 Nm. Kesimpulannya, turbin Propeller adalah lebih baik dibandingkan dengan turbin Tidal.

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psi	pound per square inch
gpm	gallons per minute
m^3/s	cubic meters per second
lpm	liters per minute
l/s	liters per second
m/s	meter per second
kW	kilo watts
P	power
ω	angular velocity
τ	torque
A	swapped area
ρ	density
ν	velocity
η	efficiency

LIST OF ABBREVATION

MHP	Micro Hydro Power
JPS	Jabatan Pengairan dan Saliran
AC	Alternating Current
DC	Direct Current

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays there are many sources that use to sustainable the energy for example micro hydropower, solar energy, biomass, geothermal and etc. The energy is generating from natural resources such as water, radiation, wind and tides etc. which are renewable in nature. Hydro power plants convert potential energy of water into electricity and it is a clean source. The water, after generating electrical power is available for irrigation and purposes. A micro hydro power plant has a capacity of up to 100kW. Micro hydroelectric power system can produce enough electricity for home, farm, ranch or village. Hydroelectric power generated from water is not yet all tapped completely. Micro hydro power plants are emerging as a major renewable energy resource today. However, they require control system to limit the huge variation in input flow expected in rivulets over which these are established so as to produce a constant power supply. This also helps in achieving the competitive cost of generated power which is possible by using hydro power. In planning of micro hydro power plant, it is necessary to mention the power demand of that region. New micro Grid (MG) is to be introducing in existing power system based on the local power supply conditions. Potential improve the Self-supply Ratio (a percentage of the valid power obtained from local power source) in power consumption. It should be considered that in the view of overall condition of energy development, the potential power existing in the weak natural energy regions usually ignored due to low benefit and long repayment period. In reality, almost all parts of region in which people are living are usually with the natural energy. World energy shortage points out that it becomes urgency to develop the weak natural energy around local inhabitants. In economic analysis, it is found that the payback is severely affected by the effective water- head that the water flow rate. It could be observed that to select an irrigation canal with higher water head for installing mini hydro power plant, it is more important than to select a canal with larger water flow rate.

In this project, the simulations have done for micro hydro power at Sungai Pahang. From this experiment the water flow into the turbine and then will rotate the turbine, after that it will generate hydro power. After generation of power, it can use for people that live at the area which is the people that live near to Jambatan Pekan. This concept is useful to utilize untapped renewable energy. Various basic parameters such as section of site, hydrological and topographical survey and its analysis is studied for deciding the suitable micro hydro power.

1.2 PROBLEM STATEMENTS

Geographical factor play an important role in micro hydro power plant. The height (head) of river, velocity of flow, water traffics, river contamination and topology data differs in every place. These factors may affect the performance and efficiency of micro hydro power. Different types of micro hydro power differ in performance and efficiency. The effectiveness of micro hydro power is influenced by surrounding factors.

1.3 OBJECTIVES

The main objective of this project is to simulate flow of downstream river for different turbine in micro hydro power. There are two types of turbine which is Propeller and tidal turbine.

Next objective is to determine the performance and efficiency of micro hydro power in the downstream river configuration.

And the last objective is to determine the availability of micro hydro power in the rural area.

1.4 SCOPES

The analysis that used in this project is for Sungai Pahang. This project focuses on the downstream river configuration where the velocity, pressure and topology data is to be determined.

This project is more focus on simulation of the micro hydro power. All parts in the water turbine system have been done using SolidWorks 2012. Based on the data collected, the simulations have been done using ANSYS (CFX). From the result obtained, we can know the suitable micro hydro power based on higher performance.

CHAPTER 2

LITRTURE RIVIEW

2.1 INTRODUCTION

Following and falling water have potential energy. Hydro power comes from converting energy in following water by means of water wheel or through a turbine into useful mechanical power. This power is converted into electric using an electric generator or is used directly to run milling machines.(DOE, 2001). Micro-hydro power is the small-shale harnessing of energy from falling water; for example harnessing enough water from a local river to power a small factory or village. This fact sheet will concentrate mainly at micro-hydro power.

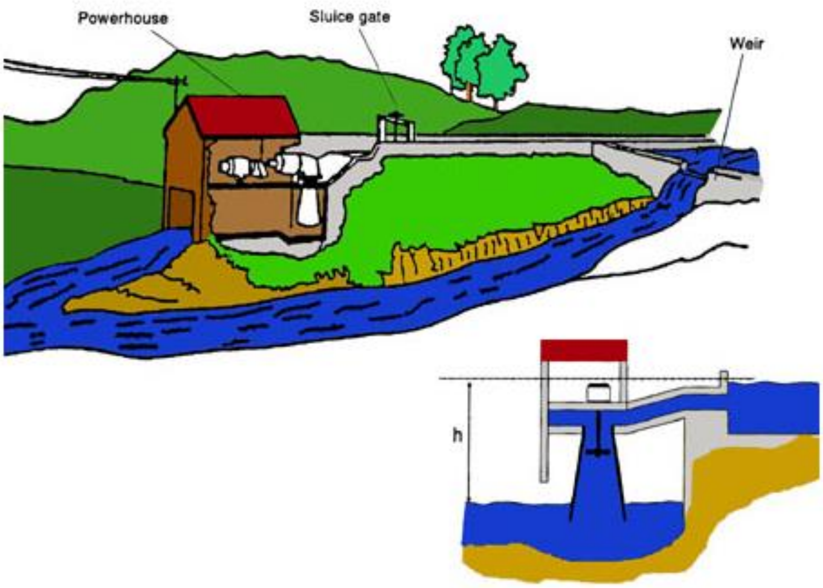


Figure 2.1: A low-head micro-hydro installation

Source: Fraenkel et al(1991)

Table 2.1: Classification of hydropower by size

Type of Hydro Power	**Power generated**
Large hydro	More than 100MW and usually feeding into a large electricity grid
Medium hydro	15 – 100MW usually feeding a grid
Small hydro	1 – 15MW usually feeding into a grid
Mini hydro	Above 100kW, but below 1MW; either stand-alone schemes or more often feeding into the grid
Micro hydro	From 5kW up to 100kW; usually provided power for a small community or rural industry in remote areas away from the grid
Pico hydro	From a few hundred watts up to 5kW

Source: S.P Adhau, R.M Moharil, P.G Adhau, (2012)

Hydro power plants also classified based on water- head as under:

Table 2.2: Classification of water head

Head	**Type**
Ultra low head	Below 3 m
Low head	Less than 40 m
Medium/high head	Above 40 m

Source: S.P Adhau, R.M Moharil, P.G Adhau (2012)

To determine the suitable of turbine for micro hydro power, the first thing to known is the head of river. Because from the head of river can determine the turbine using the turbine application chart.

2.2 General Principle of MHP

Power generation from water depends upon a combination of head and flow. Both must be available to produce electricity. Water is diverted from a stream into a pipeline, where it is directed downhill and through the turbine (flow). The vertical drop (head) creates pressure at the bottom end of the pipeline. The pressurized water emerging from the end of the pipe creates the force that drives the turbine. The turbine in turn drives the generator where electrical power is produced. More flow or more head produces more electricity. Electrical power output will always be slightly less than water power input due to turbine and system inefficiencies.

Water pressure or Head is created by the difference in elevation between the water intake and the turbine. Head can be expressed as vertical distance (feet or meters), or as pressure, such as pounds per square inch (psi). Net head is the pressure available at the turbine when water is flowing, which will always be less than the pressure when the water flow is turned off (static head), due to the friction between the water and the pipe. Pipeline diameter also has an effect on net head.

Flow is quantity of water available, and is expressed as ‘volume per unit of time’, such as gallons per minute (gpm), cubic metres per second (m^3/s), or liters per minute (lpm). Design flow is the maximum flow for which the hydro system is designed. It will likely be less than the maximum flow of the stream (especially during the rainy season), more than the minimum flow, and a compromise between potential electrical output and system cost (Singh.D, 2009)

2.3 Power from a MHP

To know the power potential of water in a stream it is necessary to know the flow quantity of water available from the stream (for power generation) and the available head.

The quantity of water available for power generation is the amount of water (in m^3or litres) which can be diverted through an intake into the pipeline (penstock) in a certain amount of time. This is normally expressed in cubic meters per second (m^3/s) or in litres per second (l/s).

Head is the vertical difference in level (in meters) through which the water falls down.

The theoretical power (P) available from a given head of water is in exact proportion to the head and the quantity of water available.

$$P = Q \times H \times e \times 9.81 \text{ Kilowatts (kW)} \tag{1}$$

Where,

P =Power at the generator terminal, in kilowatts (kW)

H =The gross head from the pipeline intake to the tail water in metres (m)

Q =Flow in pipeline, in cubic metres per second (m^3/s)

e =The efficiency of the plant, considering head loss in the pipeline and the efficiency of the turbine and generator, expressed by a decimal (e.g. 85% efficiency= 0.85) 9.81 is a constant and is the product of the density of water and the acceleration due to gravity (g) (Singh D, 2009)

This available power will be converted by the hydro turbine in mechanical power.

2.3.1 The losses in a hydro plant are

Losses in energy caused by flow disturbances at the intake to the pipeline, friction in the pipeline, and further flow disturbances at valves and bends; and loss of power caused by friction and design inefficiencies in the turbine and generator.

The energy losses in the pipeline and at valves and bends are called head losses: they represent the difference between the gross head and the net head that is available at the turbine. The head losses in the pipeline could range from 2 percent to 10 percent of the gross head, depending on the length of the pipeline and the velocity of the flow. The maximum turbine efficiency could range from 80 percent to 95 percent depending on the type of turbine, and the generator efficiency will be about 90 percent.

Usually for design purposes, the head losses can be combined with the losses in the turbine and generator, and an overall plant efficiency of 85 percent (or e = 0.85) can be used. (Singh. D, 2009)

2.4 Component of MHP

2.4.1 Turbine

Turbine is the main piece of equipment in the MHP scheme that converts energy of the falling water into the rotating shaft power. The selection of the most suitable turbine for any particular hydro site depends mainly on two of the site characteristics – head and flow available. All turbines have a power-speed characteristic. This means they will operate most efficiently at a particular speed, head and flow combination. Thus the desired running speed of the generator or the devices being connected/ loading on to the turbine also influence selection. Other important consideration is whether the turbine is expected to generate power at part-flow conditions.

The design speed of a turbine is largely determined by the head under which it operates. Turbines can be classified as high head, medium head or low head machines. They are also typified by the operating principle and can be either impulse or reaction turbines. The basic turbine classification is given in the table below:

Table 2.3: Turbine application

Turbine	**Head (Pressure)**		
	High (30m +)	**Medium**	**Low (<10m)**
Impulse	Pelton Turgo	Cross flow Pelton Turgo	Cross flow
Reaction	-	Francis Pump	Propeller Darius

Source: Singh, D. 2009

Impulse Turbine, which has the least complex design, is most commonly used for high-head micro hydro systems. They rely on the velocity of water to move the turbine wheel, which is called the runner. The most common types of impulse turbines include the Pelton wheel and the Turgo wheel.

Difference between impulse and reaction turbines

The rotating part (called ‘runner’) of a reaction turbine is completely submerged in water and is enclosed in a pressure casing. The runner blades are designed in a manner such that the pressure difference across their surface imposes lift forces (similar to the principle used for airplane wings) which cause the runner to turn/rotate.

The impulse turbine (as the name suggests) on the other hand is never immersed in water but operates in air, driven by a jet (or jets) of water striking its blades. The nozzle of the penstock converts the head of the water (from forebear tank) into a high speed jet that hits the turbine runner blades that deflect the jet so as to utilize the change of momentum of the water and converting this as the force on the blades – enabling it to rotate.

Impulse turbines are usually cheaper than reaction turbines because there is no need for a pressure casing nor for carefully engineered clearances, but they are also only suitable for relatively higher heads.

1. Pelton turbine

Pelton wheel used the concept of jet force to create energy. Water is funnelled into a pressurized pipeline with a narrow nozzle at one end. The water spray out of the nozzle in a jet, striking the double-cupped buckets attached to the wheel. The impact of the jet spray on the curved buckets creates a force that rotates the wheel at high efficiency rate of 70-90%. Pelton wheel turbines are available in various sizes and operate best under low-flow and high-head condition.

Figure 2.2: Pelton Turbine

2. Turgo turbine

Turgo impulse wheels an upgraded version of the Pelton. It uses the same jet spray concept, but the Turgo jet, which is half the size of the Pelton, is angled so that the spray hits three buckets at once. As a result, the Turgo wheel moves twice as fast. It's also less bulky, needs few or no gears, and has a good reputation for trouble-free operations. The Turgo can operate under low-flow conditions but requires a medium or high head.

Figure 2.3: Turgo Turbine

3. Cross flow turbine

Cross flow turbine is widely considered by many to be the most efficient and apt type of turbine for application in micro hydro projects. Also called a Michell-Banki turbine a cross flow turbine has a drum-shaped runner consisting of two parallel discs connected together near their rims by a series of curved blades. A cross flow turbine always has its runner shaft horizontal (unlike Pelton and Turgo turbines which can have either horizontal or vertical shaft orientation).

Unlike most water turbines, which have axial or radial flows, in a cross flow turbine the water passes through the turbine transversely, or across the turbine blades. As with a waterwheel, water enters at the turbine's edge. After passing the runner, it leaves on the opposite side. Going through the runner twice provides additional efficiency. When the water leaves the runner, it also helps clean the runner of small debris and pollution. The cross-flow turbines generally operate at low speeds.

The turbine consists of a cylindrical water wheel or runner with a horizontal shaft, composed of numerous blades (up to 37), arranged radially and tangentially. The edges of the blades are sharpened to reduce resistance to the flow of water. A blade is made in a part-circular cross-section (pipe cutover its whole length). The ends of the blades are welded to disks to form a cage like a hamster cage and are sometimes called "squirrel cage turbines"; instead of the bars, the turbine has trough-shaped steel blades.

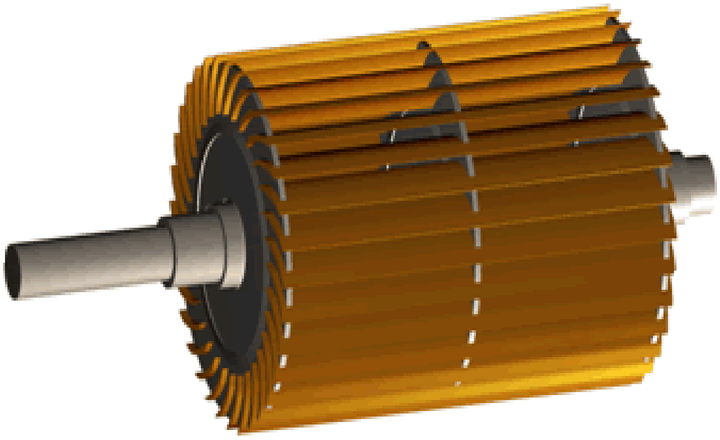


Figure 2.4: Cross Flow Turbine

Source: Joe Cole. *Crossflow Turbine Abstract.*

Reaction Turbine

Reaction Turbine are acted on by water, which changes pressure as it moves through the turbine and gives up its energy. They must be encased to contain the water pressure (or suction), or they must be fully submerged in the water flow.

The more popular reaction turbines are the Francis turbine and the propeller turbine. Kaplan turbine is a unique design of the propeller turbine. Given the same head and flow conditions, reaction turbines rotate faster than impulse turbines. This high specific speed makes it possible for a reaction turbine to be coupled directly to an alternator without requiring a speed-increasing drive system. This specific feature enables simplicity (less maintenance) and cost savings in the hydro scheme. The Francis turbine is suitable for medium heads, while the propeller is more suitable for low heads.

The reaction turbines require more sophisticated fabrication than impulse turbines because they involve the use of larger and more intricately profiled blades together with carefully profiled casings. The higher costs are often offset by high efficiency and the advantages of high running speeds at low heads from relatively compact machines. Expertise and precision required during fabrication make these turbines less attractive for use in micro-hydro in developing countries. Most reaction turbines tend to have poor part-flow efficiency characteristics.

4. Francis turbine

The Francis turbine is a reaction turbine where water changes pressure as it moves through the turbine, transferring its energy. A watertight casement is needed to contain the water flow. Generally such turbines are suitable for sites such as dams where they are located between the high pressure water source and the low pressure water exit.

Figure 2.5 Francis Turbine

The inlet of a Francis turbine is spiral shaped. Guide vanes direct the water tangentially to the turbine runner. This radial flow acts on the runner's vanes, causing the runner to spin. The guide vanes (or wicket gate) are adjustable to allow efficient turbine operation for a wide range of flow conditions. As the water moves through the runner, it’s spinning radius decreases, further delivering pressure acting on the runner. This, in addition to the pressure within the water, is the basic principle on which the Francis turbine operates. While exiting the turbine, water acts on cup shaped runner buckets leaving without any turbulence or swirl and hence almost all of the kinetic or potential energy is transferred. The turbine's exit tube is shaped to help decelerate the water flow and recover the pressure.


Figure 2.6: Francis turbine blade

5. Propeller turbine

Propeller turbine is lowered into the water and held into place with a steady mount (not include). Power output is directly related to water speed and at a flow of 6mph output will be around 60W, while at a flow of 9mph power generation will increased to 100w.

Figure 2.7: Propeller Turbine

Source: ABS Alaskan.2008

6. Kaplan turbine

Kaplan turbine is basically a propeller with adjustable blade inside a tube. It is an axial-flow turbine, which means that the flow direction not change as it crosses the rotor. Depending on the position of the inlet guide-vanes they introduce differing amount of 'swirl' to the flow and ensure that the water hits the rotor at the most efficient angle for the highest efficiency. The rotor blade pitch is also adjustable, from a flat profile for very low flows to a heavily pitched profile for high flow (see figure 2.8). This adjustability of both inlet guide-vanes and rotor blades means that the flow operating range is very wide (a Characteristic from the inlet guide-vane) and the turbine efficiency is high and the efficiency curve very flat (a Characteristic from the adjustable rotor blades allowing optimum alignment of the blade to the oncoming flow).

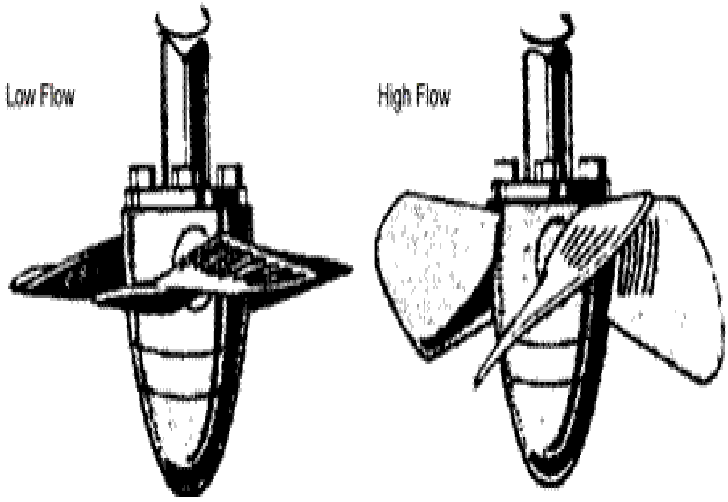


Figure 2.8: Kaplan Turbine

Source: Renewables First. 2010

There are variants of Kaplan Turbines that only have adjustable inlet guide-vanes or adjustable rotor blades, which are known as semi-Kaplan. Although the performance of semi- Kaplan's is compromised when operating across a wide flow range, for applications where the flow does not vary much they can be a more cost-effective choice. Figure 2.9 below shows how the efficiency various across the operating flow range for a full-Kaplan (curve A), a semi-Kaplan with adjustable blades (curve B) and a semi-Kaplan with adjustable inlet guide-vanes (curve D), It also shows the efficiency curve for a propeller turbine a Kaplan with fixed blades and fixed inlet guide-vanes (curve C).

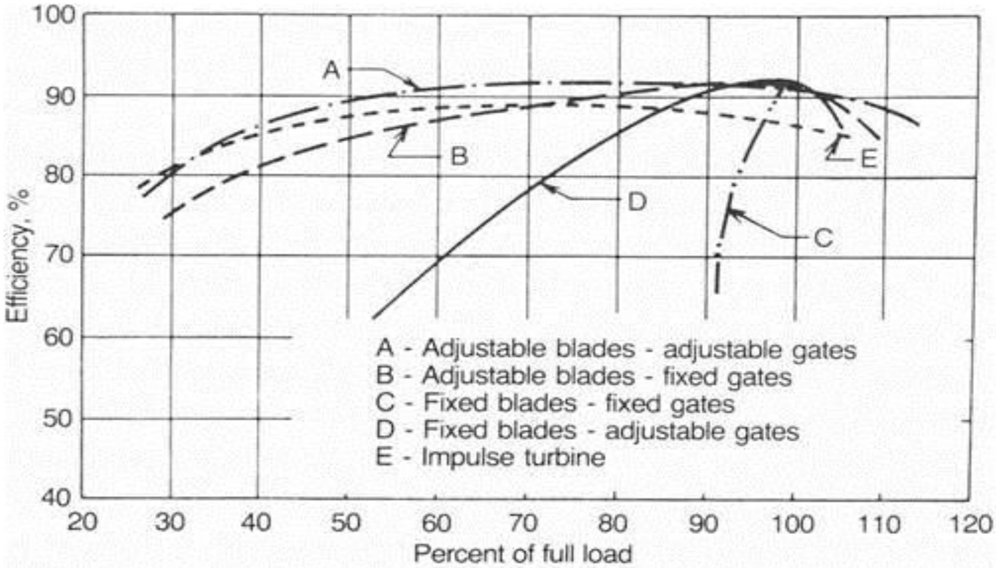


Figure 2.9: Kaplan turbine efficiency curve comparison

Source: Renewables First. 2010

2.4.2 Generator

A device that converts mechanical energy to electrical energy is known as a generator. A generator is similar to that of a water pump. A generator also creates flow of changes through its wires but does not create electricity. Sample generators are shown in figure 2.12. In most cases the source of mechanical energy required for the functioning a generator comes from:

- Water falling from a height through a turbine
- A wind turbine
- An internal combustion engine
- Compressed air.

Generator are divided into two major categories depending upon the source of current i.e. Alternating Current (AC) and Direct current (DC). Through the basic working principles of both these generators are similar, they differ in construction. These machines are also classified on the basis of the mechanical energy by which they are powered, like water of stream power.

If a coil of wire, kept in a magnetic field and connected to a galvanometer, is rotated then current will be induced within the coil. When current gets induced the galvanometer shows deflection. Factor on which the magnitude of induced current depends are:

- Strength of the magnetic field
- Length of the coil.
- Velocity with which the coil rotates within the field.

The main idea behind the rotation of the coil is to make it in motion with respect to the magnetic field. Although in most cases, DC generators have a stationary magnetic field and a rotating coil and vice-versa for AC generators.

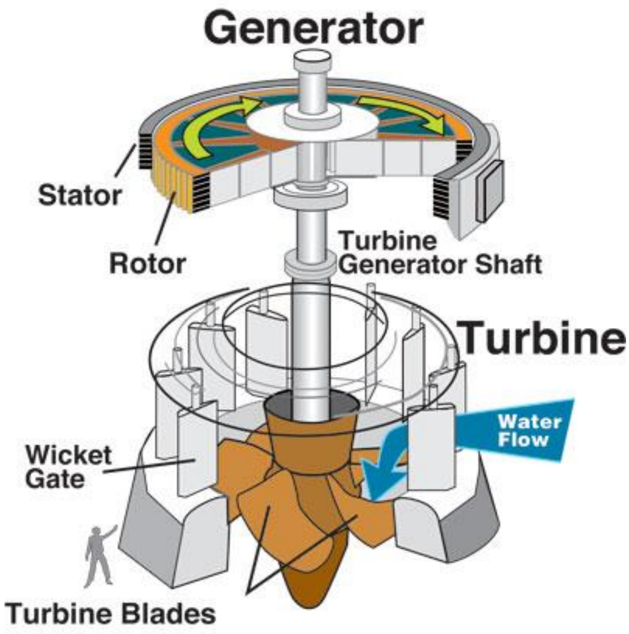


Figure 2.10 Working System of Generator

Source: Ahmad Kamal. A.M, 2010

For an electric generator, the galvanometer gets replaced by some electrical device. The electric power produced by the generator changes constantly as the coil moves through the magnetic field. Initially the induced current moves in single direction. When the coil becomes parallel to the magnetic lines of forces, the current produced is zero. Thereafter, the lines of forces are cut in the opposite direction by the coil as it continues to rotate. Hence, the generated current also flows in the opposite direction. Now, as a result, a rotating coil in a fixed magnetic field of this type will produce alternating current. This type of current travels in one direction for a moment and then the opposite direction at next moment. Alternating current is used in most household appliances. Keeping a soft iron core inside the coil of wire can increase the efficiency of a generator. Longer the wire greater will be the efficiency.

Direct current electricity can be produced by modifying an AC generator. A commutator helps in doing the needful. A commutator basically is a half cut slip from one half of the commutator to the other when the direction of the current in the coil reverses. They are arranged in a manner to make the slip easy. As a result of which external circuit current always flow in the same direction making it a direct current. (Ahmad Kamal. A.M, 2010)

2.5 ADVANTAGE AND DISADVANTAGE OF MHP

Hydropower is very clean source of energy. It does not consume but only uses the water, after used for hydro power it is available for other purposes (although on a lower horizontal level). The conversion of the potential energy of water into mechanical energy is a technology with a high efficiency (in most cases double that of convention thermal power stations).

The use of hydropower can make a contribution to savings on exhaustible energy sources. Each 600kW of electricity generated with a hydro plant is equivalent to 1 barrel of oil (assuming an efficiency of 38% for the conversion of oil into electricity) (Wim Klunne, 2007)

2.5.1 Advantage of Micro Hydro

The first advantage is micro hydro can deliver the best bang per buck when it comes to providing electrical service from renewable energy. Significant power can be generated with flows of two gallons per minute. Or from drops as small as two feed, and power can be delivered, in a cost effective fashion, a mile or more from where it is generated to where it is being used.

Clean energy source: Hydropower does not produce greenhouse gas emissions, which are the major cause of the international concerns about environmental problems: Hydroelectricity does not involve a process of combustion, therefore it avoids polluting emissions like carbon dioxide (responsible for global warming) that otherwise would be produced by conventional energy when burning fossil fuels. MHP is a clean energy source (it does not produce waste in the rivers, or air pollutions) and renewable (the fuel for hydropower is water, which is not consumed in the electricity generation process)

Efficient energy source: It only takes a small amount of flow (as little as two gallons per minute) or a drop as low as two feet to generate electricity with micro hydro. Since MHP is a decentralised energy source located close to the consumers, transmission losses can be reduced. Although electricity can be delivered as far as a mile away to the location where it is being used.

Reliable electricity source: Hydro produces a continuous supply of electrical energy in comparison to other small-scale renewable technologies. The peak energy season is during the winter months when large quantities of electricity are required. Power is usually continuously available on demand and the energy available is predictable.

No reservoir required: Micro hydro is considered to function as a ‘run-of-river’ system, meaning that the water passing through the generator is directed back into the stream with relatively minimal or no impact on the surrounding ecology.

Power for developing countries: Because of the low-cost versatility and longevity of micro hydro, developing countries can manufacture and implement the technology to help supply much needed electricity to small communities and remote villages. No fuel and limited maintenance are required, so running costs are low (compared with diesel power). Localized power can be utilized for the benefit of the local economy.

2.5.2 Disadvantage of Micro Hydro

Site specific technology: In order to take full advantage of the electrical potential of small streams, a suitable site is needed. Factors to consider are: distance from the power source to the location where energy is required (this is not very common to find), stream size (including flow rate, output and drop), and a balance of system components — inverter, batteries, controller, transmission line and pipelines.

Energy expansion not possible: There is always a maximum useful power output (size and flow from small streams for example) available from a given hydropower site, which limits the increase in power generation and the level of expansion of activities which can make use of the power.

Seasonal variations: In many locations the flow in a stream fluctuates seasonally and this can limit the firm power output to quite a small fraction of the possible peak output. During summer months there is likely to be less flow and therefore less power output. Advanced planning and investigations are needed to ensure adequate energy generation and power demands are met.

Environmental and ecological concerns: MHP, like any energy-production activity, has impacts on the local ecosystem (on the quality of river and river ecosystems, noise, landscape). However, new legislative frameworks, innovative technology, improved methods of operating MHP and above all the willingness of all actors to integrate environmental concerns are steadily reducing these local environmental impacts. MHP plants, if well equipped, with fish ladders and environmentally friendly runner blades, are not an obstacle even for fish migration. (Singh. D. 2009)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In doing this project there are several steps that need to do. The first step is site visit at Sungai Pahang, Pekan. After that, find the data. Next design the turbine and lastly do the simulation. The simulation is to know the power produced.

3.2 SITE VISIT

This project has done at Sungai Pahang, at the bridge that connecting Pekan town and the village at Kuala Pahang.

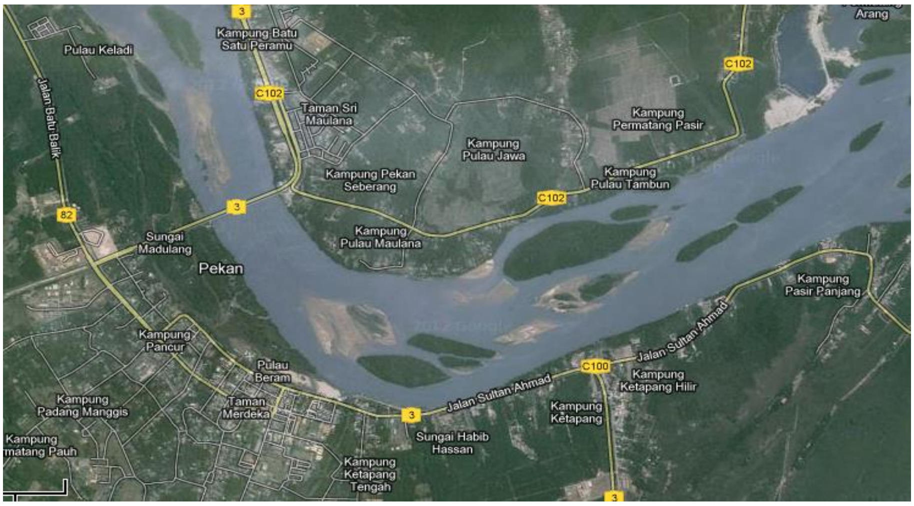
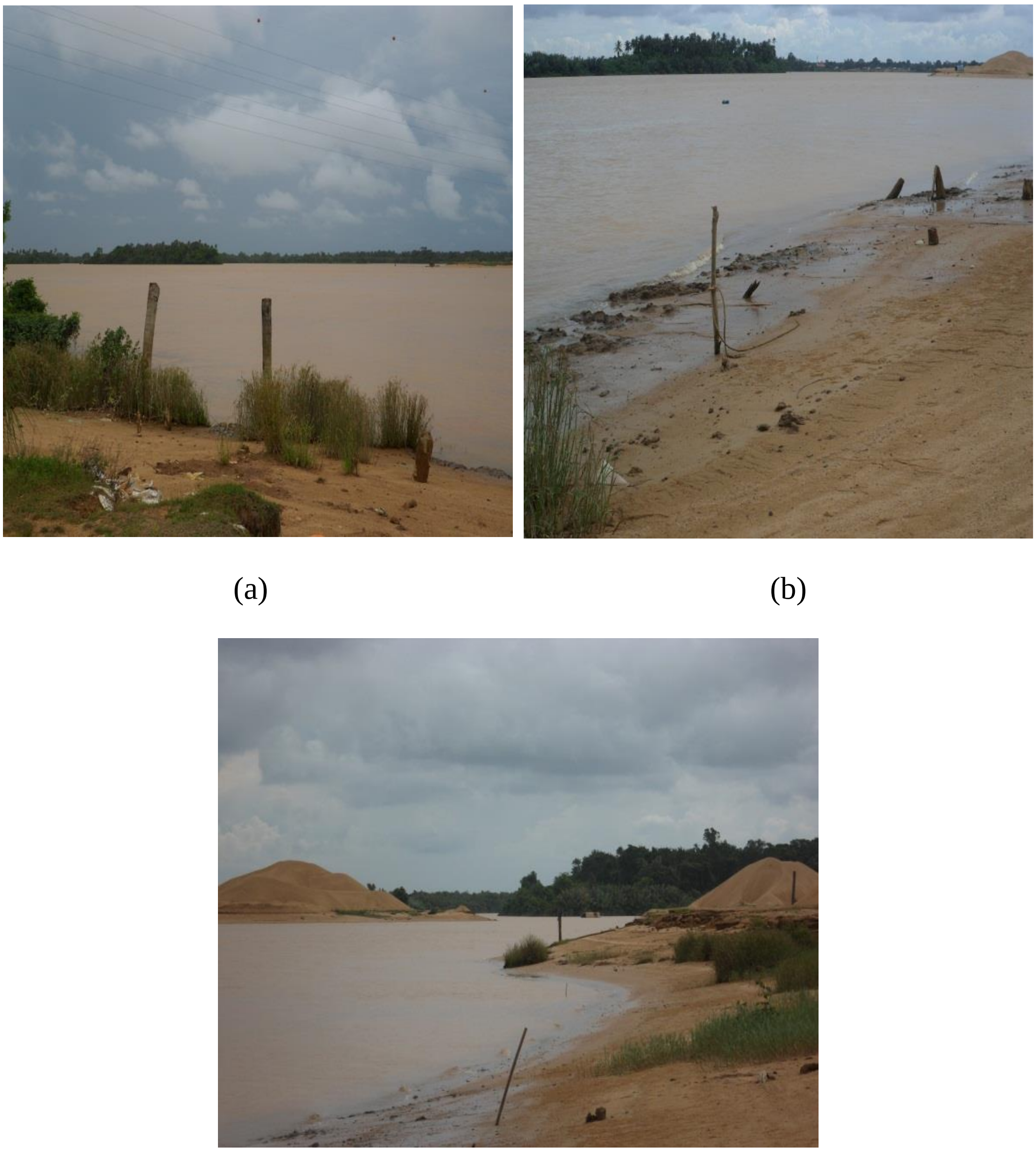


Figure 3.1: Sungai Pahang

The figure above shows a part of Sungai Pahang, there are two different place that have been see but only one place is suitable for this Micro Hydro Power.



(a) (b)

(c)

Figure 3.2: Sungai Pahang near to Kampung Pulau Tambun

Kampung Pulau Tambun is 8 km from UMP Pekan Campus. This village are near to the Sungai Pahang. The river for this village is not suitable for the Micro Hydro Power because some of reason. In the Figure 3.2 (a) it is to near to the electric substation. Next in Figure 3.2 (b), the sand at side of river is sludge. And the last Figure 3.2 (c) is the sand mining. It will cause of sedimentation in the river.

The factors that affect the Micro Hydro Power are the sludge and sand sedimentation, where it will affect the blade of turbine and the flow of water. In this case also affect the head (height) of the river. All the factor will interfere the velocity of the river.

(a)

(b)

(c)

Figure 3.3: Near to Pekan bridge

Figure above is close to Pekan Bridge. It is about 11km from UMP Pekan Campus. Figure (a) and (b) are taken from the village side. And the Figure (c) is taken from Pekan Town side. At this place, the flow of water are good not have any disruption like at river near to Kampung Pulau Tambun.

3.2.1 Potential of Micro hydro power

From the site visit that has done, there is not having the rubbish in the river that can affect the turbine when we do the project there. And there is no sediment at that place.

The site visit has done because to make sure the place is suitable or not. Because there have some point that we need to take serous, like the geographical factor. Geographical factor is like the river shape or size and the height of river. Other than that, need to know the water contaminator. The water contaminator includes the ecosystem in river, rubbish and others.

Also the main part to know in the site visit is to know the fluid flow at the river. The fluid flow can know using experimental or take from Jabatan Pengairan dan Saliran (JPS). In this project the data have been taking from JPS, the data had been taken is the velocity of river for year 2013 is 2.4667 m/s.

The conclusion from the site visit is the place that choose is suitable for apply the micro hydro power. So, the suitable place to make the Micro Hydro Power is Near to Pekan Bridge. It is because when consider about the geographical factor, water contains and water flow, river near to the Pekan Bridge is more suitable.

3.3 DATA COLLECTION

From the data that have from the site visit. Now need to choose the suitable turbine for micro hydro power.

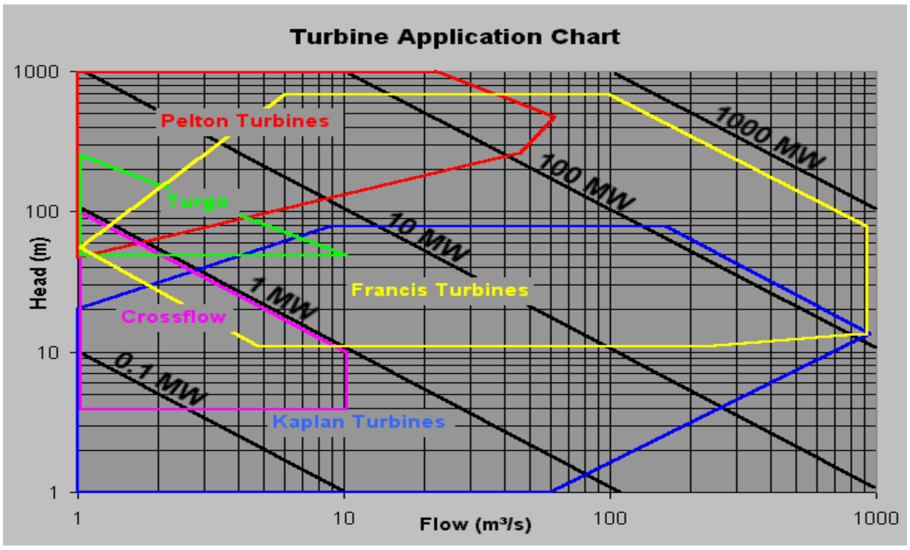


Figure 3.4: Turbine Application Chart

From the Figure 3.4 we can determine the suitable turbine that can use. The power that can produce for Micro hydro power is 5kw until 100kw. From this chart the suitable turbine that can use is Kaplan and Cross flow turbine. And there is other one turbine that will use, it is tidal turbine. Tidal turbine usually used in ocean. But it will try that is suitable or not that turbine used in river. At New York City at East River. The project is in construction that have been started 2006 and finish at 2015.

3.3.1 Propeller Turbine

The primary purpose of turbine is to function as the prime mover providing direct horsepower to the generator. It is the most significant system in a hydro unit. How the turbine is designed, operated and maintained provides the most impact to the efficiency, performance, and reliability of hydro unit. The propeller type turbine is typically used in a low head and high flow application. Fixed blade propeller types have a very narrow range of high efficiency operation.

Figure3.5 : Propeller turbine

3.3.2 Tidal Turbine

Tidal power is also one of the renewable energy and this technology is also known as hydro power. Tidal strength of water and back forth movement in seas, rivers or oceans. Tidal power exploits kinetic energy of water and back and forth movements in movement between the wings which rotate the turbine to produce electricity. (NRCan's, 2004)

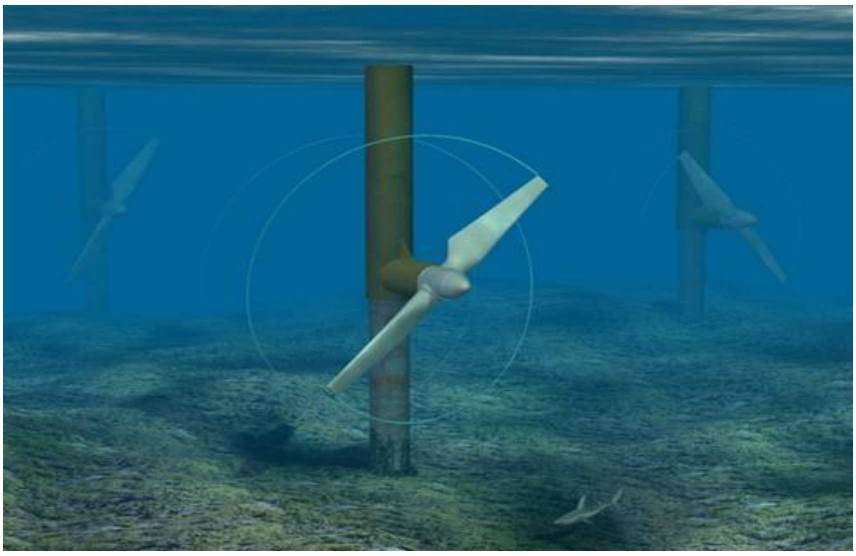


Figure 3.6: Tidal Turbine

3.4 DESIGN OF TURBINE

Every turbine has the different design and dimension. To get the good or the quality of turbine it must have a good part where every parts of the turbine have their own specification. In this project the diameter and material of turbine will be same.

3.4.1 Flow chart for turbine design

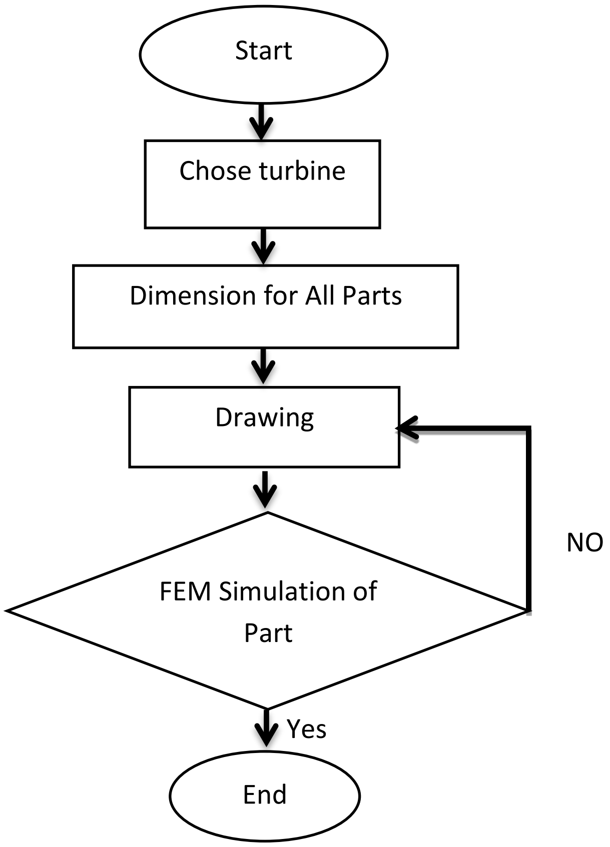


Figure 3.7: Flow chart for turbine design

All the drawing of the turbine is using SolidWorks 2012. It is because SolidWorks can be transfer into ANSYS. To draw the cross flow turbine there are some journals that have refer.

The suitable material must use for the turbine because to make sure the life time of the turbine are more longer compared before this. The suitable for this turbine is stainless still.

3.4.2 Design of turbine

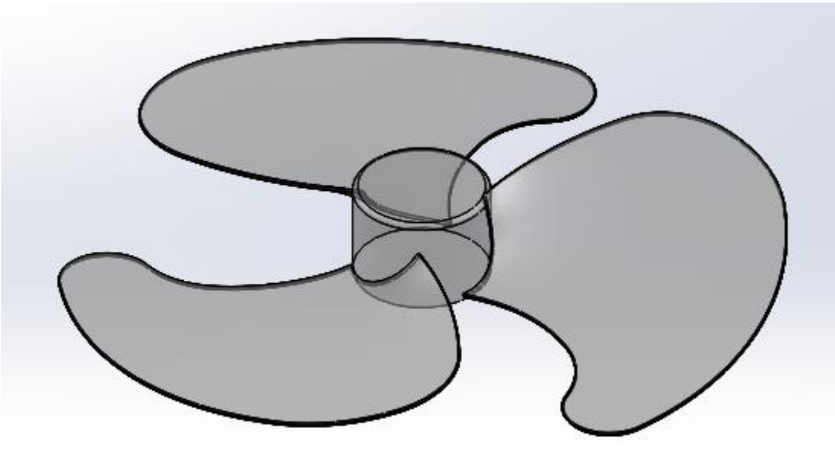


Figure 3.8: Model Propeller turbine

Diameter of the blade is 0.5 m and 0.07 m height. The blade has three blades that are same distance of each other.

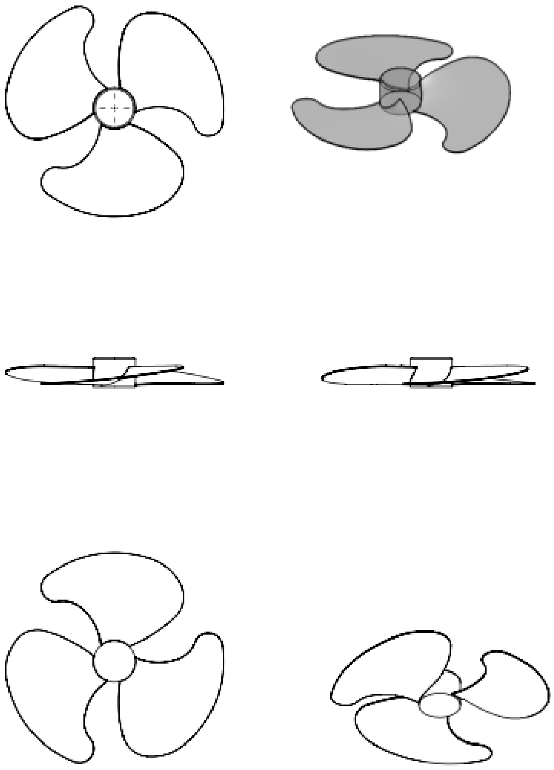


Figure 3.9: Isometric view for Propeller turbine

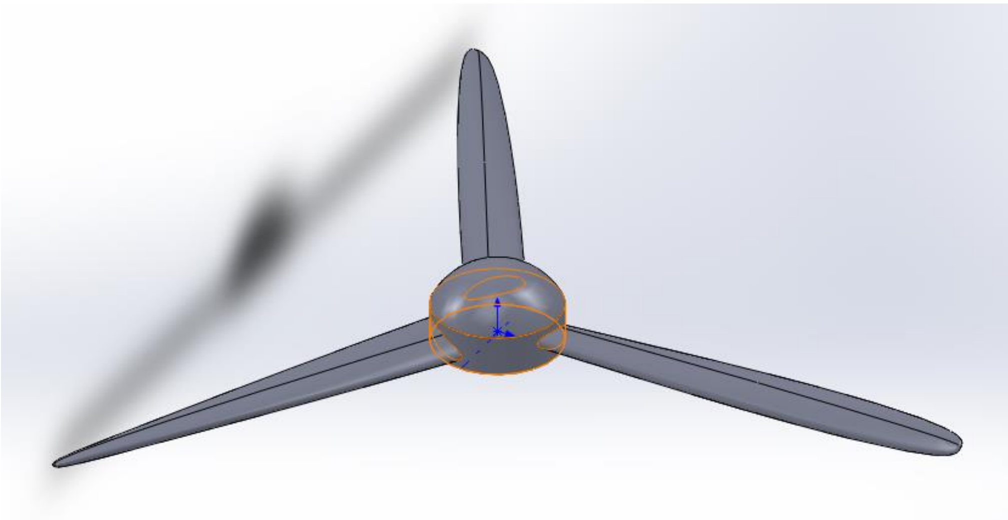


Figure 3.10: Tidal turbine model

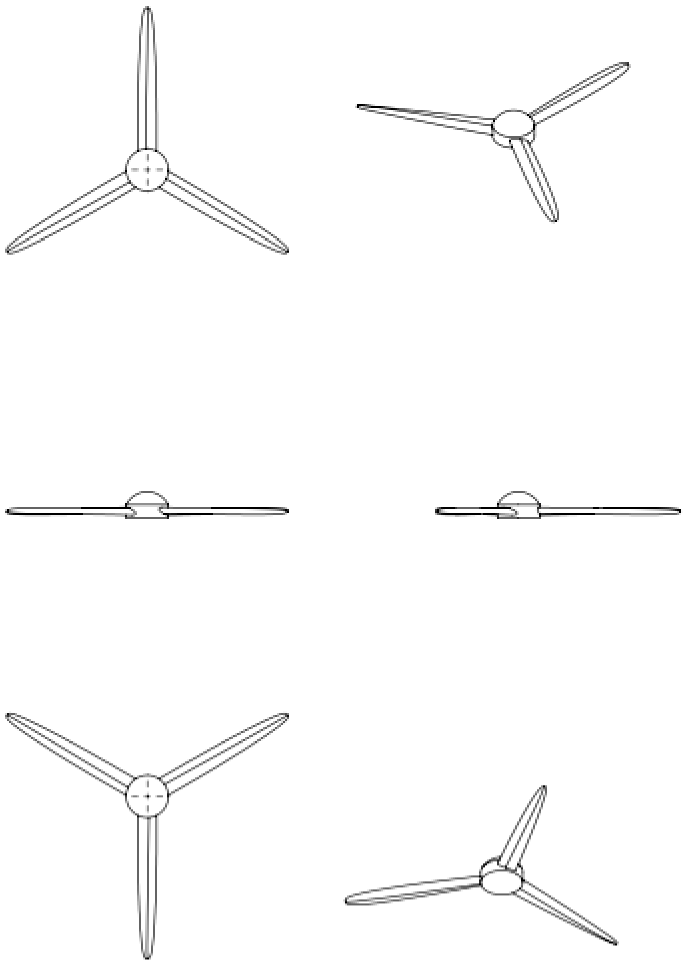


Figure 3.11: Isometric view for tidal turbine

3.5 SIMULATION OF MHP

The software that used in this project is ANSYS CFX.

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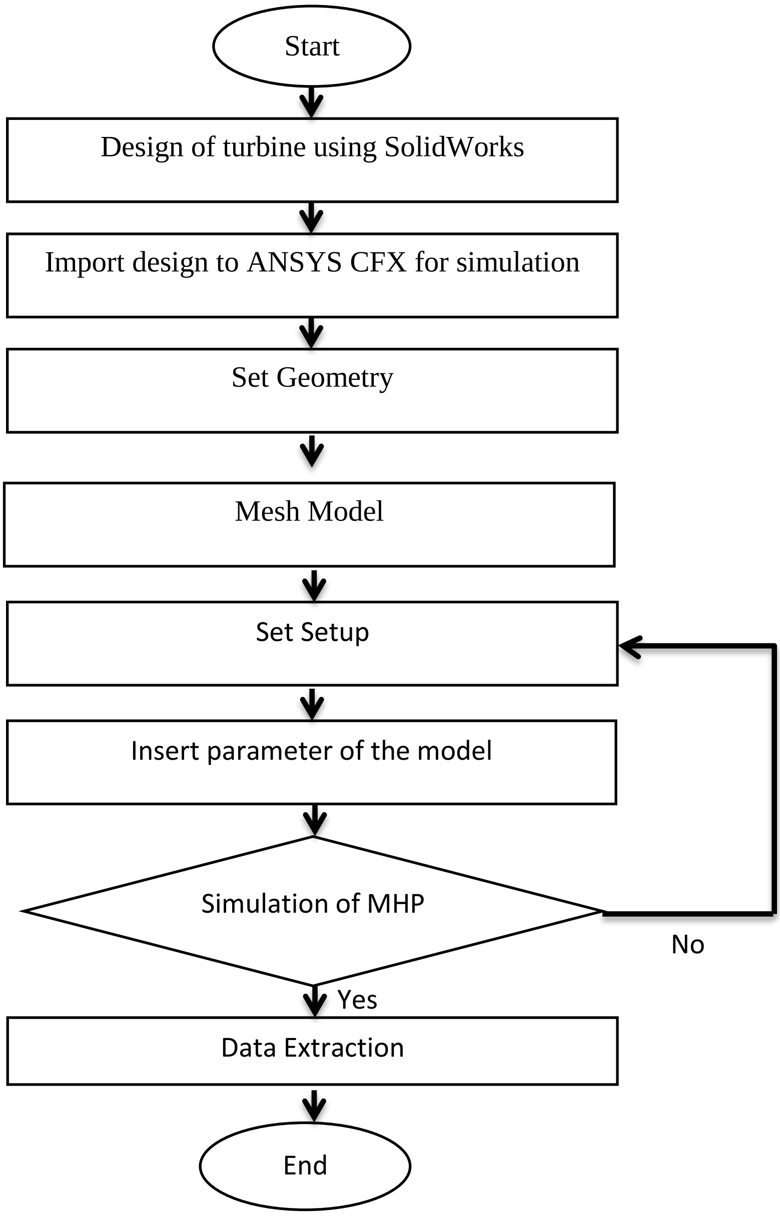


Figure 3.12: Flow chart for simulation

3.6 SETUP OF ANSYS CFX

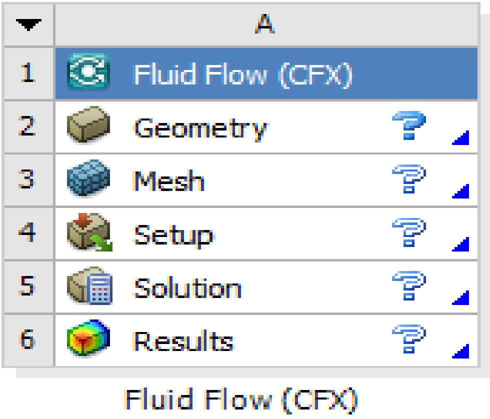


Figure 3.13: Setup for CFX

This is the first thing when click the CFX ANSYS Workbench. In have five step to complete the ANSYS CFX. First is Geometry, second is Mesh, next is Setup, then Solution and lastly is Result.

3.6.1. Geometry

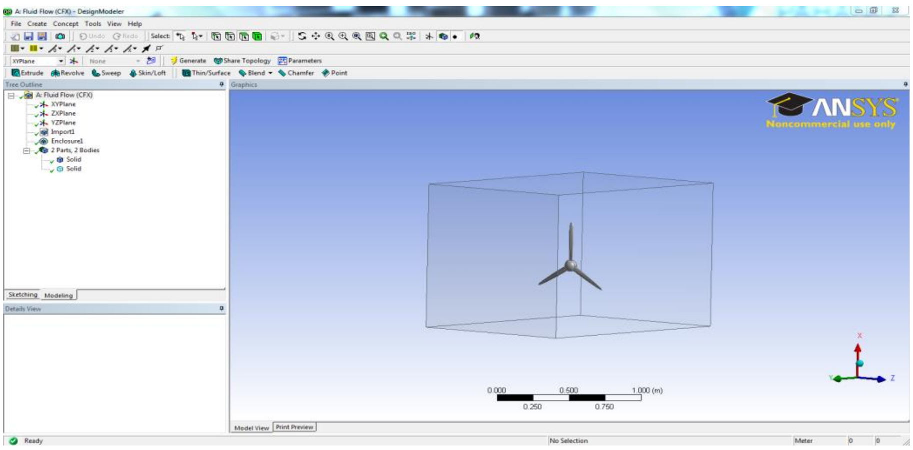


Figure 3.14: Geometry

In this setup, need to import the geometry file. The file is in IGES format. If the file is in other file it will be error when run the result.

3.6.2 Meshing

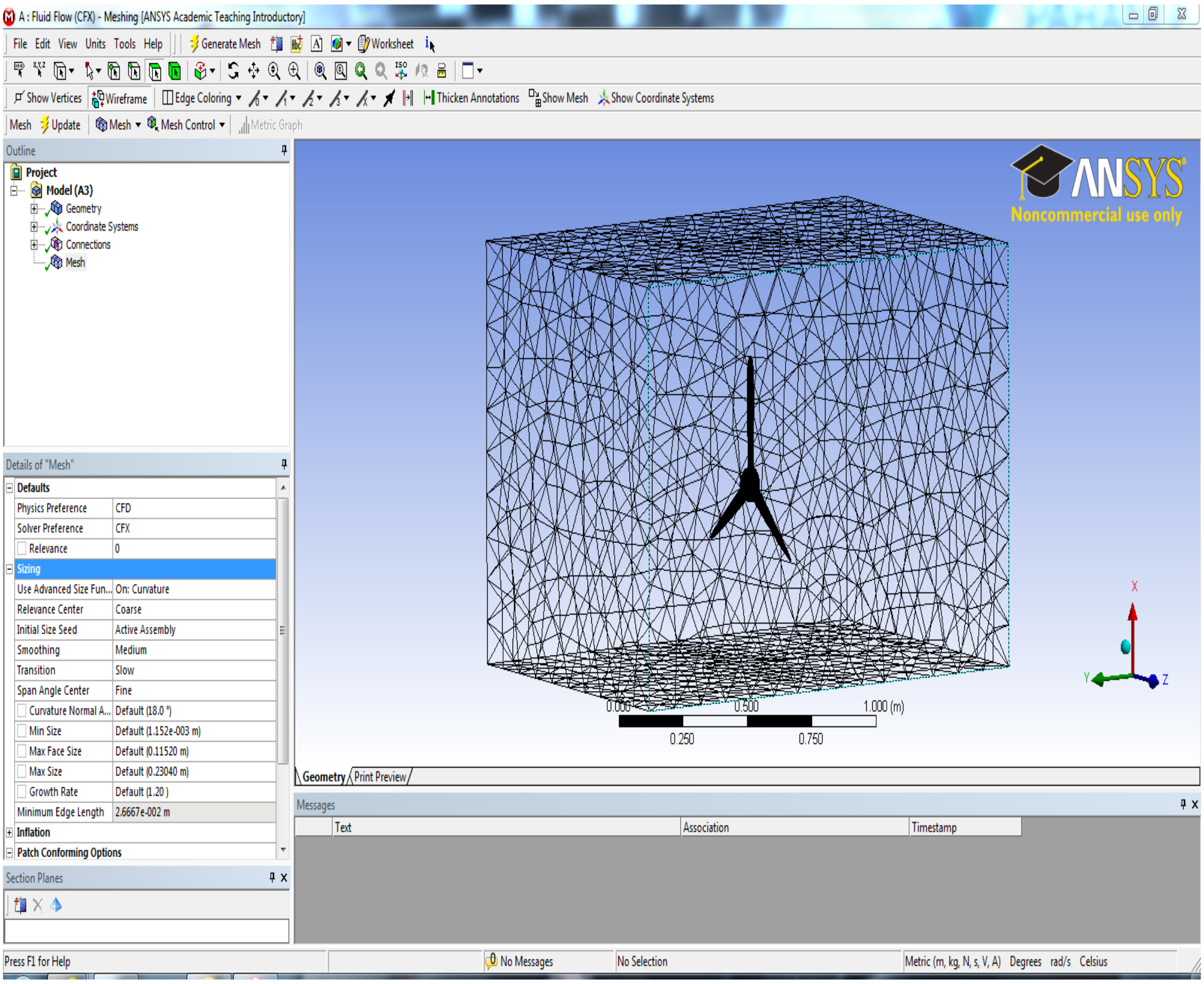
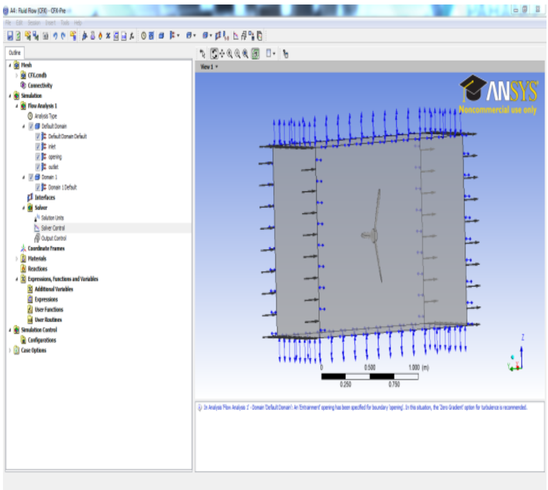


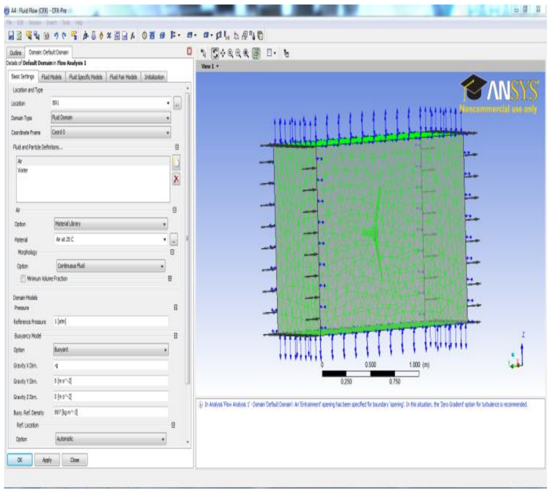
Figure 3.15: Mesh

In mesh process, need to choose the sizing to make sure the size is suitable to the size of geometry.

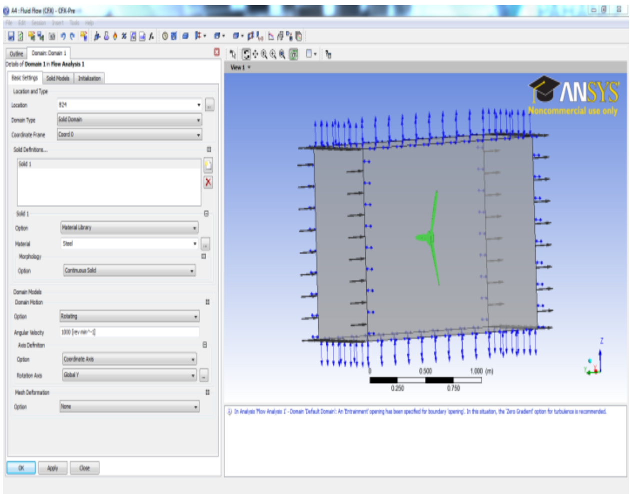
3.6.3 Setup



(a) Boundary



(b) Water



(c)Turbine

Figure 3.16: Setup(a) Boundary (b) Water (c) Turbine

The figure (a) is the first view when click the setup. In the setup, need to insert the velocity of turbine and properties of the system. At the setup, need to insert the boundary and domain. In the figure (b) is the water part setup, need to insert the properties of water, where the water part are contain water and air. Then setup the velocity of water is 2.4667 m/s at the inlet. The figure (c) is for turbine setup.

3.6.4 Solution

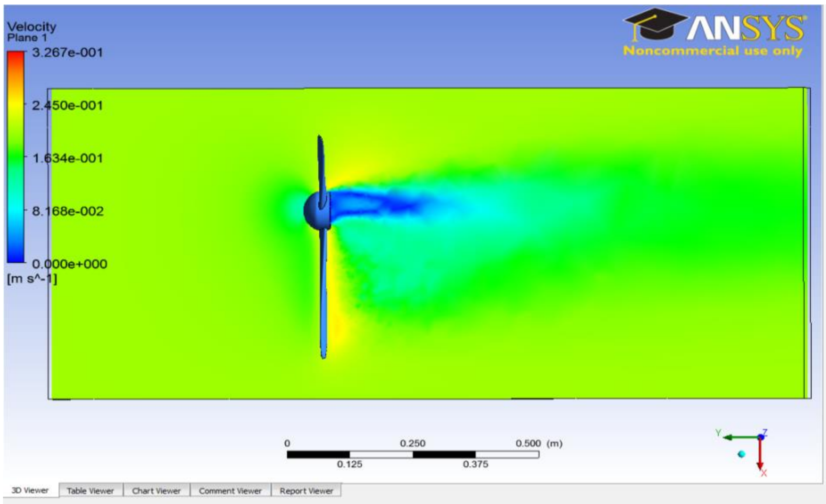


Figure 3.12: Solution in Plane

In the solution part, there are many choice that can chose like, streamline, plane, vector, contour and other. This is the results that want to appear. Other than this, can view the chart, graph, and data of the simulation.

3.7 MEASURE THE POWER OUTPUT

Powers are measure from calculation. And the data are got from the simulation and some of the book or journals.

$$P = \rho g h Q \eta$$

P = Power

ρ = density of water

g = Gravitational constant

Q = volume flow rate

η= efficiency of turbine

h= head of river

$P = \tau\omega$

τ= torque

ω= angular velocity

$$Q = vA$$

v=velocity of flow
A=area

$$T = Fr$$

F= force
R=radius

Source: Yunus A. Cengel, John M. Cimbala,2010

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

From the result obtain ANSYS (CFX), the parameters output Propeller turbine and Tidal turbine is observed. The result is obtain when the water impact the Propeller turbine and Tidal turbine. The data is from the analysis flow, and then compared the suitable turbine.

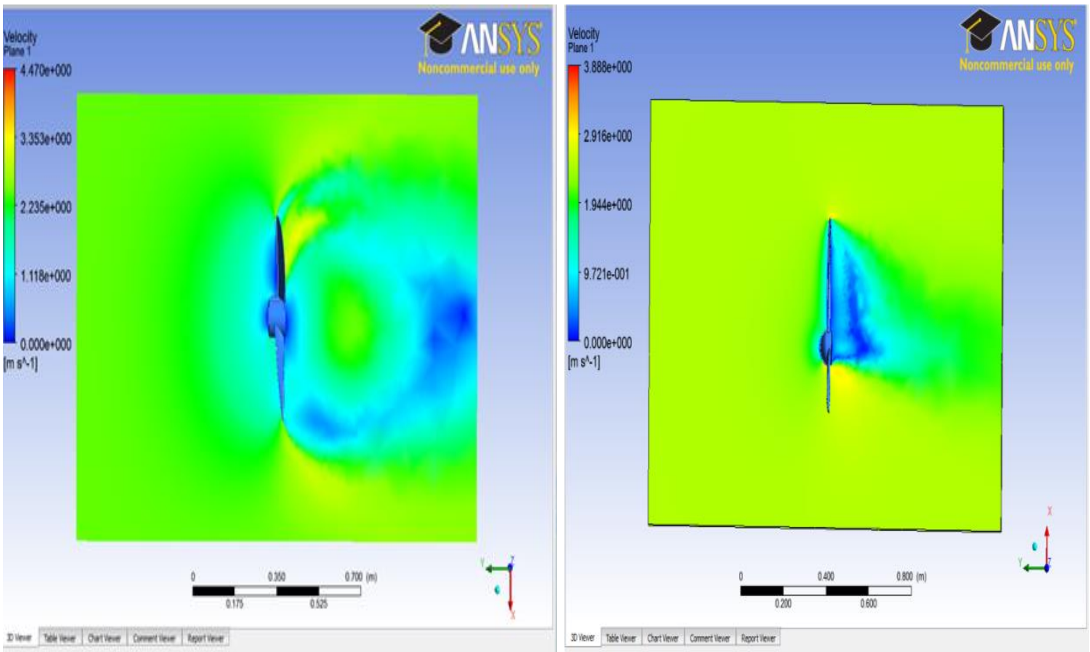
The velocity of the water is taken from *Jabatan Pengairan dan Saliran (JPS)* Pahang. The design of the blade size will affect the value of force and torque of each turbine. On the other hand, the power output and the efficiency of the turbine are also affected. The comparisons are made according to the data obtained from the simulation.

All the simulations are done successfully produced the force applied, velocity and torque on the propeller and tidal turbine.

4.2 SIMULATION RESULT

4.2.1 CFX Simulation Result

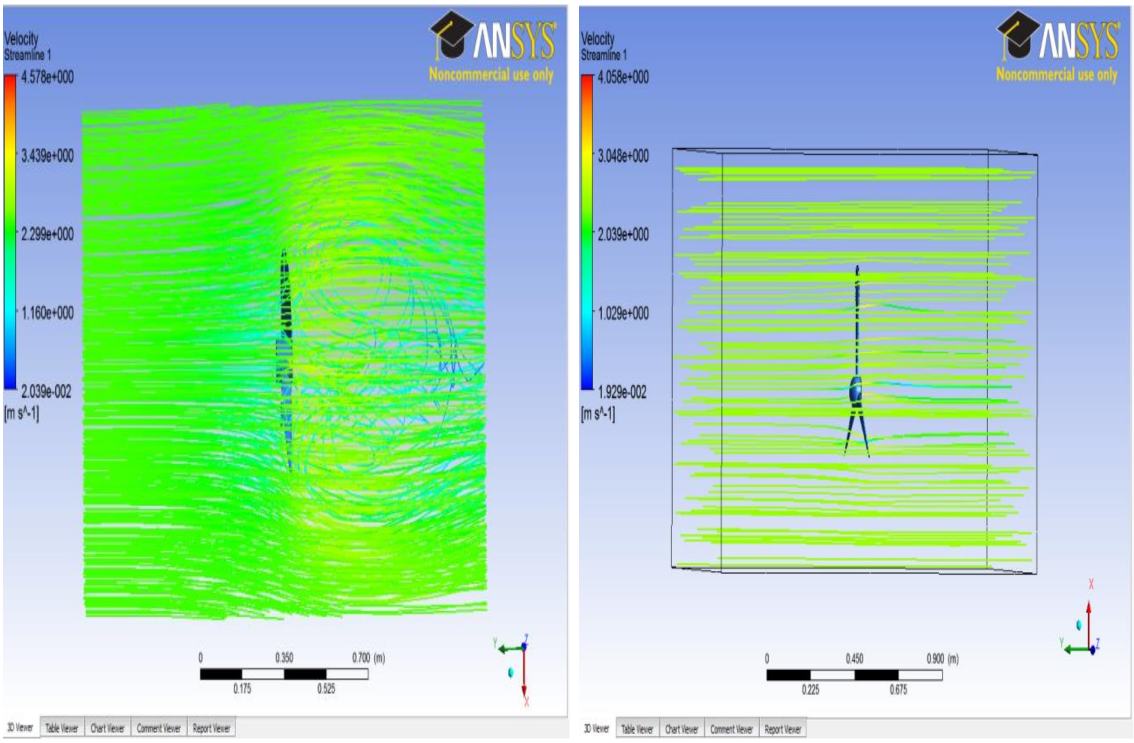
The visualization of water flow through the blade is shown. The water re pass through the blade and act as potential energy and kinetic energy. The speed of water through the blade is 2.4667 m/s.



(a) Propeller (b) Tidal

Figure 4.1: Plane XY axis (a) Propeller Turbine (b) Tidal turbine

Figure above is the result using plane. The plane is for velocity. It is the side view of the simulation. In the simulation can see the velocity of water is increase after pass through the turbine. And the water behind the turbine becomes turbulence. Some of the velocities behind the turbine are height and some of it low.



(a) Propeller (b) Tidal

Figure 4.2: Stream line

Figure above show the streamline of velocity. In the streamline can see the part of the turbulence wave. After pass through the turbine the water become turning effect of the water movement.

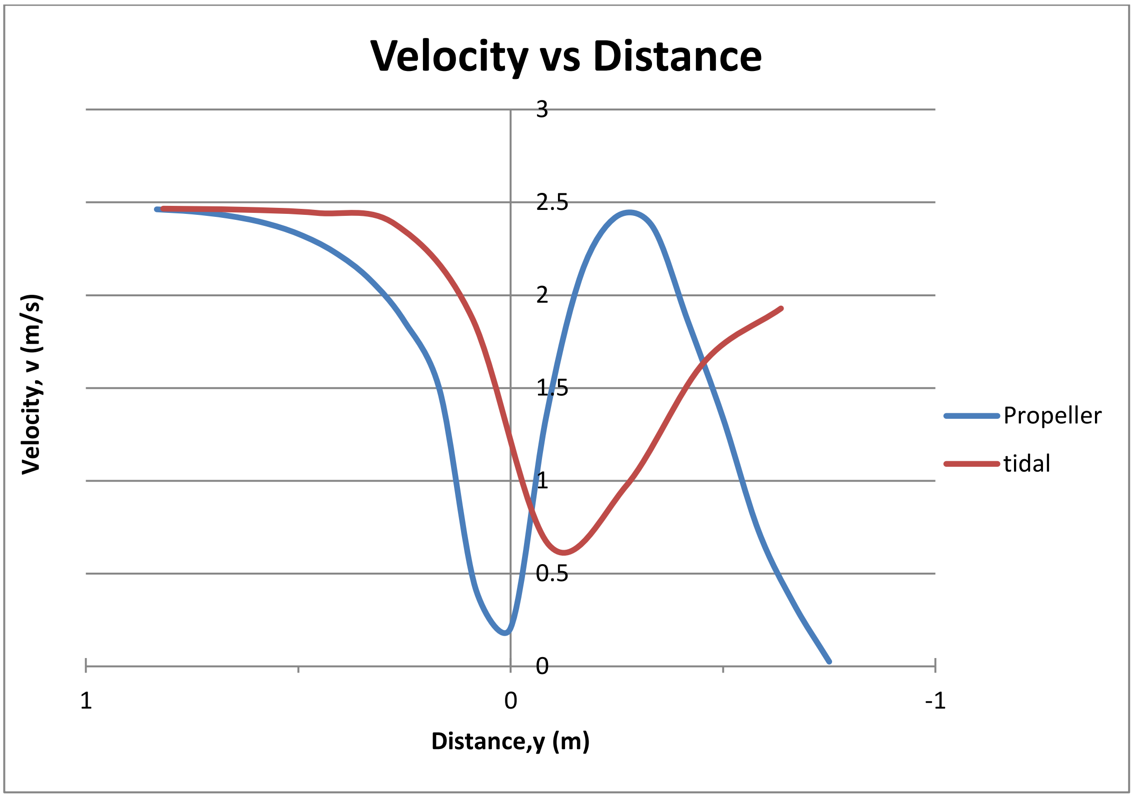


Figure 4.3: velocity in line

Figure above shown the velocity in the one line. The starting point x,y,z (0,1,0) and end at point (0,-1,0). The velocity decrease before hit the turbine and increase again after pass through the turbine. For propeller turbine the velocity increase and decrease and reach zero at a last point. It is because the velocity is reach at breakpoint. But for tidal the velocity is increase after the turbine.

4.2.2 Data of Performance Micro Hydro Power

Table 4.1: Data of simulation

MHP	Propeller	Tidal
Total Torque, τ (Nm)	17.295	11.901
Total Force, F (N)	-614.12	-114.22

From the data that get from the simulation. The power that generate can be determine by using formula and some assumption. In this project need to assume the value of angular velocity, ω.

Table 4.2: Performance of Micro Hydro Power

MHP	**Propeller**		**Tidal**	
ω(RPM)	**P(W)**	**η (%)**	**P (W)**	**η(%)**
100	181.28	12.31	124.63	8.473
200	362.27	24.63	249.25	16.96
300	543.34	36.94	373.88	25.42
400	724.45	49.25	498.47	33.89
500	905.57	61.5	623.08	42.36
600	1086.67	73.87	747.70	50.8
700	1267.93	86.2	872.32	59.3
800	1448.9	98.5	996.93	67.78
900	1630.20	110.8	1121.55	76.25
1000	1811.13	123.1	1246.17	84.72

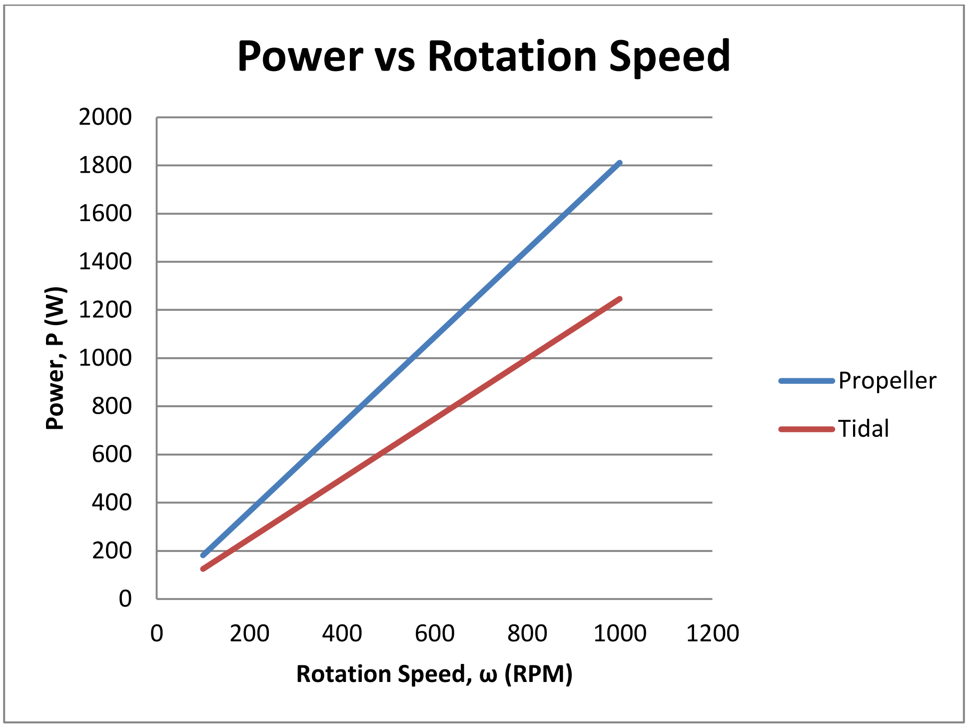


Figure 4.4: Graph of power vs rotation speed

From the figure above, the power are increases when the rotations of speed are increase. Power for propeller turbine is higher compare to the tidal turbine.

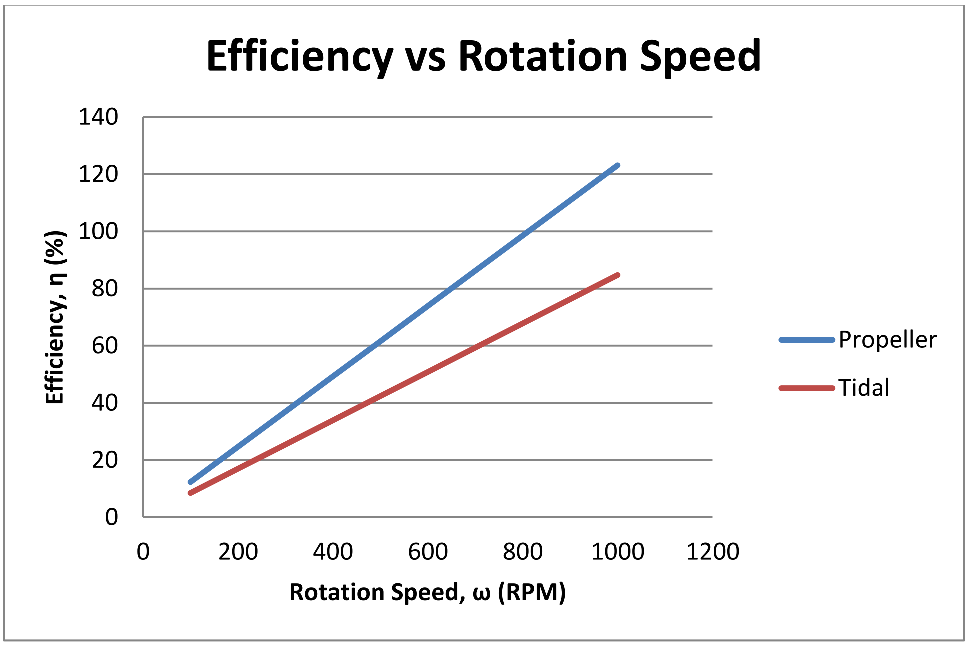


Figure 4.5: Graph efficiency vs rotation speed

Efficiency of propeller turbine are higher compare to the tidal turbine. It is shown in figure 4.5.

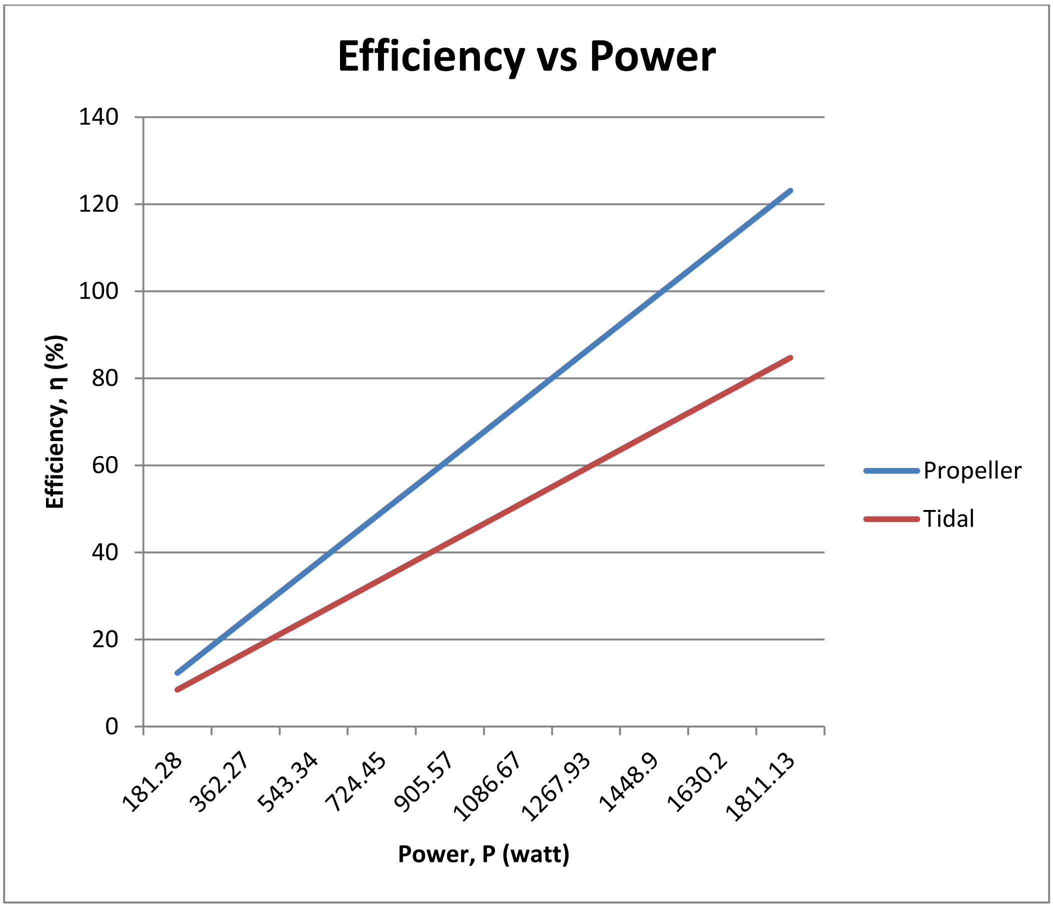


Figure 4.6: Graph efficiency vs power

4.3 CALCULATION OF PERFORMANCE

i. Convert the unit for angular velocity
ω = 100 rpm = 1000 x 2π /60

= 10.472 rad/s

ii. Power generated
P = $\omega\tau$
= 10.472 rad/s x 17.295 Nm
= 181.11324 W

iii. Sweep Area

$A = \pi r^2$

$= \pi \text{ x } 0.25 \text{ m}$

$= 0.785 \text{ m}^2$

iv. Power Available

$P = (\rho A v^3)/2$

$= (1000 \text{ x } 0.785 \text{ x } (2.4667)^3)/2$

$= 1470.8727 \text{ watt}$

From the calculation, power generated for the Propeller blade is close to the simulation results. Next step is to calculate the efficiency of the Propeller turbine. The maximum theoretical efficiency can be determined from the following equation:

$\eta = P_{generated} / P_{available}$

$= 181.11324 / 1470.8727$

$= 12.31\%$

CHAPTER 5

5.1 INTRODUCTION

This water turbine system was design to obtained electricity by running the turbine blade. The water turbine system could manage to generate electricity from renewable energy which cheap, clean and friendly to environment.

5.2 MICRO HYDRO POWER SYSTEM

The simulations of micro hydro power have been done for Sungai Pahang. From the simulation only small values of watt have been produce. The suitable turbine to use is Propeller Turbine where it generates more power compared to the tidal turbine. The power that propeller turbine generated is 181.11324 W compare to the tidal only 124.722 W.

The efficiency of the propeller turbine is greater compare to the Tidal turbine. And the suitable turbine for micro hydro power is Propeller; it is because the torque is higher compare to the tidal turbine.

5.3 RECOMMENDATION

Micro hydro power is suitable for Sungai Pahang, but need to choose the right turbine and the right place. It is more suitable when put many turbine because it can generate more power to supply for the people that live near to Sungai Pahang.

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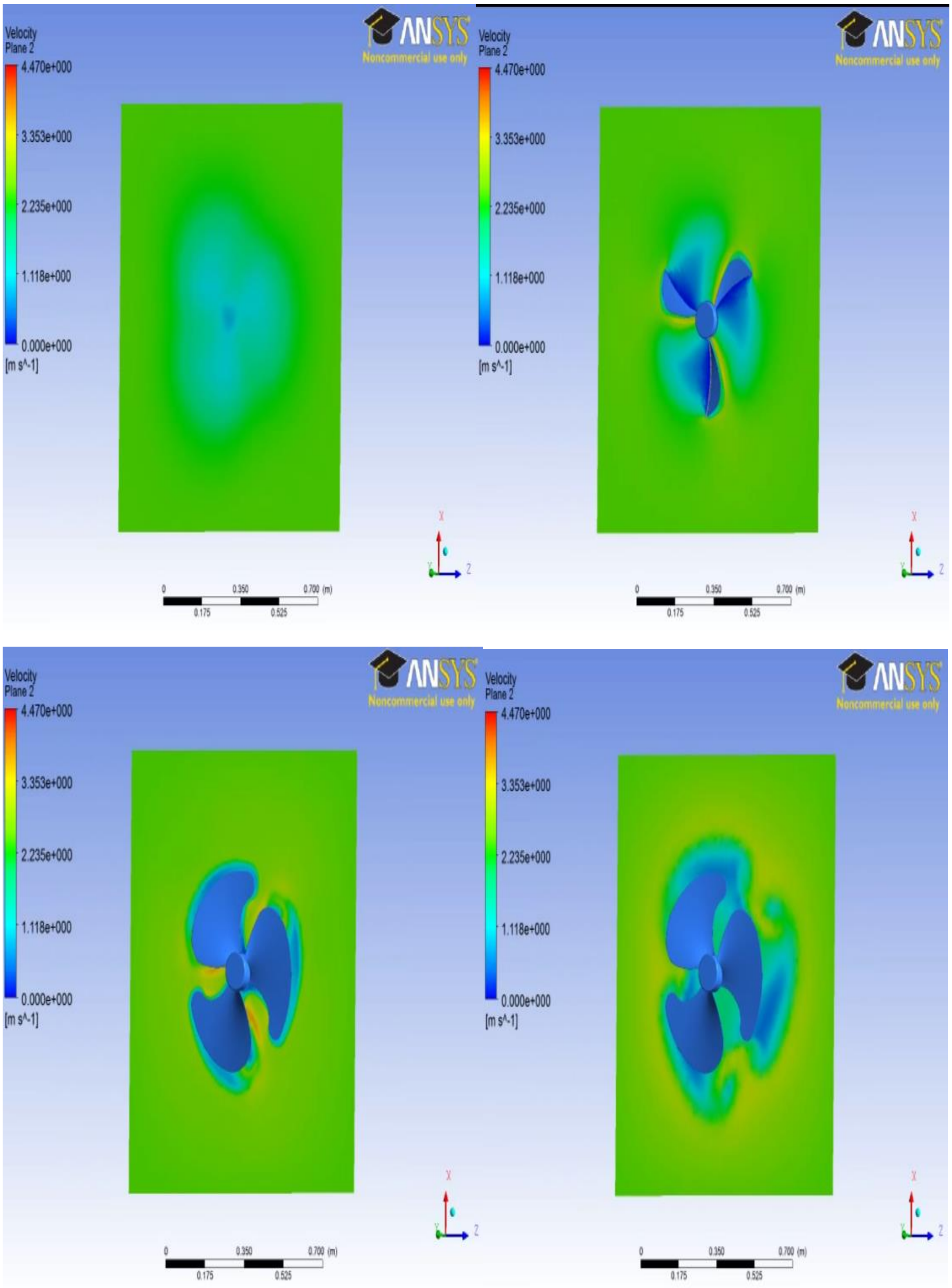
APPENDIX A

GANTT CHART

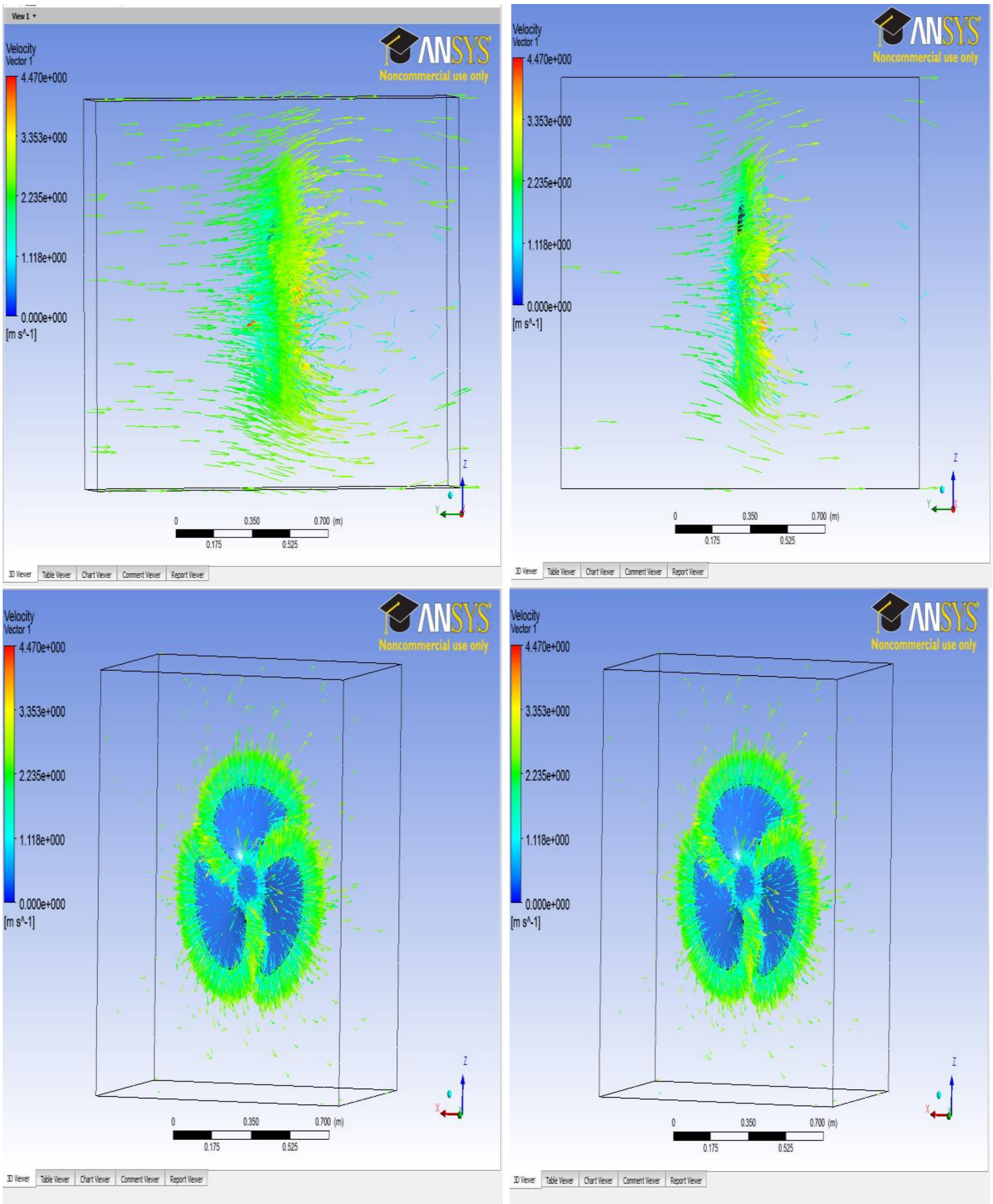
NO	TASK / MONTH	SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY				MARCH				APRIL				MAY			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	PROBLEM DEFINITION	■	■	■	■	■	■																														
2	LITERACTURE REVIEW					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
3	LEARN ANSYS FLUENT							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
4	SITE VISIT							■	■	■	■	■	■																								
5	DATA COLLECTION									■	■	■	■	■	■																						
6	MODELING OF RIVER													■	■	■	■	■	■	■	■	■	■	■	■												
7	MODELING OF MHP													■	■	■	■	■	■	■	■	■	■	■	■												
8	SIMULATION																	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
9	DATA EXTRACTION																					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	DATA ANAYLISIS AND DISCUSSION																									■	■	■	■	■	■	■	■	■	■	■	■
11	CONCLUSION																													■	■	■	■	■	■	■	■

APPENDIX B

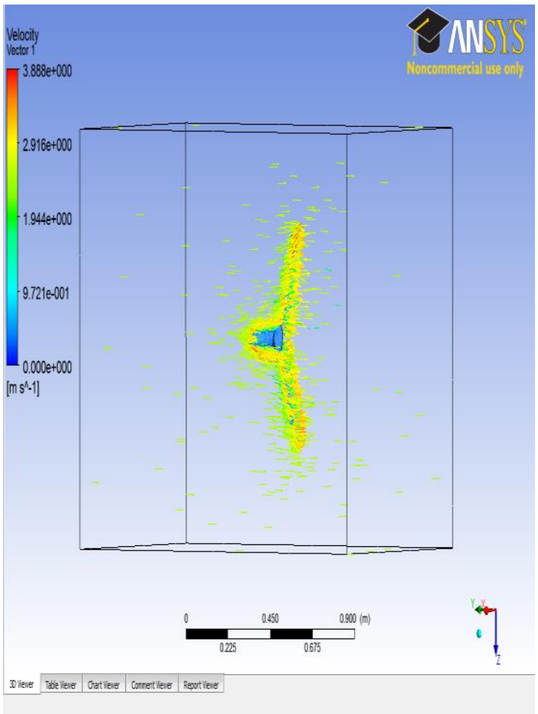
FRONT VIEW FOR PROPELLER TURBINE

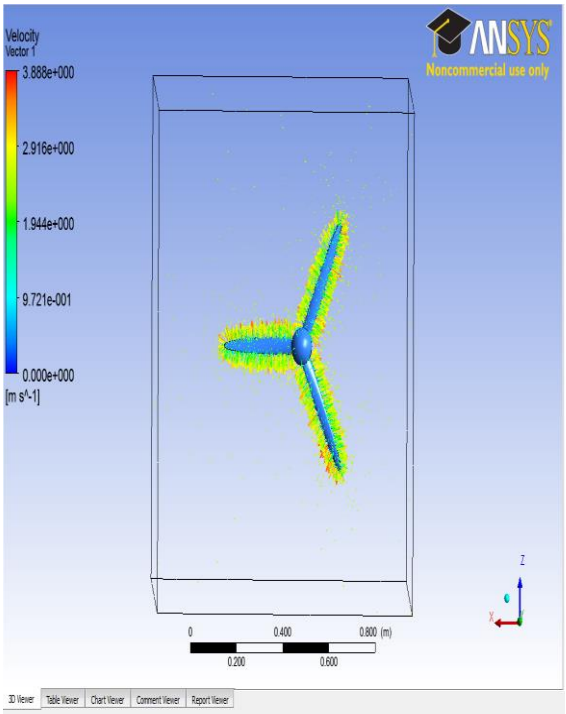


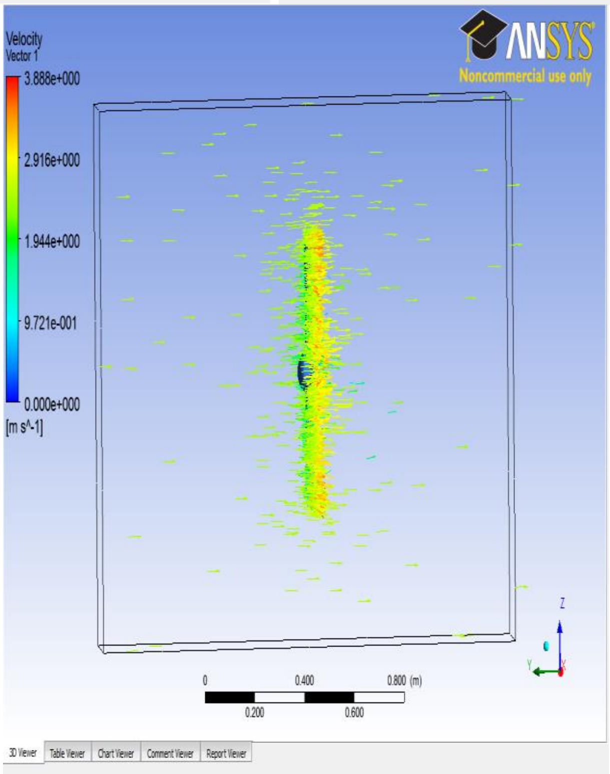
VECTOR VIEW FOR PROPELLER TURBINE



VECTOR VIEW FOR TIDAL TURBINE

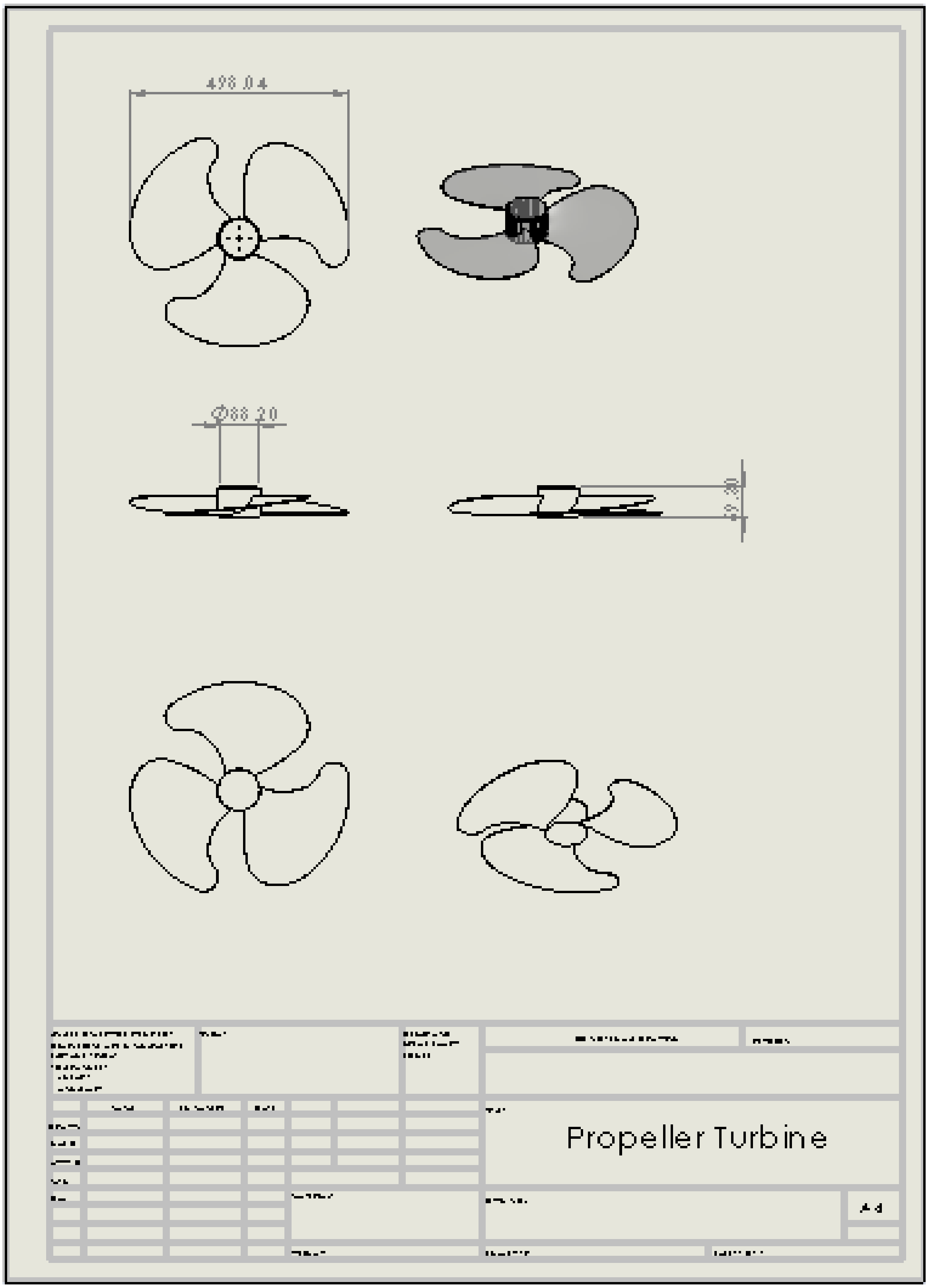






APPENDIX C

DIMENSION OF PROPELLER TURBINE



DIMENSION OF TIDAL TURBINE