# DEVELOPMENT OF CROSS FLOW TURBINE WITH DIFFUSER FOR HYDROKINETIC ENERGY HARNESSING

MUHAMMAD ALIF RASYDAN BIN RUHATAN

BACHELOR OF ELECTRICAL ENGINEERING TECHNOLOGY (POWER AND MACHINE) WITH HONOURS

UNIVERSITI MALAYSIA PAHANG

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MUHAMMAD ALIF RASYDAN BIN RUHATAN

Thesis submitted in fulfillment of the requirements
for the award of the degree of
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## ABSTRAK

Projek ini menekankan peranti jana kuasa tenaga hidrokinetik. Sebagai alternatif, penggunaan sistem turbin ini boleh ditukarkan tenaga kinetik air untuk menjana tenaga elektrik. Projek ini memfokuskan pada sistem bebas supaya peranti dapat dikonfigurasi dengan mudah. Oleh itu, beberapa faktor yang perlu diambil berat dari segi saiz dan potensi saliran kuasa untuk peranti yang dicadangkan. Ciri-ciri kelajuan air juga merupakan cabaran yang perlu diambil kira. Dalam tesis ini, reka bentuk turbin aliran silang dengan perumah dan bilah peranti serta tenaga air yang digunakan oleh alternator diterangkan untuk membangunkan peranti penuaian tenaga hidrokinetik. Pembangunan peranti melaksanakan penggunaan perisian SolidWorks untuk reka bentuk dan pembuatan sehingga proses pemasangan, sambil menggabungkan pelbagai proses penciptaan nilai di sepanjang proses pemasangan. Keputusan menunjukkan kesan kelajuan pada voltan yang dijana dan kesan beban pada penjana AC.

## ABSTRACT

This project emphasizes the hydrokinetic energy energy harvesting device. Alternatively, the use of this turbine system can be converted kinetic energy of water to generate electricity. This project focuses on a device independent system to easily configure it. Therefore, several keys stand out in terms of size and potential power drain for the proposed device. The fluctuating characteristics of the water speed are also the challenges to be considered. In this thesis, the design of a cross-flow turbine with the device housing and blade and the raw energy used by the alternator is explained to develop a hydrokinetic energy harvesting device. The development of the device implements the use of SolidWorks software for design and manufacturing through to the assembly process, while incorporating multiple value creation processes along the way. The results show the effects of speed on the generated voltage and the effects of load on the AC generator.

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| | |
|---|---|
| ρ | Density of the fluid (water) |
| A | Frontal area of the hydrokinetic turbine |
| $V^3$ | Velocity |
| Cp | Turbine power coefficient |
| P | Power(watt) |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| IoT | Internet of Thing |
| MPPT | Maximum Power Point Tracking |
| WECS | Wind Energy Conversion System |
| PMSG | Permanent Magnetic Synchronous Generator |
| DC | Direct Current |
| AC | Alternating Current |
| WCT | Water Current Turbine |


IoT Internet of Thing

MPPT Maximum Power Point Tracking

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Project Background

Hydroelectric energy is used to create electricity through water movement. Water runs over a turbine and rotates a generator blade. Strom is then supplied to the electricity grid, a customer or a storage device(Kim & Bernitsas, 2016). A dam where water is kept until power has to be generated is the most frequent form of hydroelectric plant. Hydrokinetic energy transmission systems are mechanisms capable of transforming kinetic energy into electrical water from river streams, tidal tides or man made waves. (Lago et al., 2010).

Three forms of energy can utilise hydrokinetic power, inland (rivers), tidal (estuary) and ocean (currents). Most of the HEC technology research and development too far has been targeted to tidal systems, and development of internal or ocean current devices has been rather low(Lee et al., 2011). Inland locations usually confront more user strife than coastal and tidal locations. Current makers of sea equipment have an important challenge in the creation of cheap deep water mooring systems (Valentine & Von Ellenrieder, 2015).

Two methodologies are generally used to use water energy, namely hydrostatic and hydrokinetic ways. Hydrostatic technique is the traditional method of storing water in reservoirs for generating a pressure head and obtaining potential energy from water by means of appropriate turbo-machinery. The benefits of hydro-kinetic energy technologies are the standard ways of manufacturing. Hydrokinetic systems need little civil labour. An electromechanical device is a hydrokinetic system which transforms the kinetic energy of water flow into electric energy through a generator and power electronic converter, as shown in figure 1.1 below (Khan et al., 2008).

Furthermore, a hydrokinetic system is built on free flowing water without building a reservoir or a floor. Because of the compact size of the plant, the system is easy to move and transfer (Ibrahim et al., 2021). There are many types of hydrokinetic turbines that can be implementing as an energy conversion to extract the energy. Nevertheless most of them were applied in conventional hydropower and wind energy conversion system (WECS). Hydrokinetic turbines may fundamentally be classified as horizontal and vertical axes. Two groups can divide the horizontal axis turbines. The initial rotary axis is parallel to the direction of the water stream. The other axis is perpendicular to the direction of the water stream. The perpendicular horizontal axis turbines, which will be no longer available since the technology is ancient and well-known, can be categorised as water wheel or cross-flow turbines (Güney & Kaygusuz, 2010).

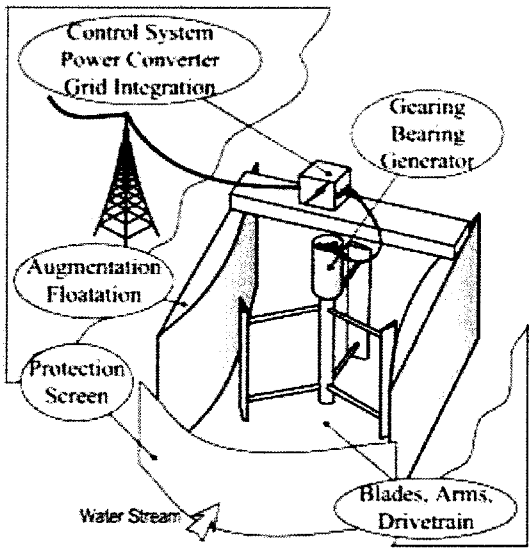



Figure 1.1 The hydrokinetic system is converting to electrical energy

Source: (Khan et al., 2009)

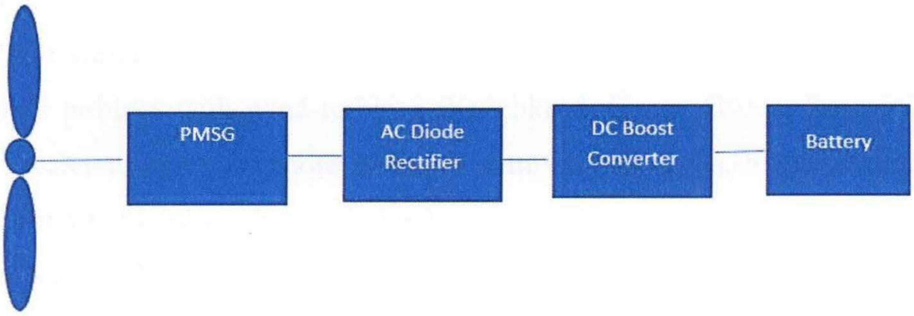



Figure 1.2 Operation of Stand-alone hydrokinetic
Source: (Ibrahim et al., 2021)

Figure 1.2 is shows the operation of Stand-Alone of Hydrokinetic Design. As can be seen in figure 1.2, it does consist a generator (PMSG), Ac Diode Rectifier, DC converter and 12V battery.

The aim of control a turbine system is to optimize its energy efficiency, since the optimum hydrokinetic turbine power is achieved at different turbine rotor speeds at different water speeds.

Hydrokinetic studies are not only evaluations and the enhancement of turbines, but also non-turbine conversion of energy and environmental study (Arias & De Las Heras, 2019). Several organisations have studied various concepts for hydrokinetic hydropower conversion systems, such as a membrane a flapping foil and two tandem flapping hydrofoils (Duarte et al., 2019).

The kinetic energy can be captured directly in the speed of flowing water by hydrokinetic equipment instead of the possible energy of falling water. This is a new hydropower type with little environmental impact (Ginter & Pieper, 2011). Various methods, such float or boom systems and oscillate water column devices, are being developed to collect hydrokinetic energy. Hydrokinetic turbines are one of the most often utilised of these technologies. The physical principles of use, the electrical hardware and the variable speed capability for optimum energy extraction are closely like hydrokinetic turbines with wind turbines (Kuschke & Strunz, 2011). Even at low current speed, water turbines are more effective than wind turbines. Furthermore, the technology of wind turbines requires a big land area, whereas hydrokinetic turbines may function under water (Wind, 2011).

The pitch angle control is typically used in medium to large turbine systems to maximize power output and to minimize torque and power output changes for high water speeds. The mechanical arrangement limitations, however, make the pitch angle control unreal for small-size turbine systems. Therefore, a power converter in small-scale turbine systems such as the boost converter is generally implemented for the MPPT control. A microcontroller is needed to control the operation of the power converter (Kim et al., 2021).

In order to run at the highest power stage, the signature turbine power versus rotating speed is preserved in memory for one particular turbine. The difference between the maximum power available and the actual output power can be found by measuring the rotational speed of the turbine. Therefore, a dynamic control strategy for a small-scale hydrokinetic turbine system is proposed in this project (Sun & Bernitsas, 2019).

### 1.2 Problem statement

Hydrokinetic technology is one of the best options to provide the electricity at the remote area near to the river, nevertheless several issues need to consider such as low water velocity and shallow water depth.

Second, low energy extraction due to pattern and variation of water flow which is non-linear water velocity and required a control strategy for max energy harnessing.

### 1.3 Objectives

i. To design a turbine that can be used in hydrokinetic energy harvesting system using SolidWorks software

ii. To design and develop a cross flow turbine for stand alone hydrokinetic energy harnessing

### 1.4 Scope

The scope of the development of stand-alone hydrokinetic energy harnessing:

- The focus of this study is on harnessing hydrokinetic energy, by using nature flow of the water, we will use the turbine to generate kinetic energy.
- By using vertical axis turbine, the water will flow direct onto the turbine and generate the electricity.
- This project will use the rectifier to convert AC to DC to charge the battery, then the project will use boost converter to step up the voltage and finally, by using the rectifier, it's will charge battery for consumer.
- Output power is limited to 200W
- The depth of river is limited to 5m
- The width of river is limited to 5m

# CHAPTER 2

# LITERITURE REVIEW

## 2.1 Introduction

The hydro-kinetics generated electricity availability depends on the speed of the stream, ocean, or tidal current stated according to the water density multiplied by the speed of the cured water stream (Ding et al., 2019).

As the demand for reliable energy sources is growing, research have shown that hydrokinetic energy projects based in rivers and seas may supply more than 10% of our energy demands one day. As a result, worldwide efforts to evaluate the possibilities of this seemingly endless water-based energy sources are already under way (Lv et al., 2021).

Unlike more typical hydroelectric projects, massive dams, impoundments of water, canals and water diversions are not required for hydrokinetic energy projects. Rather, hydrokinetic projects create energy by the use of flowing water power in waves, water streams and waterways. The major ways hydrokinetic energy and its place is utilised by the hydrokinetic technologies may be categorised (Zhang et al., 2019).

Hydrokinetic turbines are often imagined to include a fixed-speed rotor with a steady pace of rotation (rpm). For increased efficiency, more professional systems are using variable speed mechanisms. Same may be done with the assignment of the variable pitches mechanism to the propeller hydrokinetic turbines (Kirke & Lazauskas, 2011).

The power output of rotating current energy conversion systems is evaluated in the following manner:

$$p = \frac{1}{2}\rho \text{ x A x Cp x } V^3 \qquad 2.1$$

Where P is the total power output of the turbine in Watts, ρ is the fluid density, A is the swept area of the rotor blades (m2), V is the flow velocity (m/s), and CP is the turbine's power coefficient, which also indicates the overall efficiency.

The horizontal flow of generates energy for in-stream hydrokinetic systems. These energy-generation projects employ a wide range of technologies, including:

- Horizontal axis turbines
- Vertical axis turbines

## 2.2 Horizontal axis turbines

As the rotors are more efficient in converting the water into rotating energy, horizontal axis turbines shown in figure 2.1 are used. Today, all commercial wind turbines connected to the Grid are built with a horizontal axis propeller type rotor (i.e. a horizontal main shaft). Of course, the objective of the rotor is to convert the water's linear movement into a rotary energy that can be used to drive a generator. In a modern wind turbine with parallel flow of wind to the rotating axis of the turbine blades, the same fundamental principle is applied. Water Turbine's horizontal Axis is a rotary press which has a horizontal rotational axis used for generating electricity. Water Current Turbine (WCT), Ultra-low-head Hydro Turbine, Free Flow/Stream Turbine, Zero Head (Ladokun et al., 2018).

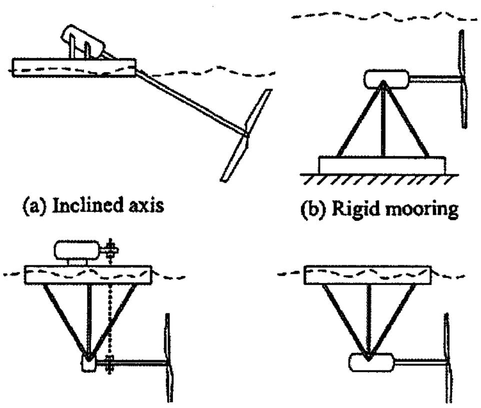



Figure 2.1 Type Horizontal-axis turbine arrangements
Source: (Ladokun et al., 2018)

### 2.3 Vertical axis turbines

Numerous academics have been particularly interested in developing vertical axis turbines in recent years, since they have many advantages, but also disadvantages. (Khan et al., 2009) attempted to illustrate different layouts of this type in Figure 2.2.

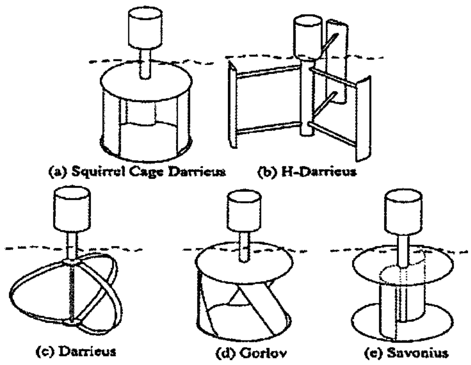



Figure 2.2 Vertical-axis turbine arrangements.
Source: (Möllerström et al., 2019)

The vertical type of Darrieus turbines is mostly recognised. The Darrieust turbine is split into two groups: the straight blade and the curved blade (Squirrel Cage Darrieus and H-Darrieus) (Darrieus). Gorlov turbine is an invention for improved performance from a modified darrieus turbine [14, 15, 16]. The form of his blade is helical. Lift devices are Darrieus turbines and gorlov turbines. It is a drag device, differing from the savonic turbine.

## 2.4 Diffuser-augmented Turbines

The diffuser-augmented turbine technology presents enormous prospects for the development of conventional hydropower from low-speed currents with low head values, particularly due to improved performance in diffuser turbine technologies. It should be mentioned, though, that diffuser may have additional potential advantages, such as flow alignment, protecting rotors and generators from materials carried and supporting rotor loads. In comparison with dam-based hydroelectric technology, such technologies are an excellent alternative as an economic source of permanent energy, provided that a current is available.

Most diffuser-augmented turbine technology components are common as shown in figure 2.3. The cycles, prices and standards of assembly development are therefore likely to be constrained. These technologies complement a solar system, do not need access to wide areas of flood or civil infrastructure and have little environmental consequences. Parameters of hydrodynamic performance of diffuser-augmented turbines are modelled and examined by changing cambers and attack angles in the cross section of the diffuser (El-Samanoudy et al., 2010).

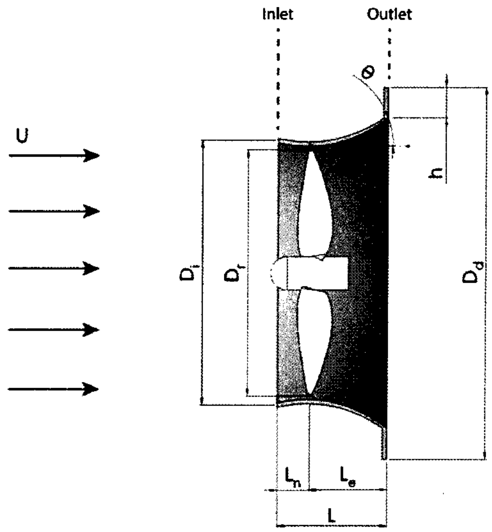



Figure 2.3 Parameters on a diffuser-augmented turbine
Source: (El-Samanoudy et al., 2010)

Whether or not the turbine is connected is important for the turbine's performance. Ducts or diffusers are designed structures which, in the hydrokinetic converter, increase the energy density of water flow (Khan et al., 2009). The conduit or increase channel considerably enhances the overall potential power collection. Furthermore, the rotor speed can be controlled and low speed drive train design difficulties can be eliminated. Two opposing considerations are of great importance to evaluate these technologies. Firstly, power capacity is being increased and therefore energy costs are being reduced. There could be a lack of, on the other hand confidence concerning their survivability and design(Khan et al., 2009). Figure 2.3 illustrates some of the types.

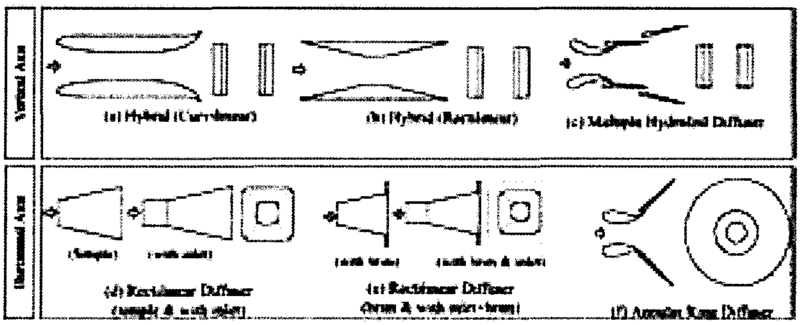


Figure 2.4 Example type of diffuser-augmented
Source: (El-Samanoudy et al., 2010)

Many investigations of diffuser-augmented or conducted turbines were carried out since diffusers may improve the amount of energy extracted and enhance the mass flow through the rotor in relative terms. These diffusers and duction turbines are based on the same idea, where the flowing fluid kinetic energies are used to rotate an electromechanical energy converter to create electricity. This diffuser uses wind turbines also, with the addition of a diffuser to a turbine achieving high performance.

## 2.5 Rotor Design

Changing the shape of the rotor is frequent to boost the power coefficient of the basic turbine. Most works do not modify their current rotor project in the design of a diffuser and strive to fit the diffuser to that project. This is not an ideal procedure since the rotor was not meant to work by improving the diffuser. The optimization was carried out for the rotor blades in view of a diffuser design already described. By means of a one-dimensional analysis they identified ideal rotor load and used this as a base for the strength of a vortex cylinder in the actuator model. The model has resulted in the velocity distribution of the ideal loading factor that was employed by the blade element dynamic approach to build a new rotor (Maldonado et al., 2014).

Tests on the new rotor indicated a 15 percent improvement on the power coefficient (CP) on the same diffuser over the prior rotor. The use of algorithms was based on multifocal genetic approaches. This approach processes the adjustment of numerous diffuser or blade shape parameters, evaluating thousands of design points for diffuser-enhanced turbines.

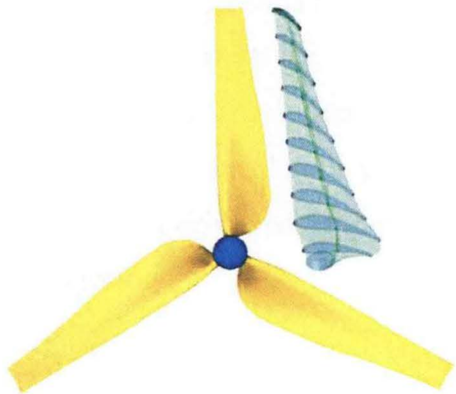


Figure 2.5 Example of rotor and hydrofoil.
Source: (Aguilar et al., 2021)

Figure 2.5 illustrates a rotor example with hydrofoils, which indicates that a rotor is not necessarily producing maximal yearly energy for optimum hydrodynamic efficiency, but rather maximize by turbine efficiency (increasing angle of approach and velocity). The example of a turbine is Figure 2.5.

A rotor design based on BEM with a tip loss correction is carried out using hydrofoils created by the KMUST Fluid Structure Coupling Innovation Team. The rotor has 3 blades and is 1.98 m in diameter, as seen in Figure 2.5.

## 2.6 Debris Protection

Several types and sizes of natural woody debris were prepared for use in the study to represent at scale the range of piece sizes and shapes that might be encountered in nature, from large trees to smaller branches. (Perry et al., 2018) found that creating model debris from real tree branches provides a more realistic simulation of conditions in nature. For added realism, the model debris pieces used in this study were created from real tree branches complete with knots and bends, and not from smooth, straight wooden dowel (Rochman et al., 2015). The properties of the three different classes of model debris (named small, medium and large) prepared for use in the study are summarized in Table 1 Each piece of debris was painted to make them more visible and make it easier to track their trajectory.

Table 2.1 Example of size debris

| Debris class FS | Diameter (m) | FS Length (m) | MS Diameter | (m)MS Length |
|---|---|---|---|---|
| Small | 0.01-0.05 | 0.9-1.1 | 0.001-0.005 | 0.09-0.11 |
| Medium | 0.1-0.2 4-6 | 4-6 | 0.01-0.02 | 0.4-0.6 |
| Large | 0.2-0.3 | 8-12 | 0.02-0.03 | 0.8-1.2 |

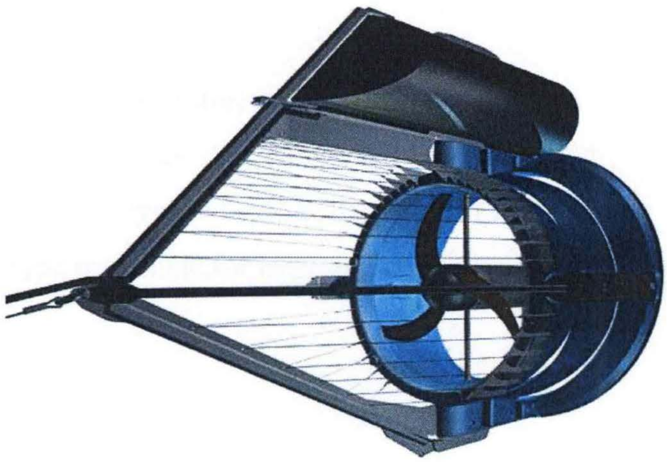


Figure 2.6 Example of debris protection attach
Source: (Rochman et al., 2015)

A conical debris filter is fitted to the front of the shield to protect the blade and preserve its performance. The four load-bearing bars in figure 2.6 are linked to a big ring (which fits with the diameter of the shoulder aperture) and a tiny ring (connecting to the main anchor line). Kevlar string will be run lengthwise from ring to ring for the filtering of smaller scraps. The strength and stiffness of the debris filter were validated using a final element analysis. As seen in Figure 2.6, the cables are carefully constructed in stainless steel so that the debris does not collect or damage the blades.

### 2.7 Generator

An AC three-phase generator, these generators are running consecutively between the two of them, with an offset of 120° at a time. The generator therefore generates three waves in one cycle of AC voltage which make steady voltage supply easier. This generator type is suitable for large and continuous power demands.

Figure 2.7 YC-200W generator

YC-200W as shown on figure 2.7 model High efficiency generator came simple structure, high reliability, small size, light weight and high power output. The speed at medium and low to generate the power, YC-200W performance well and can significantly extend the battery life, reduce battery maintenance. Brushless permanent magnet generator with no slip ring construction eliminates radio interference caused by carbon brush and slip ring friction, but also decreases the generator's ambient temperature needs.

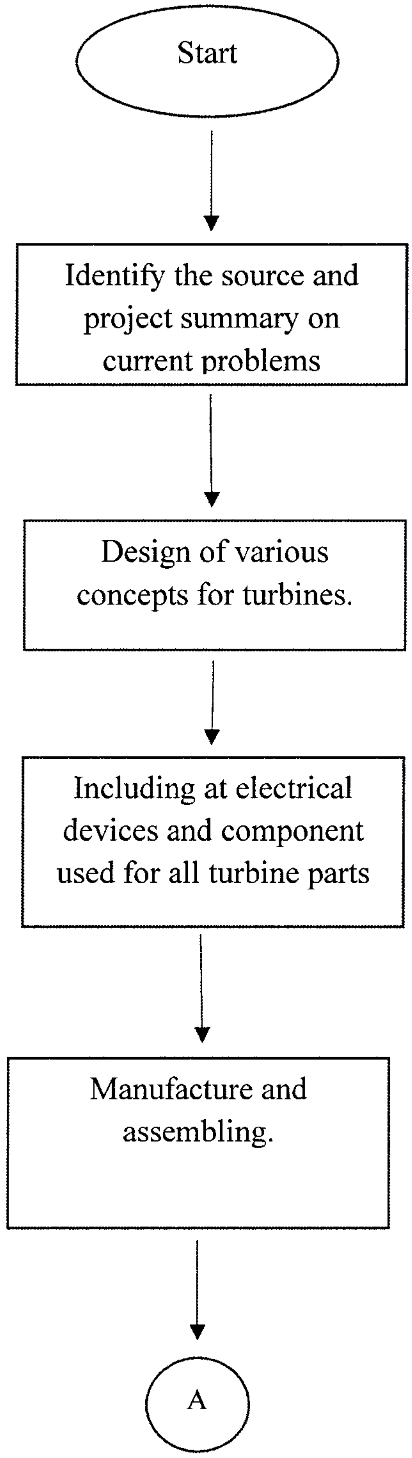
# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter details the techniques for the implementation of the hydrokinetic turbine generating system scheme. The approaches employed in this chapter seek to achieve the project goals, which will yield satisfactory results on the electrical system and monitoring system efficiency of hydrokinetic turbines.

### 3.2 FLOW CHART OF THE PROJECT



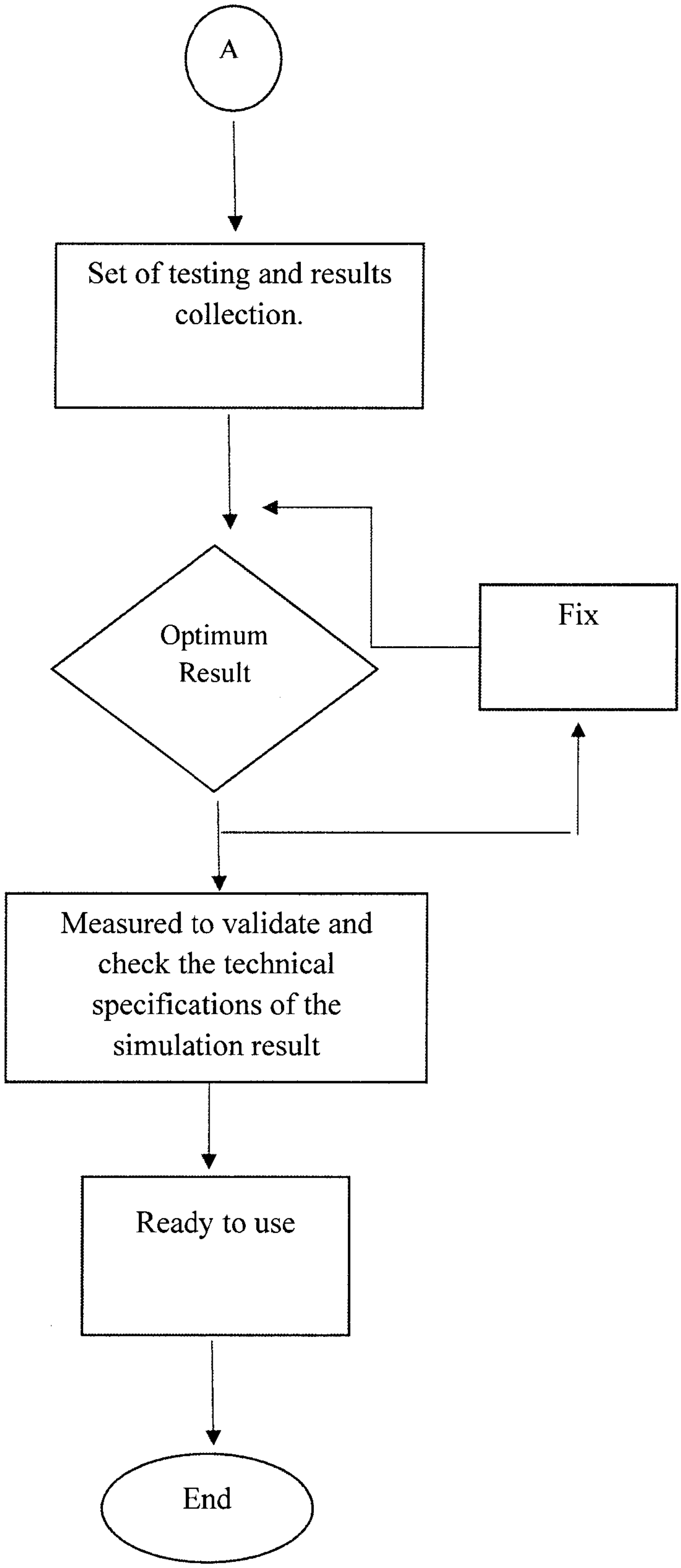



Figure 3.1 Flowchart System

Figure 3.1 is show the flowchart system for this Stand-Alone Hydrokinetic Energy. Identify the source and project summary on current source to make choose the correct design and settle out the problem from the project. Choosing the right turbine with the various type of turbine to make sure it's suitable with the project design. Including the electrical devices and component for all turbines parts. The assembling and set up is started when the entire component and the material is suitable to follow the design of Stand-Alone Hydrokinetic design. The testing must be same with the simulation result and if not, it will have to fix it. The technical specification of the simulation result must to check and starting to write a report.

### 3.3 DESIGN OF THE PROJECT USING SOLIDWORKS

Figure 3.2 SolidWorks software

Mechanical, electrical, and electronics experts employ Solidworks software solutions to create a linked design. The suite of applications is intended to keep all engineers in touch and capable of responding to design demands or modifications. Circuit works, an electrical CAD/ECAD converter that allows engineers to generate precise 3D models of circuit boards, is one of the items included in Solidworks, according to their website. Students majoring in mechatronics at Capitol will take CAD, automated systems design, and mechatronic systems design courses.

The design process usually involves the following steps:

- Identify the model requirements.
- Conceptualize the model based on the identified needs.
- Develop the model based on the concepts.
- Analyze the model.
- Prototype the model.
- Construct the model.
- Edit the model, if needed.

Before developing the model, it is beneficial to have a methodology for constructing the model. After determining the needs and isolating the appropriate ideas, build the model:

- Sketches

Create the sketches and decide how to dimension and where to apply relations.

- Features

Select the appropriate features, such as extrudes and fillets, determine the best features to apply, and decide in what order to apply those features.

- Assemblies

Select the components to mate and the types of mates to apply.

### 3.3.1 DESIGN OF THE TURBINE

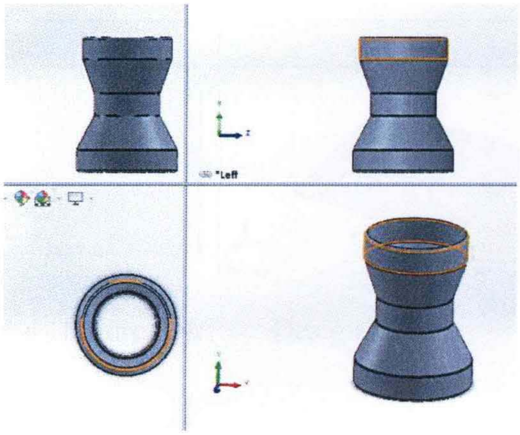


Figure 3.3 Design of the turbine using solidworks software

This turbine for this project use the specific parameter shown in table 3.1 use to design the turbine such as figure 3.3 using solidworks software.

Table 3.1 Dimension of turbine

| **Item** | **Size(m)** |
|---|---|
| Turbine diameter for input(m) | 0.4m |
| Turbine diameter for output(m) | 0.5m |
| Length turbine(m) | 0.4m |

### 3.3.2 Design of base

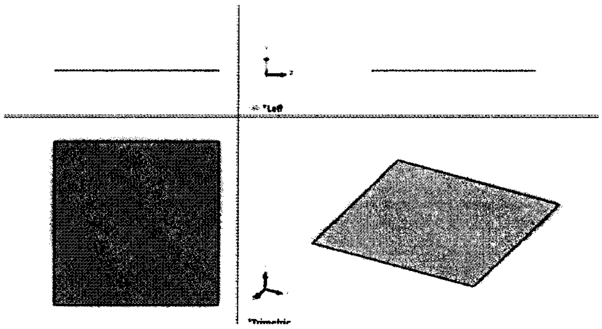


Figure 3.4 Design of base

The table 3.1 had shown the parameter to make sure the base fix well while attach to the turbine and also can hold the generator.

Table 3.2 Specific parameter for Base design

| Item | Size(m) |
|---|---|
| Base length(m) | 0.6m |
| Base width (m) | 0.6m |
| Thickness of base (m) | 0.02m |

### 3.3.3 Design of inlet water system

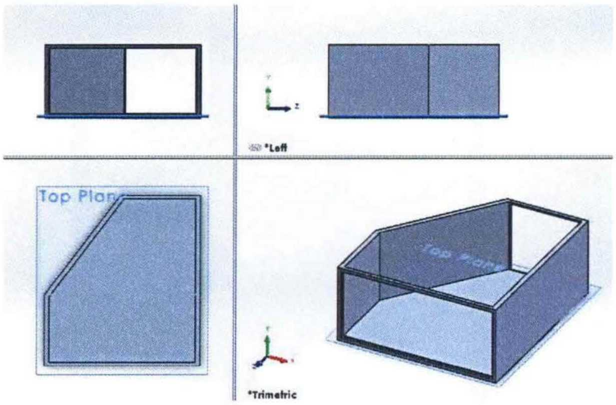



Figure 3.5 Design of Inlet Water system

The inlet water system (Figure 3.5) use to generate the vortex for water to move the blade that attach to generator.

Table 3.3 Dimension of inlet water system

| Item | Size(m) |
|---|---|
| Length(m) | 0.3m |
| Width(m) | 0.3m |
| High(m) | 0.08m |

### 3.3.4 Final design

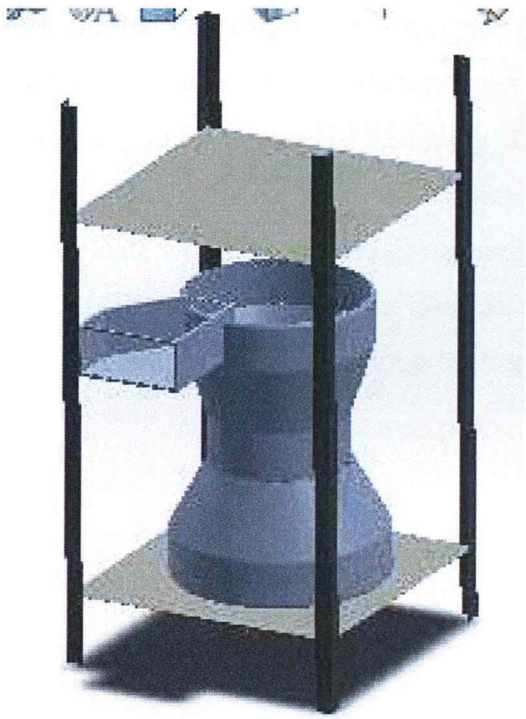


Figure 3.6 Final Design

Every product needs a complete design with exact measurement before it can be fabricated. The design plays a fundamental role in this project. Therefore, prior to the design process, a few criteria were considered. The design of the cross flow turbine with diffuser for hydrokinetic energy harnessing shown in Figure 3.6 was created by using Solidworks. For visualized our entire sketch by using a more practical picture.

### 3.4 Hardware Design

For the cross flow turbine with diffuser, we designed the turbine dimensions and the main components, which allowed the base and inlet water system for attachment. Material selection is a core step in the process of designing any physical object. The systematic selection of the best material for the given application begins with the properties and costs of candidate materials. Selecting the appropriate material is one of the keys that lead to success. The turbine is made of fiberglass. fiberglass is used mainly for its hardest the part and make the build long lasting and it eases the process of building the prototype.

#### 3.4.1 The turbine

Figure 3.7 The Turbine

The turbine take a several day to complete the design . the design use some material to get the specific turbine shape such as wire mesh , tape , and some boxes . using the dimension L=0.5m W=0.5 and H=0.6m . for diameter , the turbine have 3 specific size for each layer. For the input , the diameter were 0.5m. the diameter at the turbine use 0.3m and the output of turbine used 0.4m for the diameter. After get the shape by using the material , the fiberglass used to get the final shape and make the turbine hard.

### 3.4.2 The base

Figure 3.8 The Base

The base design only take a few hours, the material use for this design were angle bar and plastic wrap. The angle bar need to assemble and make the perfect square with dimension L=0.6 and W=0.6m. This material also used the fiberglass same like the turbine.

### 3.4.3 The inlet water system

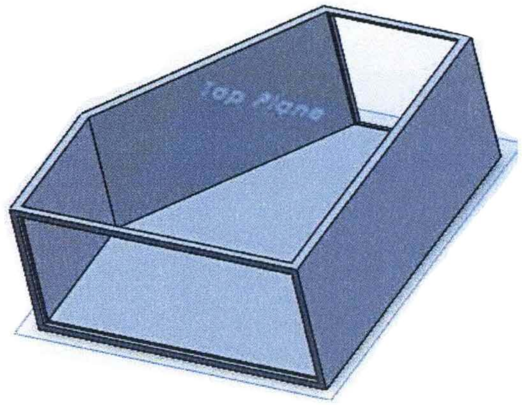



Figure 3.9 The Inlet Water System

The inlet water system used the box to shape for this design using the dimension L=0.3m , W=0.3m and H= 0.08m .The input size for this design 0.3m x 0.08m and the output 0.15m x 0.8m. This design use the fiberglass.

### 3.4.4 Final design product

Figure 3.10 Final Design Product

During the manufacturing process, the materials were constructed by combining the parts and components to obtain the finished product and finally, the installation of the final project was done. The fiberglass underwent a plaining process to avoid fiberglass chips prior to the cutting and assembly process. The underlying principle involved cleaning the fiberglass surface of the cutter mark The fiberglass surface was smoothed after coming out of the kiln dry After completing the fiberglass processes, all the pieces were joined based on the design made by using the Solidwork software. The assembling process was performed using angle bar, bold, and nut which hold all parts of the cross flow turbine with diffuser including its base , turbine and generator. Every part had to be secured by bold and nut to ensure strength and durability. The assembly product is illustrated in Figure 3.10.

### 3.5 Identify the problem

In this part there are a few problems has been identified as below:

i) The renewable energy likes wind and solar is rarely used because it can't continuously generate energy like hydrokinetic energy.

ii) With the existing energy, they can't use that kind of renewable energy to produce electricity.

To overcome this problem, the stand-alone hydrokinetic energy harnessing will design for consumer too gets electricity without using more energy. After that, that is a renewable energy source and does not emit any greenhouse gases and also it is not linked to waste production and does not contribute to air pollution, to use hydrokinetic energy, without mining materials.

### 3.6 List of material

Table 3.4 below shows a list of materials used and the estimated cost for this project.

Table 3.4 Material cost list

| No. | Item | Quantity / set | Price per Unit(RM) | Total (RM) |
|---|---|---|---|---|
| 1 | Generator | 1 | 349.33 | 349.33 |
| 2 | Fiberglass 10m | 1 | 100.00 | 100.00 |
| 3 | Polyester Resin 10 kg | 1 | 106.60 | 106.60 |
| 4 | Angle Bar 0.6m | 8 | 2.50 | 20.00 |
| 5 | Angle Bar 1.2m | 4 | 5.00 | 20.00 |
| 6 | Corner Plate | 16 | 0.20 | 3.20 |
| 7 | Pvc Base for Angle Bar | 2(set) | 3.00 | 6.00 |
| 8 | Bolt and Nut | 56 (set) | 1.00 | 56.00 |
| 9 | Fan Blade 12 inch | 1 | 27.10 | 27.10 |
| 10 | Steel rod 8mm(0.6m) | 1 | 12.50 | 12.50 |
| 11 | Shaft coupling 16mm to 8mm | 1 | 15.19 | 15.90 |
| 12 | Rigid Flange Coupling 8mm | 2 | 2.02 | 4.04 |
| Total (RM) | | | | 720.67 |

Table 3.4 above shows the table above shows a complete list of components used, the quantity of each component required as well as the price of each component according to the current market price

### 3.7 Summary of the Chapter

In a nutshell, creating a flowchart is a crucial step when designing and planning a process. This type of chart helps identify the essential steps and simultaneously offer the bigger picture of the process. All the materials used in this project were readily available and accessible to access.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Introduction

This section includes results and a discussion of this project. The information gathered from previous studies was analysed to determine how the devices operate. Therefore, a proper experiment has been set up to get the necessary data. The results section presented all the findings, whether in graphs. In contrast, the discussion section interprets the results and possible implications and describes the findings' significance.

## 4.2 Velocity of water

The speed at which water flows is known as the velocity of water. Flow rates are usually measured by the volume of water passing per minute. This flow rate can be converted to velocity with the diameter of the turbine. An initial experiment has been done to evaluate the effect of velocity of water to the turbine.he experimental setup to obtain the results is shown in the Figure 4.1 and Figure 4.2 below.

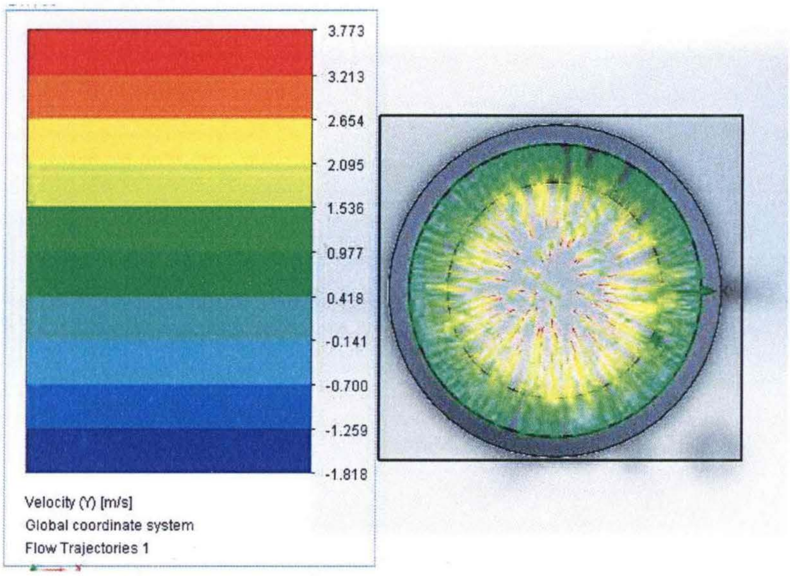



Figure 4.1 Simulation velocity 1

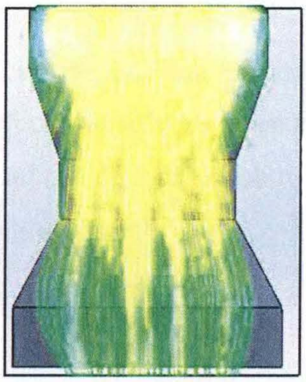


Figure 4.2 Simulation velocity 2

Figure shown in the above was the water velocity in the turbine recorded using solidworks fluid simulation method.

The water flow rate set at 1.5 m/s as a base velocity and the result of simulation shown the velocity increase by using this diffuser design.the velocity will increase from 1.5 m/s can up to 1.8m/s - 2.5 m/s. the graph figure below shown the velocity of water after trough the turbine.

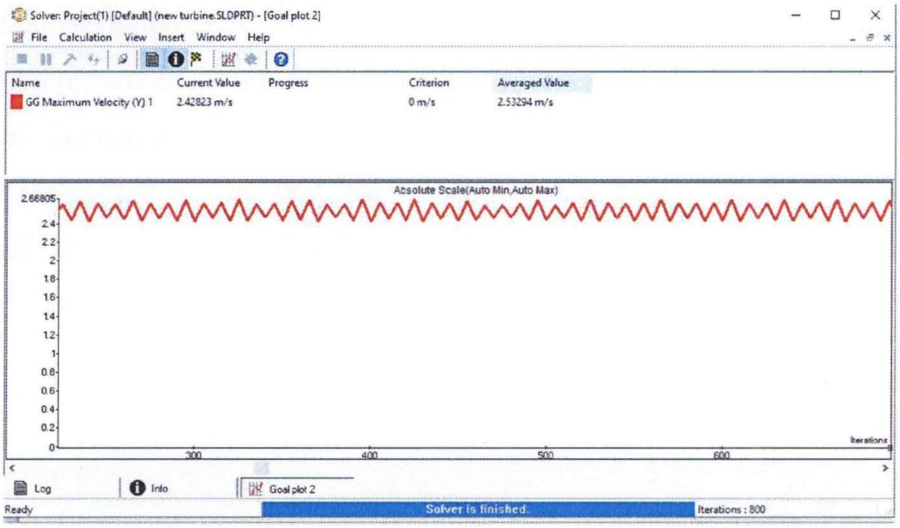



Figure 4.3 Graph for maximum velocity

The graph in Figure 4.3 above shows the data that has been taken for maximum velocity in the turbine. The data readings for velocity water were taken simultaneously in solidworks fluid simulation. By using the formula and the data based on the graph , the turbine design can get the output velocity as the objective want.

## 4.3 Obstacle

The obstacle face during hardware fabrication is to provide the medium sie of the turbine. Less tools to make the turbine are too late finish. To make the turbine are perfect, need more time and skill to get the specific size.

## 4.4 Limitation

The limitation for this project, the space to build this design are limit, its need large space and also have limit timing. Weather not always good , the resin take time to harder when raining days. This is the reason this project need more time and space.

## 4.5 Summary of the Chapter

All the developmental processes and experimental setup were successfully done. Several problems were encountered during this process, but they have been described in previous sub chapters and successfully resolved. The operation of  requires more research. It is not easy because this design need to test at the real situation to produce the real result. So, to get an accurate result, a flow rate sensor must be use in this experiment in the real situation.

# CHAPTER 5

# CONCLUSION

## 5.1 Introduction

This section includes conclusion and a recommendation of this project. The information gathered was analysed to determine how the devices operate. The results of the research provide an overview of this case study.

## 5.2 Conclusion

The hydro-kinetic energy sector has received a positive reaction for commercial purposes. Compared to grid-tied system, stand-alone system relies batteries to store the electricity harnessed by the hydro-kinetic energy. Stand alone system was the easy alternative for rural area. As a result, it is not surprising that many rural place are interested in getting into the hydro-kinetic industry. Through some research conducted, the velocity of water were not consistent.the water flow might be high or extreme slow. The diffuser design was the best solution for the low velocity water. According to experiments conducted on the normal velocity water, by using this method the velocity of water will increase. In contrast, the velocity of water 1.5m/s is exceedingly cannot rotate the blade of the generator

The proposed design has addressed the issues raised in the problem statement section. The project may assist the user to solve the velocity problem. However, this project has its limitations:

i. The blade design not good enough to spin when the water trough the turbine.

ii. The generator not enough torque to get full power output

iii. The debris can stop the blade to spin.

## 5.2 Recommendation

To enhance the lack of a proposed project, various recommendations for future work can be made to alleviate the project's limits, which are:

i. Replace the blade with aerodynamic design to get full speed of power for blade spin .

ii. Using the gearbox to to get full speed rotation of blade. Gearbox can make the blade rotate more faster when the velocity of water drop . The generator can generate the power when low velocity applied on the turbine.The gearbox can move the blade easily even though in higher torque .

iii. Add the debris protect system to avoid the failure of the blade and also can protect the aquatic ecosystem.

To sum up, all the objectives in this project have been achieved. This project has successfully developed a system capable to increase the velocity of water by using the diffuser design. This research also raises

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# APPENDICES

Appendix A: **GANTT CHART(SDP 1)**

| | DEVELOPMENT STAND-ALONE HYDROKINETIC ENERGY HERNESSING | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MARCH | | | | APRIL | | | | MAY | | | | JUNE | | | |
| | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 |
| SDP1 Brefing | ■ | | | | | | | | | | | | | | | |
| Project Meeting | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Gather Information | ■ | ■ | | | | | | | | | | | | | | |
| Project Statement & Design Features | | | ■ | ■ | ■ | | | | | | | | | | | |
| Evaluate Design Concept | | | | | | ■ | | | | | | | | | | |
| Cost Analysis | | | | | | | ■ | | | | | | | | | |
| First Draft of Proposal | | | | | | | | ■ | ■ | | | | | | | |
| Second Draft of Proposal | | | | | | | | | ■ | ■ | | | | | | |
| Third Draft of Proposal | | | | | | | | | | ■ | ■ | | | | | |
| Presentation Reheasel | | | | | | | | | | | ■ | ■ | | | | |
| SDP Presentation Day | | | | | | | | | | | | | ■ | | | |
| Procument | | | | | | | | | | | | | | ■ | | |

Appendix B: TOTAL COST TABLE

| **No.** | **Item** | **Quantity / set** | **Price per Unit(RM)** | **Total (RM)** |
|---|---|---|---|---|
| 1 | Generator | 1 | 349.33 | 349.33 |
| 2 | Fiberglass 10m | 1 | 100.00 | 100.00 |
| 3 | Polyester Resin 10 kg | 1 | 106.60 | 106.60 |
| 4 | Angle Bar 0.6m | 8 | 2.50 | 20.00 |
| 5 | Angle Bar 1.2m | 4 | 5.00 | 20.00 |
| 6 | Corner Plate | 16 | 0.20 | 3.20 |
| 7 | Pvc Base for Angle Bar | 2(set) | 3.00 | 6.00 |
| 8 | Bolt and Nut | 56 (set) | 1.00 | 56.00 |
| 9 | Fan Blade 12 inch | 1 | 27.10 | 27.10 |
| 10 | Steel rod 8mm(0.6m) | 1 | 12.50 | 12.50 |
| 11 | Shaft coupling 16mm to 8mm | 1 | 15.19 | 15.90 |
| 12 | Rigid Flange Coupling 8mm | 2 | 2.02 | 4.04 |
| Total (RM) | | | | 720.67 |