DESIGN AND FABRICATION OF LABORATORY SCALE MICRO-HYDROTURBINE TEST-RIG

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A report submitted for partial fulfillment of the requirement for the Diploma of Mechanical Engineering award.

Faculty of Mechanical Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature:
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Position:
Date:

STUDENT DECLARATION

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

Signature:
Name:
ID Number:
Date:

ACKNOWLEDGEMENT

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ABSTRACT

This report shows the design and fabrication of laboratory scale micro-hydroturbine test rig. The objective of this report is to develop the procedures to design and fabricate a prototype of micro-hydroturbine test rig to generate energy. This report also includes the design selection and analysis of the micro-hydroturbine. Design generation is showed and solid three dimensional structures modelling of the solar turbine was developed with computer aided design software. Material selection and the reason behind the selection are shown based on criteria predetermined. Based on the selection, stainless steel is selected. The result from testing the hydroturbine shows that the test-rig is able to support the turbine and allow water to flow out from it. Ideas of improvement for the micro-hydroturbine test rig is also provided to further improve the system.

ABSTRAK

Laporan ini menunjuk rekaan dan cara-cara membuat alat ujikaji hidroturbin-mikro skala makmal. Objektif laporan ini adalah untuk menambahbaikkan cara-cara untuk mereka dan menghasilkan prototaip alat uji-kaji hidroturbin-mikro untuk menghasilkan tenaga. Laporan ini juga merangkumi pemilihan reka bentuk dan analisis hidroturbin-mikro. Penghasilan reka cipta dan struktur 3 dimensi hidroturbin-mikro telah dijana menggunakan perisian lukisan berbantu computer. Pemilihan material dan sebab-sebab pemilihan telah ditunjukkan berdasarkan criteria yang telah ditetapkan. Berdasarkan pemilihan tersebut, stainless steel telah dipilih. Keputusan daripada percubaan alat ujikaji hidroturbin-mikro tersebut menunjukkan ia mampu menampung berat turbin tersebut dan memnbenarkan air mengalir keluar daripadanya. Idea-idea pembaikan untuk alat ujikaji hidroturbin-mikro juga diberi untuk menambah baik sistem tersebut.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This project's title is design and fabrication of laboratory scale hydroturbine test rig. Hydropower comes from converting energy in flowing water by means of a water wheel or through a turbine into useful mechanical power that is conversion of water's potential and kinetic energy into electrical energy.

1.2 PROJECT BACKGROUND

This project is about designing and fabrication of laboratory scale or can be said as micro-hydroturbine. Micro-hydropower systems are relatively small power sources that are appropriate in most cases for individual users or groups of users who are independent of the electricity supply grid. A micro-hydropower system is generally classified as having a generating capacity of less than 100 kW. Water is pumped from the source and channeled into a turbine. The turbine blades are now turned by the flowing water and creates a rotary movement of the turbine. The rotary movement is then used to turn the generator. The generator converts the mechanical rotary movement into electrical energy.

1.3 PROBLEM STATEMENT

Since the industrial revolution begun in the 18th century, fuel has become one of the vital energy in our life. However the amount of non-renewable fuels such as gasoline are shrinking day by day and will eventually depleted at the end. In order to ensure having the sufficient alternative energies for future, renewable energies should be produced. One of the most effective renewable energy is the hydropower which uses hydroturbines to generate electricity.

1.4 PROJECT OBJECTIVE

1. To design and fabricate a laboratory scale hydroturbine test rig using the most suitable design for indoor use.
2. To conduct a simple analysis of the design of the turbine and to set up the hydroturbine.

1.5 PROJECT SCOPE

1. To set-up a portable micro-hydroturbine test rig for indoor use.
2. To use water obtained through submersible water pump as water source for turbine.
3. To set-up the micro-hydroturbine and analyze the design.

1.6 GANTT CHART

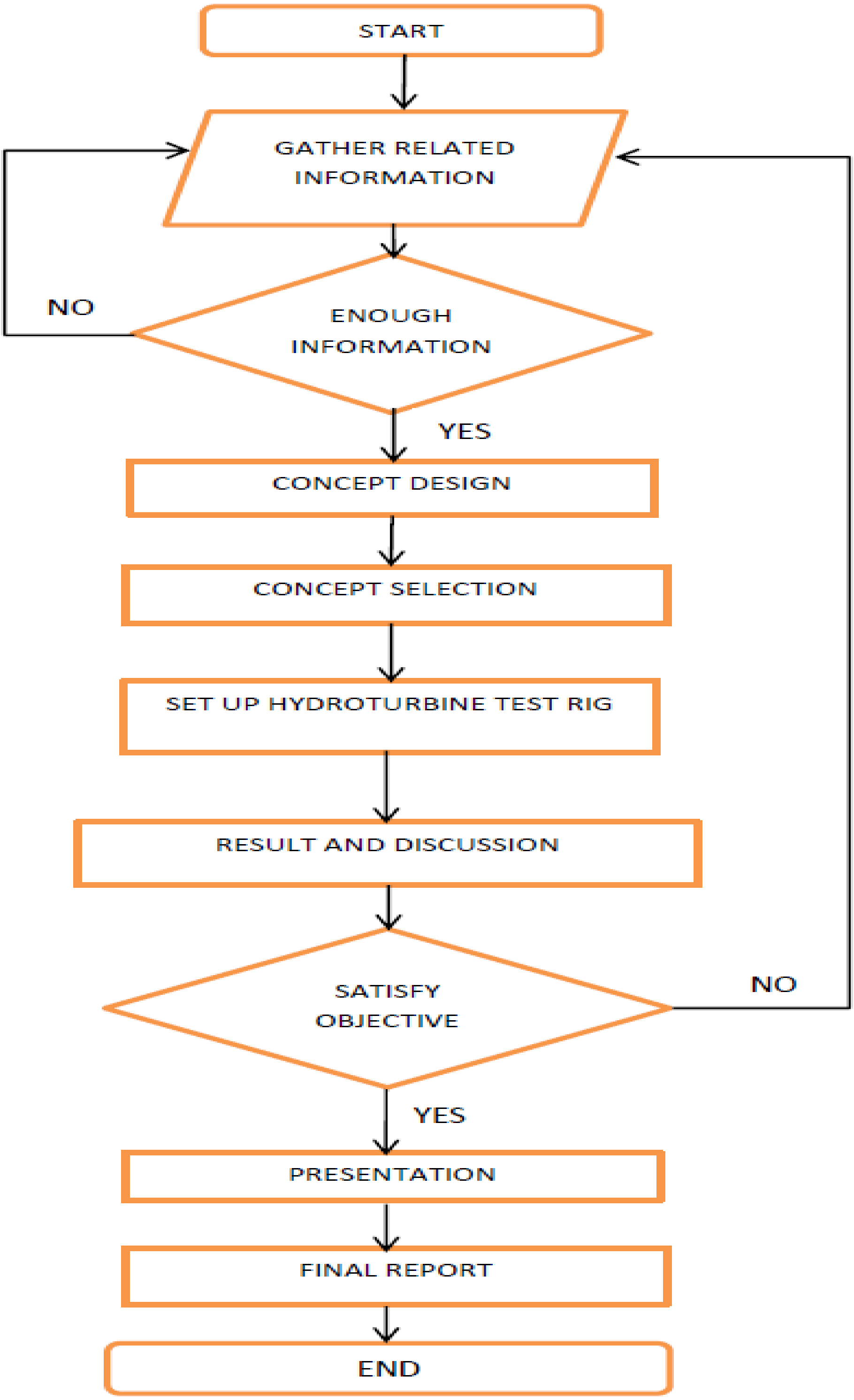
Table 1.1 shows the Gantt chart of the project. In this table, the duration for the planned timing for each task and the actual time used during completing the project is shown.

Table 1.1: Gantt chart

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
DISCUSSION REGARDING PROJECT	PLANNING	🟦	🟦												
	ACTUAL		🟥												
LITERATURE REVIEW	PLANNING	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
	ACTUAL	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥						
SKETCH AND DESIGN	PLANNING			🟦	🟦										
	ACTUAL			🟥	🟥										
FINALIZE DESIGN	PLANNING					🟦									
	ACTUAL					🟥									
SIMPLE ANALYSIS	PLANNING					🟦									
	ACTUAL					🟥									
FABRICATION	PLANNING						🟦	🟦	🟦	🟦	🟦				
	ACTUAL							🟥	🟥	🟥	🟥	🟥	🟥	🟥	
FIRST PRESENTATION	PLANNING								🟦						
	ACTUAL								🟥						
TEST, ANALYSIS AND DISCUSSION	PLANNING											🟦	🟦	🟦	🟦
	ACTUAL											🟥	🟥	🟥	🟥
FINAL PRESENTATION	PLANNING														🟦
	ACTUAL														🟥
FINAL REPORT	PLANNING						🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
	ACTUAL										🟥	🟥	🟥	🟥	🟥

1.7 FLOW CHART

The flow chart shows the steps that is carried out during planning and carrying out the project. It includes all the steps from gathering the information till writing the final report.


START
GATHER RELATED INFORMATION
ENOUGH INFORMATION
NO
YES
CONCEPT DESIGN
CONCEPT SELECTION
SET UP HYDROTURBINE TEST RIG
RESULT AND DISCUSSION
SATISFY OBJECTIVE
NO
YES
PRESENTATION
FINAL REPORT
END

CHAPTER 2

LITERATURE REVIEW

2.1 Micro-hydro system

2.1.1 Hydropower

Flowing and falling water have potential energy. Hydropower comes from converting energy in flowing water by means of a water wheel or through a turbine into useful mechanical power. This power is converted into electricity using an electric generator or is used directly to run machines. Small-scale hydropower systems, however, are receiving a great deal of public interest as a promising, renewable source of electrical power for homes, parks and remote communities. Hydropower technology has been with us for more than a century.

Micro-hydropower systems are relatively small power sources that are appropriate in most cases for individual users or groups of users who are independent of the electricity supply grid. Hydropower systems are classified as large, medium, small, mini and micro according to their installed power generation capacity. Electrical power is measured in watts (W), kilowatts (kW) or megawatts (MW).A micro-hydropower system is generally classified as having a generating capacity of less than 100 kW. Systems that have an installation capacity of between 100 kW and 1000 kW (1.0 MW) are referred to as mini-hydro. Small hydro is defined as having a capacity of more than 1.0 MW and up to 10 MW, although in Canada small-hydro can be defined by provincial and territorial utilities as having a capacity of less than 30 MW or 50 MW.

2.1.2 Micro-hydro systems components

A water turbine will convert the energy of flowing or falling water into mechanical energy that drives a generator, which generates electrical power , this is the heart of a micro-hydropower system. A control mechanism will provide stable electrical power. A electrical transmission lines will deliver the power to its destination.

2.1.3 Advantages of using micro-hydropower

Depending on individual circumstances, many people find that they need to develop their own source of electrical power. Other renewable energy sources, such as solar and wind, can be used to produce electrical power. The choice of energy source depends on several factors, including availability, economics and energy and power requirements. Micro-hydropower systems offer a stable, inflation-proof, economical and renewable source of electricity that uses proven and available technologies. These technologies can produce as little as 100 W of electricity at low cost and at very competitive rates, and appropriately designed and implemented systems can provide inexpensive energy for many years. Without hydropower and other renewable energy sources, fossil fuel alone would have to meet our electricity needs. Diesel and gasoline generators are currently cheaper to buy, but the increasing cost of fuel oil and maintenance has made them expensive to operate.

There is also the effect of their long-term environmental impact. Small and micro-hydropower installations have, historically, been cheap to run but expensive to build. This is now changing, with smaller, lighter and more efficient higher-speed turbine equipment, the lower cost of electronic speed- and load-control systems, and inexpensive plastic penstock pipes. Capital investments of hydropower systems are still higher than investing in diesel equipment of comparable capacity, but their long life, low operating costs and emerging renewable energy incentives make such systems an attractive investment for many applications.

There can be several reasons for wanting to build a micro-hydropower system. It can be used generate electricity to fulfill basic needs for lighting, electronic devices, computers, small appliances, tools, washing machines, dryers, refrigerators, freezers, hot water, space heating or cooking. Other reasons is helping to protect the environment by avoiding the use of fossil fuels or to be independent of the power grid. who are considering off-grid power generation. Applying micro-hydropower technology in remote locations where electricity is provided by diesel generators offers an opportunity to replace a conventional fuel with a renewable energy source. It has been demonstrated that water power can produce many times more power and energy than several other sources for the same capital investment.

A micro-hydropower system is a non-depleting and non-polluting energy source that has provided reliable power in the past and is one of the most promising renewable energy sources for the future.

All of the commercial micro hydro generators available today use a small turbine connected to an electrical generator or alternator. Water is collected in an intake pipe upstream, travels down to the turbine in plastic pipe, and is forced through one or more nozzles by its own gravity pressure. No dam is needed : systems without a dam are called "run of river" systems. Power is generated by a generator or alternator directly connected to the turbine wheel (no gears or pulleys needed). All of the factors below must be calculated correctly for micro-hydro equipment to make power most efficiently. For proper operation, several factors must be taken into count, most importantly the vertical drop in feet (called "head"), the amount of water flow available during different seasons in gallons per minute, and the length of pipeline required to get a sufficient head.

2.1.4 Important considerations

Micro-hydro systems use flowing water to turn a water turbine that generates electricity in an alternator. The efficiency of most micro-hydro generators ranges from 30–70%. They are viable as small-scale electricity generators that can provide electricity to a building or property.

The main requirements are that the micro-hydro system has:

- sufficient water head and flow rate
- access to a regular water source (stream or spring).

i. Head

The head is the height difference between where the water would enter the hydro power system and it would leave it, measured in metres. Typically this could be the height of a weir or the vertical drop of water over a water wheel. If a waterwheel is an overshot type, the head will be the same as the wheel diameter. If the site is undeveloped and has no old watermill structures present, then the potential head would be between where the hydro intake screen would be and where the water discharged from the turbine would return to the watercourse.

With hydro it is very important to get as much head as possible can, as more head means more power for not much more cost. Depending on how much flow, the minimum amount of head required for a viable hydro system varies. If it has low head and low flow, then installing a hydro system won’t be very cost effective. Typically a head in excess of 1m is the minimum requirement.

ii. Flow

This the amount of water that can be passed through the turbine, measured in cubic meters per second. If is very difficult to work out how much flow there is at a site, and establishing this forms a large part of the feasibility studies that we offer. Estimate the average annual flow, and not the flow on the wettest day of the year.

iii. Penstocks

The penstock inlet should be located as low as possible in the water so that it remains submerged when water levels are low. However, if it is too low, it may get blocked by sediment building up in front of it. An air vent may be required near the intake to prevent damage if the intake blocks and a vacuum is created. Penstocks must slope downwards or an air lock may form, affecting performance.

A penstock should include a shut-off valve to stop water flow during maintenance of the turbine. They must be strong enough to resist the design water pressures and be protected from rapid starting and stopping of the water flow. They must also be protected from impact damage and exposure to the sun by being buried or enclosed in a box structure.

iv. Capacity

Electricity generation of micro-hydro systems is directly proportional to the head of water and the water flow rate, e.g. the same power generation can potentially be achieved by a generator with a low head and high water flow rate (e.g. flat terrain with a large water catchment) or a high head and low water flow rate (e.g. steeper terrain with less water catchment area).

v. Static head

The static head is the vertical distance between the water level at the intake and the discharge point. Both these levels are where the water has contact with air. The water discharge level for an impulse turbine is where the water leaves the inlet pipe and enters the turbine. For a reaction turbine, the discharge level is where the water is discharged from the outlet pipe.

The static head increases as the water level at the intake increases. Minimum static head is where the water level aligns with the top of the inlet pipe – keeping in mind the inlet pipe entry needs to remain submerged.

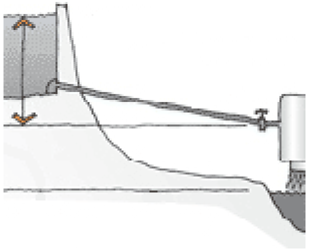


Figure 2.1: Micro-hydro static head

The static head (or gross head) is the vertical distance between the water level at the intake and the point at which the water is discharged.

vi. Dynamic head

The dynamic head (in metres) is the static head (or gross head) less the losses in the pipework. The losses are summed and converted to a pressure head value in metres. The dynamic head is therefore the actual amount of water pressure head available to generate electricity.

Friction losses should be minimised by:

- short pipe lengths
- large pipe diameters
- few pipe bends
- high-radius pipe bends
- steep gradient.

Friction losses will also occur when the intake gets blocked.

vii. Water flow rate

The water flow rate (in litres per second) is the amount of water moving through a pipe in a specific period of time. As the water flow rate increases, the turbine spins faster and more electricity is generated.

The main water flow will typically vary during the year and between years and may be dependent on:

- seasonal rainfall
- snow and ice melt in the mountains
- cycles of flooding or drought
- blockages higher up the water source.

Micro-hydro generators work best where there is reasonably continuous water supply, giving a reasonably constant static head. It is important to determine what the average year-round water level is at the intake, as this will be used for the static head to determine the year-round power output.

Any intake water storage system with a reasonably constant water flow into it will maintain a consistent or equilibrium water level. When storage water levels are:

- higher, the generator flow rate increases until the level drops
- lower, the generator flow rate decreases until the level rises.

This equilibrium water level will be the design static head for the system. However, it can be difficult to determine initially as it is related to the water flow rate through the generator and in the main water source. The water flow rate at a site is not simple to measure and may require the temporary installation of a weir. The water flow rate through the generator can be determined by iterative design techniques for different water, Turbine capacity

The micro-hydro generation capacity specific to the installed system depends on the effectiveness of converting the linear water pressure force into turbine rotary inertia and then electricity.

This increases with:

- larger pipe diameter and turbine size – allowing a higher water flow rate
- appropriate turbine blade profile for the average water flow rate and pressure
- lower friction losses in the turbine shaft assembly.

2.1.5 Installation of the micro-hydro system

To install a micro-hydro system, there are several factors to be considered, which are:

- will require a building consent and a resource consent
- should be installed as close as possible to the electricity supply or storage system, to reduce line power losses
- must withstand the water loads
- must have protection from impact, particularly for the less solid pipe work.

- generally requires little maintenance as it has few moving parts – the main issue is normally having to replace the alternator brushes and flushing the turbine
- may need regular cleaning of the filter, depending on the amount of debris in the water supply
- must incorporate a means of restricting the natural outward flow of water to build up reserve capacity
- must incorporate a bypass overflow in case of flooding of the reservoir.

2.1.6 Environmental impact

Micro-hydro generator systems have an impact on the water course. They may potentially affect:

- plant and fish life in the water
- plant and animal life beside the water
- other users of the water further down stream
- the stability of the surrounding land thought the excavation for the reservoir.

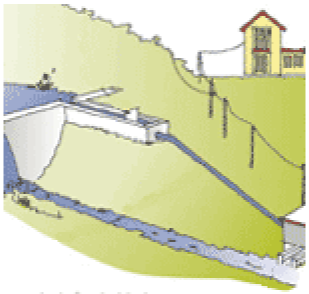


Figure 2.2: Water diversion for micro-hydro system

Even small dams can have a significant impact both downstream and upstream as they are a break-point in the water system. It is therefore more usual, and more acceptable to the consenting authorities, to temporarily divert a portion of the main water flow into the micro-hydro generator. The water is returned downstream, and there is no block in movement up or down stream. In general, the amount of water used for the micro-hydro system should be no more than 50% of the minimum seasonal flow rate of the water source.

2.2 Turbine

2.2.1 Introduction

A water turbine is a rotary engine that takes energy from moving water.Water turbines were developed in the nineteenth century and were widely used for industrial power prior to electrical grids. Now they are mostly used for electric power generation. They harness a clean and renewable energy source.

The word turbine was introduced by the French engineer Claude Bourdin in the early 19th century and is derived from the Latin word for "whirling" or a "vortex". The main difference between early water turbines and water wheels is a swirl component of the water which passes energy to a spinning rotor. This additional component of motion allowed the turbine to be smaller than a water wheel of the same power. They could process more water by spinning faster and could harness much greater heads. Later, impulse turbines were developed which didn't use swirl.

In 1849, James B. Francis improved the inward flow reaction turbine to over 90% efficiency. He also conducted sophisticated tests and developed engineering methods for water turbine design. The Francis turbine, named for him, is the first modern water turbine. It is still the most widely used water turbine in the world today. The Francis turbine is also called a radial flow turbine, since water flows from the outer circumference towards the centre of runner.

Inward flow water turbines have a better mechanical arrangement and all modern reaction water turbines are of this design. As the water swirls inward, it accelerates, and transfers energy to the runner. Water pressure decreases to atmospheric, or in some cases subatmospheric, as the water passes through the turbine blades and loses energy.

Around 1913, Viktor Kaplan created the Kaplan turbine, a propeller-type machine. It was an evolution of the Francis turbine but revolutionized the ability to develop low-head hydro sites.

In 1879, Lester Pelton(1829-1908), experimenting with a Knight Wheel, developed a double bucket design, which exhausted the water to the side, eliminating some energy loss of the Knight wheel which exhausted some water back against the center of the wheel. In about 1895, William Doble improved on Pelton's half-cylindrical bucket form with an elliptical bucket that included a cut in it to allow the jet a cleaner bucket entry.

This is the modern form of the Pelton turbine which today achieves up to 92% efficiency. Pelton had been quite an effective promoter of his design and although Doble took over the Pelton company he did not change the name to Doble because it had brand name recognition.

2.2.2 Theory of operation

Flowing water is directed on to the blades of a turbine runner, creating a force on the blades. Since the runner is spinning, the force acts through a distance (force acting through a distance is the definition of work). In this way, energy is transferred from the water flow to the turbine

Water turbines are divided into two groups; reaction turbines and impulse turbines.

The precise shape of water turbine blades is a function of the supply pressure of water, and the type of impeller selected.Turbines work in two different ways described as impulse and reaction.

i. Impulse turbines

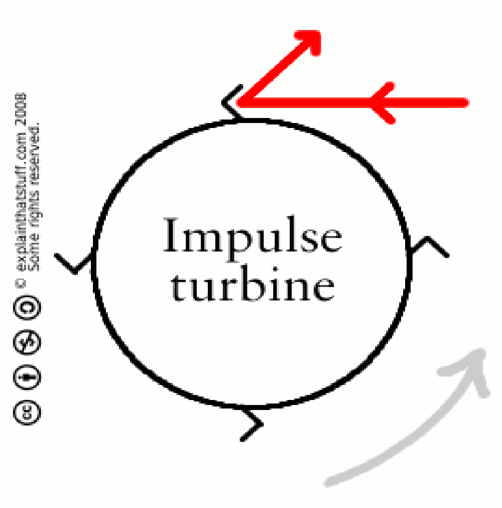


Figure 2.3: Impulse turbine

In an impulse turbine, a fast-moving fluid is fired through a narrow nozzle at the turbine blades to make them spin around. The blades of an impulse turbine are usually bucket-shaped so they catch the fluid and direct it off at an angle or sometimes even back the way it came (because that gives the most efficient transfer of energy from the fluid to the turbine). In an impulse turbine, the fluid is forced to hit the turbine at high speed.

Figure 2.4: A Pelton wheel

ii. Reaction turbines

In a reaction turbine, the blades sit in a much larger volume of fluid and turn around as the fluid flows past them. A reaction turbine doesn't change the direction of the fluid flow as drastically as an impulse turbine: it simply spins as the fluid pushes through and past its blades.

If an impulse turbine is a bit like kicking soccer balls, a reaction turbine is more like swimming—in reverse. With a reaction turbine, the water touch the blades smoothly, for as long as it can, so it gives up as much energy as possible.

The water isn't hitting the blades and bouncing off, as it does in an impulse turbine: instead, the blades are moving more smoothly, "going with the flow".

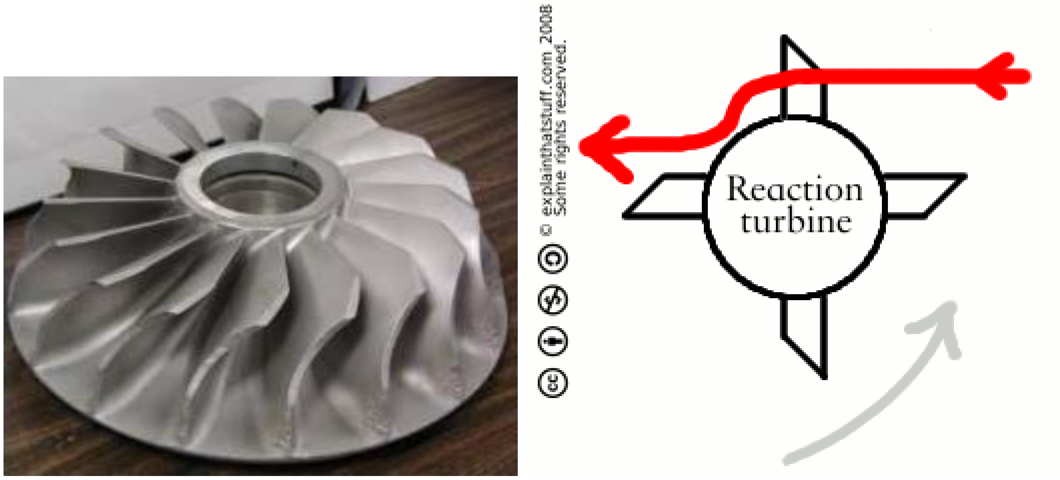


Figure 2.5: A typical reaction turbine

Water turbines are basically fairly simple systems. They consist of the following components:

- intake shaft - a tube that connects to the piping or penstock which brings the water into the turbine
- water nozzle - a nozzle which shoots a jet of water (impulse type of turbines only)
- runner - a wheel which catches the water as it flows in causing the wheel to turn
- generator shaft - a steel shaft that connects the runner to the generator
- generator - a small electric generator that creates the electricity
- exit valve - a tube or shute that returns the water to the stream it came fro
- powerhouse - a small shed or enclosure to protect the water turbine and generator from the elements

iii. **Impulse vs. Reaction Turbines**

In a reaction turbine the runners are fully immersed in water and are enclosed in a pressure casing. The runner blades are angled so that pressure differences across them create lift forces, like those on aircraft wings, and the lift forces cause the runner to rotate.

In an impulse turbine the runner operates in air, and is turned by one or multiple jets of water which make contract with the blade. A nozzle converts the pressurized low velocity water into a high speed jet much like with a garden hose nozzle. The nozzle is aligned so that it provides maximum force on the blades.

2.2.3 Types of turbine

Reaction turbines:

- Francis
- Kaplan, Propeller, Bulb, Tube, Straflo
- Tyson, Gorlov (Freeflow types)
- Water wheel
- Archimedean screw turbine

Impulse turbine

- Pelton
- Turgo
- Michell-Banki (also known as the Crossflow or Ossberger turbine)

2.2.4 Impulse Turbines

The Pelton Turbine consists of a wheel with a series of split buckets set around its rim; a high velocity jet of water is directed tangentially at the wheel. The jet hits each bucket and is split in half, so that each half is turned and deflected back almost through 180º. Nearly all the energy of the water goes into propelling the bucket and the deflected water falls into a discharge channel below.

The Turgo turbine is similar to the Pelton but the jet strikes the plane of the runner at an angle (typically 20°) so that the water enters the runner on one side and exits on the other. Therefore the flow rate is not limited by the discharged fluid interfering with the incoming jet (as is the case with Pelton turbines). As a consequence, a Turgo turbine can have a smaller diameter runner than a Pelton for an equivalent power.

The Crossflow turbine has a drum-like rotor with a solid disk at each end and gutter-shaped “slats”joining the two disks. A jet of water enters the top of the rotor through the curved blades, emerging on the far side of the rotor by passing through the blades a 2nd time. The shape of the blades is such that on each passage through the periphery of the rotor the water transfers some of its momentum, before falling away with little residual energy.

2.2.5 Reaction Turbines

Reaction turbines exploit the oncoming flow of water to generate hydrodynamic lift forces to propel the runner blades. They are distinguished from the impulse type by having a runner that always functions within a completely water-filled casing.

All reaction turbines have a diffuser known as a ‘draft tube’ below the runner through which the water discharges. The draft tube slows the discharged water and reduces the static pressure below the runner and thereby increases the effective head.

Propeller-type turbines are similar in principle to the propeller of a ship, but operating in reversed mode.

Various configurations of propeller turbine exist; a key feature is that for good efficiency the water needs to be given some swirl before entering the turbine runner. With good design, the swirl is absorbed by the runner and the water that emerges flows straight into the draft tube. Methods for adding inlet swirl include the use of a set of guide vanes mounted upstream of the runner with water spiralling into the runner through them. Another method is to form a “snail shell” housing for the runner in which the waterenters tangentially and is forced to spiral in to the runner. When guide vanes are used, these are often adjustable so as to vary the flow admitted to the runner. In some cases the blades of the runner can also be adjusted, in which case the turbine is called a Kaplan.

The mechanics for adjusting turbine blades and guide vanes can be costly and tend to be more affordable for large systems, but can greatly improve efficiency over a wide range of flows.

The Francis turbine is essentially a modified form of propeller turbine in which water flows radially inwards into the runner and is turned to emerge axially. For medium-head schemes, the runner is most commonly mounted in a spiral casing with internal adjustable guide vanes.

Since the cross-flow turbine is now a less costly (though less efficient)alternative to the spiral-case Francis, it is rare for these turbines to be used on sites of less than 100 kW output.

The Francis turbine was originally designed as a low-head machine, installed in an open chamber without a spiral casing. Although an efficient turbine, it was eventually superseded by the propeller turbine which is more compact and faster-running for the same head and flow conditions. However, many of these ‘open-flume’ Francis turbines are still in place, hence this technology is still relevant for refurbishment schemes.

2.2.6 Comparison

Several different types of water turbines can be used in micro hydro installations, selection depending on the head of water, the volume of flow, and such factors as availability of local maintenance and transport of equipment to the site. For mountainous regions where a waterfall of 50 meters or more may be available, a Pelton wheel can be used. For low head installations, Francis or propeller-type turbines are used. Very low head installations of only a few meters may use propeller-type turbines in a pit. The very smallest micro hydro installations may successfully use industrial centrifugal pumps, run in reverse as prime movers; while the efficiency may not be as high as a purpose-built runner, the relatively low cost makes the projects economically feasible.

In low-head installations, maintenance and mechanism costs often become important. A low-head system moves larger amounts of water, and is more likely to encounter surface debris. For this reason a Banki turbine, a pressurized self-cleaning crossflow waterwheel, is often preferred for low-head microhydropower systems. Though less efficient, its simpler structure is less expensive than other low-head turbines of the same capacity. Since the water flows in, then out of it, it cleans itself and is less prone to jam with debris.

2.2.7 Customizing Water Turbine Power Output

Water turbines come in a range of output voltages, to match the overall voltage of the electrical system. While 12 volt is common for small to mid-sized systems, large systems can be designed in 24 or 48 volt configurations. For marine use, most boats will have a 12 volt system.

For impulse-style turbine systems, power output can be increased in high-flow sites by using multiple nozzles on the runner enclosure and/or using a larger diameter runner. Many reaction style turbine models also come with the option for two or more runner diameters, with the larger option providing more power for higher flow sites.

In sites with sufficient water flow volume, multiple turbines of any style, or a mix of different styles in some cases, can be assembled into a single high-output system.

In order to protect a propeller generator and its mounting assembly, the entire assembly should be removed from a river when the first signs of surface-freezing appear. After the ice layer over the river has formed completely, a hole can be cut in the ice to accommodate the re-installation of the generator and mounting assembly. In spring, the generator should be removed from the river when break-up begins, and can be re-installed once the surface ice has disintegrated to the point of not posing a structural threat to the assembly.

Taking these precautions will result in losing a couple months' use of the water turbine each year, but will prove invaluable in maximizing the generator's useful lifespan.

In marine use, a propeller turbine should be mounted on a hinged pole assembly that allows it to be locked down when in use, and swung up out of the water if the boat is moving through dangerous waters. In most cases a boat mounted turbine shouldn't be a major concern, as the boat will likely be piloted in areas with plenty of underwater clearance. However, the generator mount should extend deeper than the main portion of the boat's hull, so if any significant sub-surface debris is likely to come within a couple feet of the hull bottom, it may be wisest to temporarily pull the turbine out of the water.

2.2.8 Maintenance

Figure 2.5: Rusted turbine blade

A Francis turbine at the end of its life showing cavitation pitting, fatigue cracking and a catastrophic failure. Earlier repair jobs that used stainless steel weld rods are visible.

Turbines are designed to run for decades with very little maintenance of the main elements; overhaul intervals are on the order of several years. Maintenance of the runners and parts exposed to water include removal, inspection, and repair of worn parts.

Normal wear and tear includes pitting from cavitation, fatigue cracking, and abrasion from suspended solids in the water. Steel elements are repaired by welding, usually with stainless steel rod. Damaged areas are cut or ground out, then welded back up to their original or an improved profile. Old turbine runners may have a significant amount of stainless steel added this way by the end of their lifetime. Elaborate welding procedures may be used to achieve the highest quality repairs.

Other elements requiring inspection and repair during overhauls include bearings, packing box and shaft sleeves, servomotors, cooling systems for the bearings and generator coils, seal rings, wicket gate linkage elements and all surfaces.

2.2.9 Selecting the Best Type of Turbine

Which type of water turbine is best for a particular situation often depends on the amount of head (water pressure) you will have in your location and whether you want to suspend the turbine in the water (reaction) or whether you want to use jets of water (impulse). By considering at these factors together some indication of what type of turbine design will work best could be obtained:

Table 2.1: Factors in selecting turbine

Source: hydro-turbines.com

	High Head	Medium Head	Low Head
Impulse Turbine	Pelton Turgo	cross-flow multi-jet Pelton Turgo	cross-flow
Reaction Turbine		Francis	propeller Kaplan

2.2.10 Mixed-flow turbine

A Radial Inflow Turbine or mixed flow turbine infers that the working fluid passes from the outer diameter of the turbine assembly inward and exits the turbine rotor at a smaller diameter. The incoming fluid usually passes through a set of nozzles that cause the fluid to swirl and thereby entering the turbine rotor at the proper relative velocity. The flow then continues through the rotor where it continues to expand and impart energy to the rotor. The fluid then leaves the rotor near the rotational centerline. The blade angles at the rotor exit are designed to remove exit swirl as the fluid leaves the machine. This minimizes the energy in the exhaust flow thereby increasing the turbine efficiency. In some designs the inlet nozzles are replaced with an inlet scroll sized to provide the swirl to the rotor.

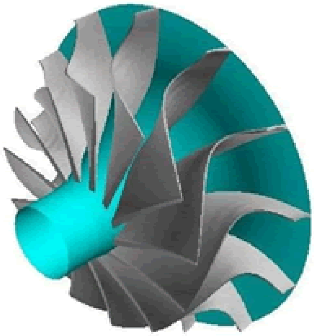


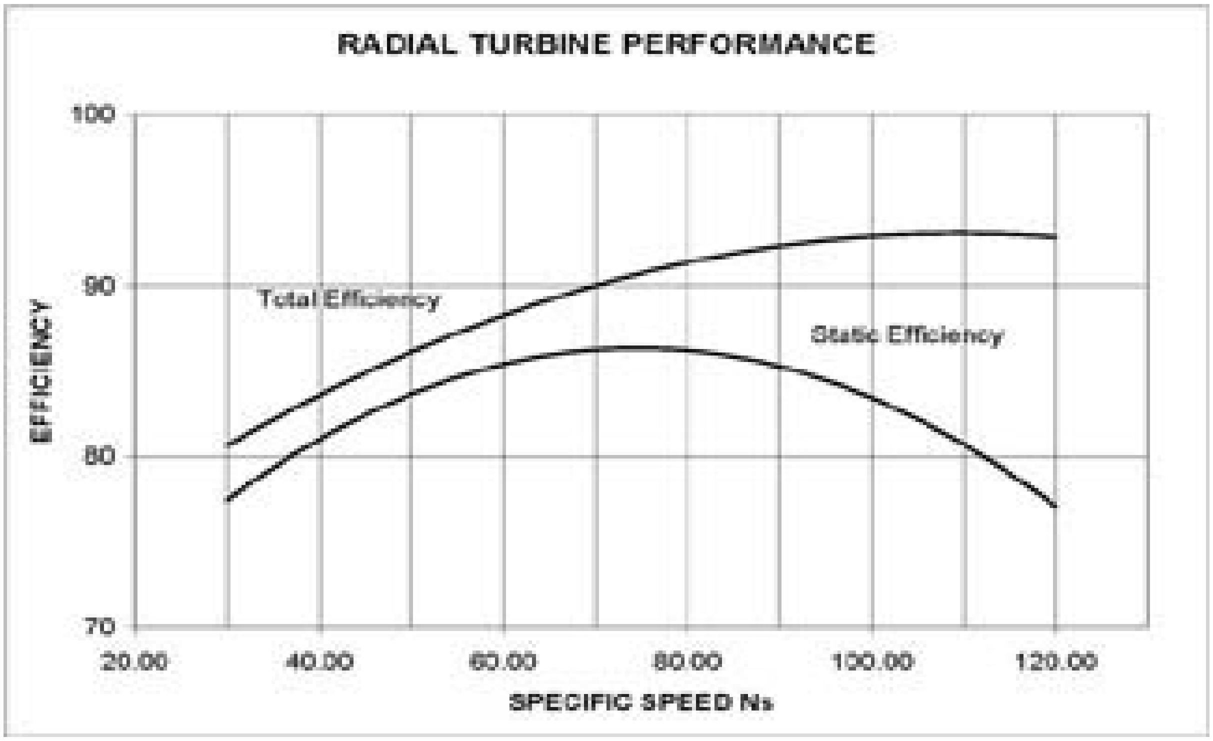
Figure 2.6: Mixed flow turbine blade

Figure 2.7: Mixed flow turbine blade

Figure 2.6 and Figure 2.7 shows mixed flow turbine blade. It clearly shows the shape of the blade. From the figure the exit design of the blade which reduces the exit swirl when water flows out from it can be seen.

Table 2.2 shows the radial turbine performance. It relates the efficiency and specific speed while comparing the static and the total efficiency.

Table 2.2: Mixed flow turbine efficiency



Submersible pump

2.3.1 Introduction

Submersible pump or electric submersible pump (ESP) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push water to the surface as opposed to jet pumps having to pull water. ESP systems are effective for pumping produced fluids to surface.

A system of mechanical seals are used to prevent the fluid being pumped from entering the motor and causing a short circuit.

The pump can either be connected to a pipe, flexible hose or lowered down guide rails or wires so that the pump sits on a "ducks foot" coupling, thereby connecting it to the delivery pipework.

Submersible pumps are found in many applications. Single stage pumps are used for drainage, sewage pumping, general industrial pumping and slurry pumping. They are also popular with aquarium filters. Multiple stage submersible pumps are typically lowered down a borehole and used for water abstraction or in water wells.

Special attention to the type of ESP is required when using certain types of liquids. ESP's commonly used on board naval vessels cannot be used to dewater contaminated flooded spaces. These use a 440 volt A/C motor that operates a small centrifugal pump. It can also be used out of the water, taking suction with a 2-1/2 inch non-collapsible hose. The pumped liquid is circulated around the motor for cooling purposes. There is a possibility that the gasoline will leak into the pump causing a fire or destroying the pump, so hot water and flammable liquids should be avoided.

A submersible water pump will not operate if it is not submerged in liquid. A submersible water pump pushes water to the surface, instead of sucking the water out of the ground like above ground water pumps. Most submersible pumps are long cylinders that are about 3 to 5 inches around and 2 to 4 feet long.

Other components of a submersible water pump are the cable, which is connected to the motor, and a pipe that transports the water to the surface of the well.

2.3.2 Advantages

Above ground water pumps have a higher rate of mechanical problems because they have to pull water up out of the well, whereas a submersible pump has fewer mechanical problems, and can last up to 25 years before needing to be replaced. An above ground water pump can suffer from a problem called cavitation, which is a common mechanical problem caused by the high elevation of the water pump compared to the surface of the water. Submersible water pumps do not get damaged due to cavitation because they are usually deep beneath the surface of the water.

2.3.3 Bringing Water to the Surface

When the pressure switch comes on, an electrical current is sent down an electrical wire to the submersible water pump. Impellers contained within the body of the pump start turning. The rotation of the impellers sucks water into the body of the pump. The impellers then push the water out of the pump and up through the pipe to the water tank. When the pressure switch cuts off, the current stops operating the submersible water pump, the impellers stop turning, and the water is no longer pushed to the surface by the pump.The advantage of this type of pump is that it can provide a significant lifting force as it does not rely on external air pressure to lift the fluid.

Submersible pumps are also used in oil wells. By increasing the pressure at the bottom of the well significantly, more oil can be produced from the well compared to natural production. This makes Electric Submersible Pumping (ESP) a form of "artificial lift" (as opposed to natural flow) along with Gas Lift, Beam Pumping, Plunger Lift and Progressive cavity pump. New varieties of ESP can include a water/oil separator which permits the water to be reinjected into the reservoir without the need to lift it to the surface.The ESP system consists of a number of components that turn a staged series of centrifugal pumps to increase the pressure of the well fluid and push it to the surface. The energy to turn the pump comes from a high-voltage (3 to 5 kV) alternating-current source to drive a special motor that can work at high temperatures of up to 300 °F (150 °C) and high pressures of up to 5000 lb/in² (34 MPa), from deep wells of up to 12000 feet (3.7 km) deep with high energy requirements of up to about 1000 horsepower (750 kW). ESPs have dramatically lower efficiencies with significant fractions of gas, greater than about 10% volume at the pump intake. Given their high rotational speed of up to 4000 rpm (67 Hz) and tight clearances, they are not very tolerant of solids such as sand.

2.4 Method of joining: Welding

2.4.1 Types of Welding

i. Arc Welding: A process utilizing the concentrated heat of an electric arc to join metal by fusion of the parent metal and the addition of metal to joint usually provided by a consumable electrode.

ii. Electro slag Welding: Deposits the weld metal into the weld cavity between the two plates to be joined.

iii. Fluxed-Core Arc Welding: Uses a tubular electrode filled with flux that is much less brittle than the coatings on SMAW electrodes while preserving most of its potential alloying benefits.

iv. Gas Metal-Arc Welding: Shields the weld zone with an external gas such as argon, helium, carbon dioxide, or gas mixtures.

v. Gas Tungsten-Arc Welding: Uses tungsten electrodes as one pole of the arc to generate the heat required. The gas is usually argon, helium, or a mixture of the two.

vi. Plasma Arc Welding: Uses electrodes and ionized gases to generate an extremely hot plasma jet aimed at the weld area.

vii. Shielded-Metal Arc Welding: Arc is generated by touching the tip of a coated electrode to the work piece and withdrawing it quickly to an appropriate distance to maintain the arc.

viii. Submerged Arc Welding: Using a granular flux fed into the weld zone forming a thick layer that completely covers the molten zone and prevents spatter and sparks.

ix. Metal Inert Gas Welding: Uses an aluminium alloy wire as a combined electrode and filler material.

x. Tungsten Inert Gas Welding: Uses a permanent non-melting electrode made of tungsten.

2.4.2 Arc welding

Arc welding is one of several fusion processes for joining metals. By applying intense heat, metal at the joint between two parts is melted and caused to intermix - directly, or more commonly, with an intermediate molten filler metal. Upon cooling and solidification, a metallurgical bond is created. Since the joining is an intermixture of metals, the final weldment potentially has the same strength properties as the metal of the parts. This is in sharp contrast to non-fusion processes of joining in which the mechanical and physical properties of the base materials cannot be duplicated at the joint.

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the actual work and an electrode (stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod with the purpose of simply carrying the current between the tip and the work. Or, it may be a specially prepared rod or wire that not only conducts the current but also melts and supplies filler metal to the joint. Most welding in the manufacture of steel products uses the second type of electrode.

Figure 2.8 shows the basic welding circuit which consists of welding machine with alternating current (AC) or direct current (DC) power source and control, electrode holder, electrode, arc, work piece, work cable and electrode cable.

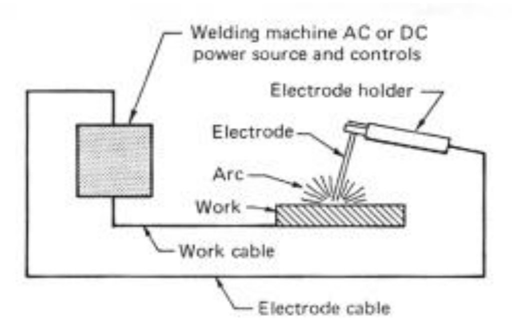


Figure 2.8:Basic Welding Circuit

i. Basic Welding Circuit

The basic arc-welding circuit is illustrated in Figure above. An AC or DC power source, fitted with whatever controls may be needed, is connected by a work cable to the workpiece and by a “hot” cable to an electrode holder of some type, which makes an electrical contact with the welding electrode.

An arc is created across the gap when the energized circuit and the electrode tip touches the workpiece and is withdrawn, yet still with in close contact.

The arc produces a temperature of about 6500ºF at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal sometimes called a “crater.” The crater solidifies behind the electrode as it is moved along the joint. The result is a fusion bond.

ii. Arc Shielding

However, joining metals requires more than moving an electrode along a joint. Metals at high temperatures tend to react chemically with elements in the air – oxygen and nitrogen. When metal in the molten pool comes into contact with air, oxides and nitrides form which destroy the strength and toughness of the weld joint. Therefore, many arc-welding processes provide some means of covering the arc and the molten pool with a protective shield of gas, vapor, or slag.

This is called arc shielding. This shielding prevents or minimizes contact of the molten metal with air. Shielding also may improve the weld. An example is a granular flux, which actually adds deoxidizers to the weld.

Figure below illustrates the shielding of the welding arc and molten pool with a Stick electrode. The extruded covering on the filler metal rod, provides a shielding gas at the point of contact while the slag protects the fresh weld from the air.

The arc itself is a very complex phenomenon. In-depth understanding of the physics of the arc is of little value to the welder, but some knowledge of its general characteristics can be useful.

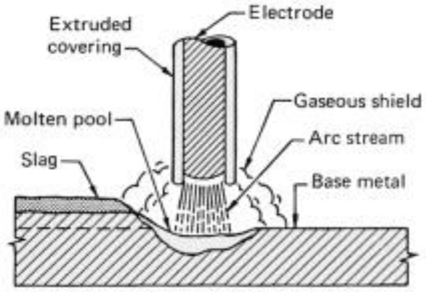


Figure 2.9: Welding diagram

This shows how the coating on a coated (stick) electrode provides a gaseous shield around the arc and a slag covering on the hot weld deposit.

iii. Nature of the Arc

An arc is an electric current flowing between two ectrodes through an ionized column of gas. A negatively charged cathode and a positively charged anode create the intense heat of the welding arc. Negative and positive ions are bounced off of each other in the plasma column at an accelerated rate.

In welding, the arc not only provides the heat needed to melt the electrode and the base metal, but under certain conditions must also supply the means to transport the molten metal from the tip of the electrode to the work. Several mechanisms for metal transfer exist. Two (of many) examples include:

i. Surface Tension Transfer - a drop of molten metal touches the molten metal pool and is drawn into it by surface tension.
ii. Spray Arc - the drop is ejected from the molten metal at the electrode tip by an electric pinch propelling it to the molten pool.
iii. If an electrode is consumable, the tip melts under the heat of the arc and molten droplets are detached and transported to the work through the arc column. Any arc welding system in which the electrode is melted off to become part of the weld is described as metal-arc. In carbon or tungsten (TIG) welding there are no molten droplets to be forced across the gap and onto the work. Filler metal is melted into the joint from a separate rod or wire.

More of the heat developed by the arc is transferred to the weld pool with consumable electrodes. This produces higher thermal efficiencies and narrower heat-affected zones.

Since there must be an ionized path to conduct electricity across a gap, the mere switching on of the welding current with an electrically cold electrode posed over it will not start the arc. The arc must be ignited. This is caused by either supplying an initial voltage high enough to cause a discharge or by touching the electrode to the work and then withdrawing it as the contact area becomes heated.

Arc welding may be done with direct current (DC) with the electrode either positive or negative or alternating current (AC). The choice of current and polarity depends on the process, the type of electrode, the arc atmosphere, and the metal being welded.

CHAPTER 3

METHODOLOGY

3.1 DESIGN GENERATION FOR ASSSEMBLY

3.1.1 Sketch 1

Figure 3.1 shows that water source is obtained from water pipe is then have to continuously transferred to the tank. Two tank is used. There is no water flow between the 2 tanks. When the turbine water is full, the operation has to be stopped and empty the tank again to ensure water does not spill out.

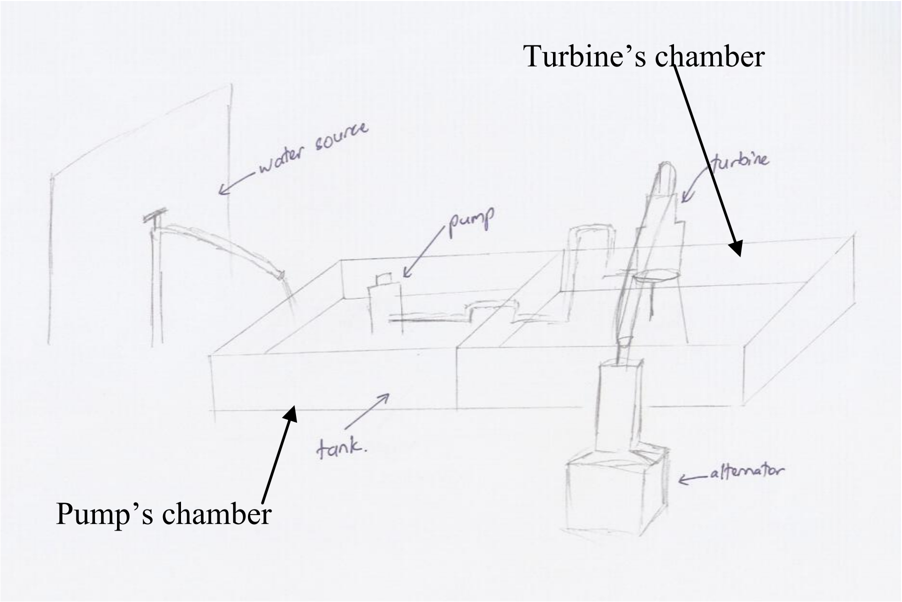


Figure 3.1: Sketch assembly 1

3.1.2 Sketch 2

In figure 3.2, only 1 tank is used. A barrier has to be produced to avoid water flow from the pump's chamber to the turbine's chamber. Space used is greatly minimized. However there is will be a shortage of water for the pump to operate because insufficient volume of water. So, water has to be continuously added to the pump's chamber.

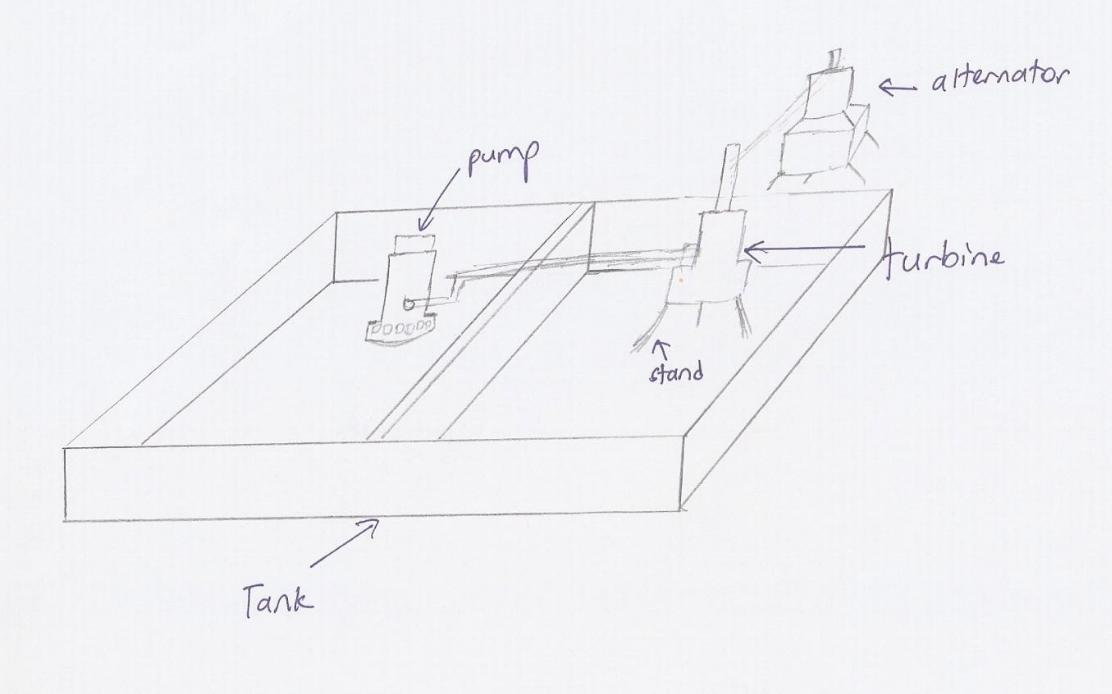


Figure 3.2: Sketch assembly 2

3.1.3 Sketch 3

In this design, 2 tanks is used separately the pump and the turbine. A piping with a ball valve as a stopper is placed between the tank to control the water flow. A large space is required to set up the design. When the pump needs refill the ball valve is opened and allow the water flow back to the pump's tank. In this case water don't have to be continuously added to the pump's tank.

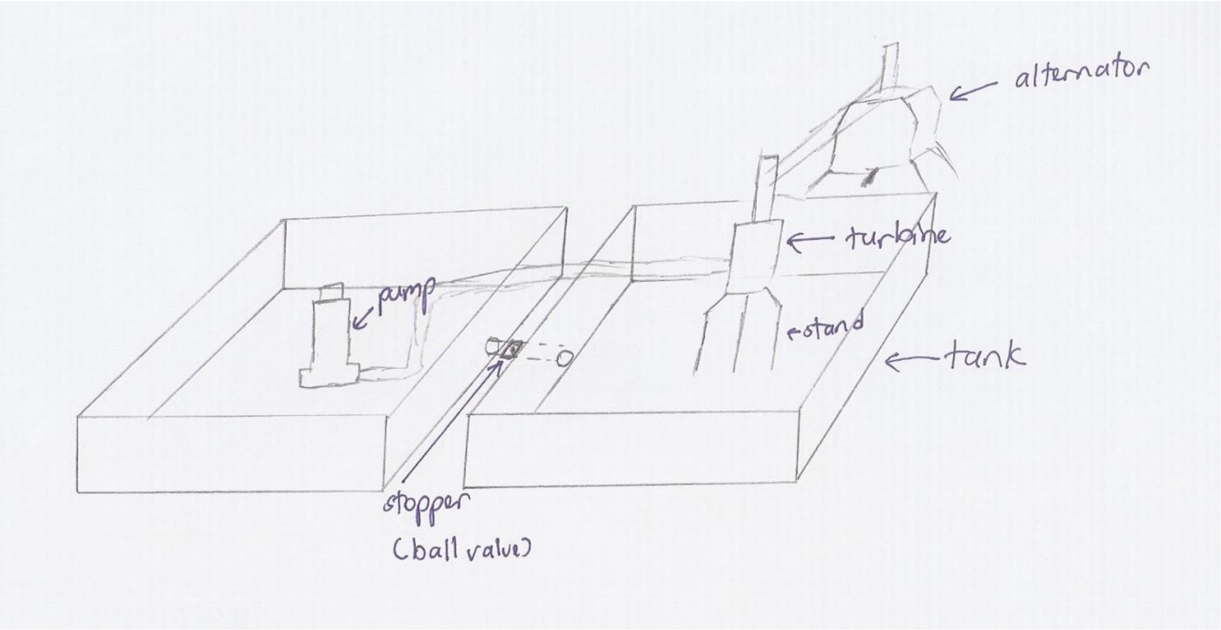


Figure 3.3: Sketch assembly 3

3.1.4 Sketch 4

In figure 3.4, this design uses only 1 tank. A special type of stand that could be placed above the tank should be designed. The water from the turbine will flow back into the pumps tank, so in this way water will continuously circulate in the process. Space used is greatly minimized. The head loss in the pipe can be greatly reduced and this would increase the turbine's efficiency. Water flow must be measured using a special device because the water will flow straight into the pump's tank.

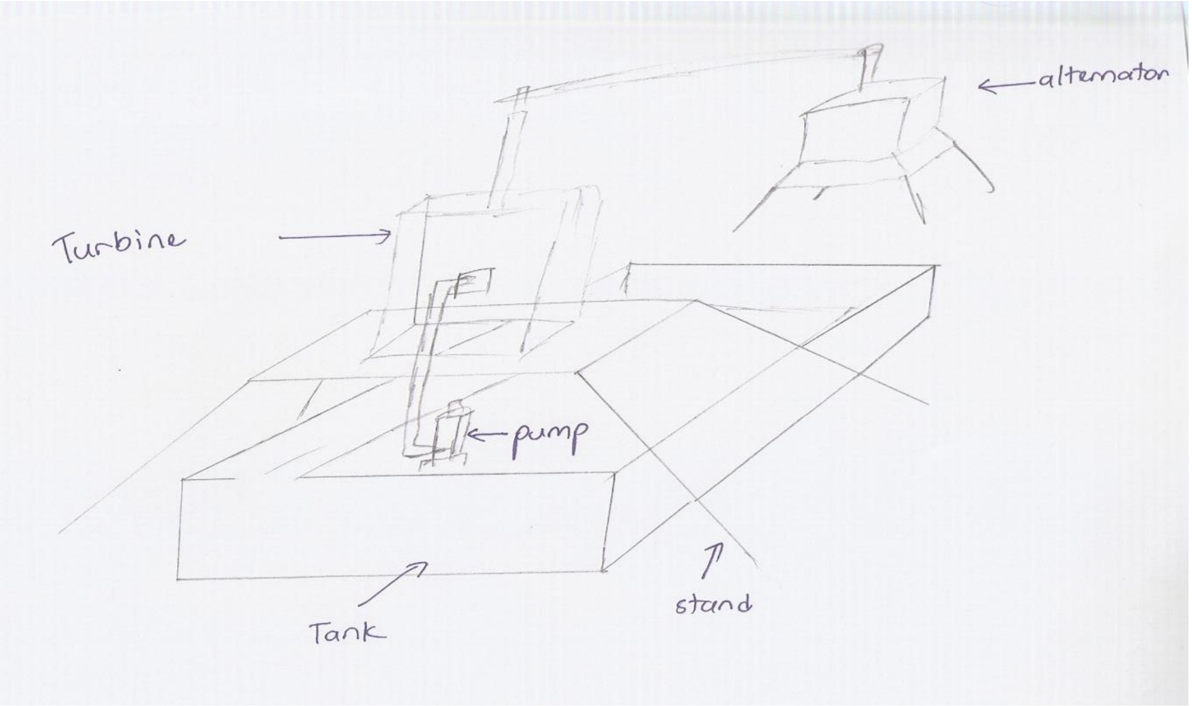


Figure 3.4: Sketch assembly 4

3.2 CONCEPT SELECTION FOR ASSEMBLY

Table 3.1: Concept variant for assembly

	Concept variants			
Selection criteria	1	2	3	4
Ease of assembly	0	0	-	0
Space optimization	-	-	+	+
Ease of water flow	-	+	0	+
Portability	-	-	+	+
Ease of handling	+	+	0	+
Plusses	1	2	2	4
Same	1	1	2	0
Minuses	3	2	1	0
Net	-2	0	1	4
Rank	4	3	2	1
Proceed ?	No	No	No	Yes

3.3 Finalized design for assembly

Figure 3.5 shows the finalized design for the assembly. In this design the test rig which will hold the turbine will be placed above the tank.

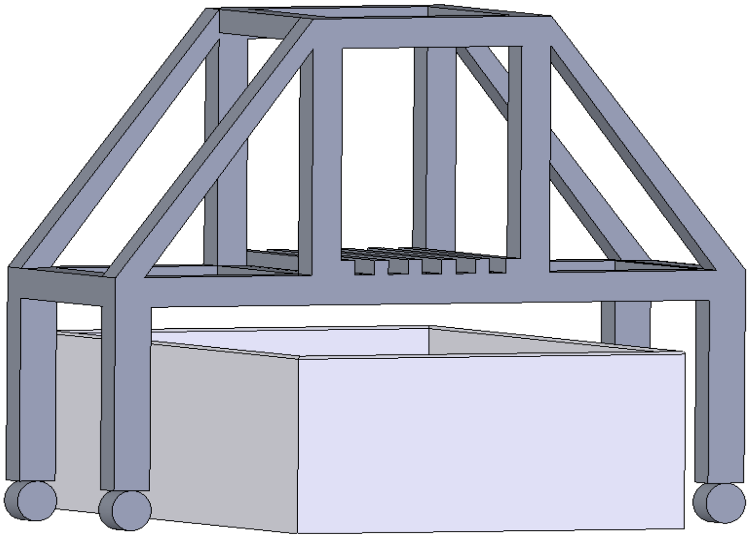


Figure 3.5: Finalized design for assembly

3.4 DESIGN GENERATION FOR TEST RIG

3.4.1 SKETCH 1

This design in figure 3.6 is easy to manufacture. This design is not stable and could not withstand a heavy load as the turbine. The legs of the stand may collapse due to heavy load. The round head of the stand would distribute the stress evenly.

Figure 3.6: Sketch stand 1

3.4.2 SKETCH 2

This design in figure 3.7 is easy to manufacture. This design is stable and could withstand a sufficient amount of load. However, the leg could also collapse if excessive load is pressurized on it. It has a square head.

Figure 3.7: Sketch stand 2

3.4.3 SKETCH 3

This design in figure 3.8 is very stable and could withstand a heavy load. The manufacture process of this design is quite hard. The turbine would vibrate while rotating because the 2 ends are open. Vibration may lead the turbine to fall. Although this design is strong, it is could not avoid the turbine from falling.

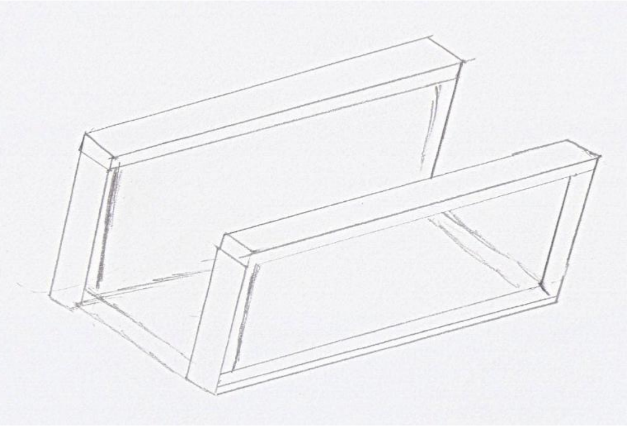


Figure 3.7: Sketch stand 3

3.4.4 SKETCH 4

This design in figure 3.8 is very stable and could withstand a very high load. It’s manufacturing process is quite hard. It could avoid the turbine from vibrating and falling apart. This structure is also strong but needs an extra support.

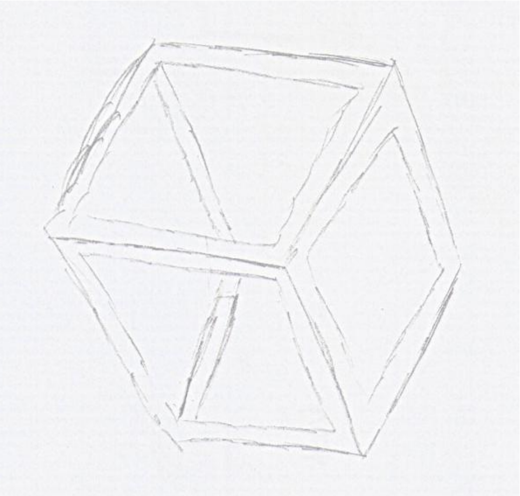


Figure 3.8: Sketch stand 4

3.5 CONCEPT SELECTION FOR TEST RIG

TABLE 3.2: Concept selection for test rig

	Concept variants			
Selection criteria	1	2	3	4
Ease of manufacture	+	+	0	-
Space optimization	+	+	0	-
Ease of water flow	0	0	0	+
Portability	0	0	-	-
Ease of handling	+	+	0	+
Stability	-	-	0	+
Durability	-	-	+	+
Strength	-	-	+	+
Plusses	3	3	2	5
Minuses	3	3	1	3
Same	2	2	5	0
Net	0	0	1	2
Rank	3	3	2	1
Proceed	No	No	No	Yes

3.6 Finalized design

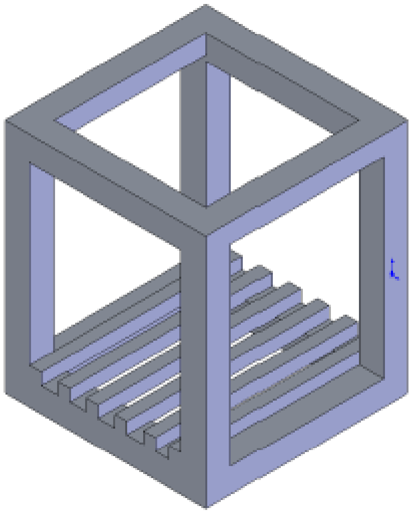


Figure 3.9: Finalized design for test rig

3.6 CONCEPT DEVELOPMENT

This design in figure 3.10 is easy to fabricate and water splash out from the turbine outlet will be fully minimized. However, this design is not stable enough to withstand the turbine's weight. The turbine will surely vibrate while rotating and this may cause the stand to fall if not stable. A supportive structure should be added to make it more stable.

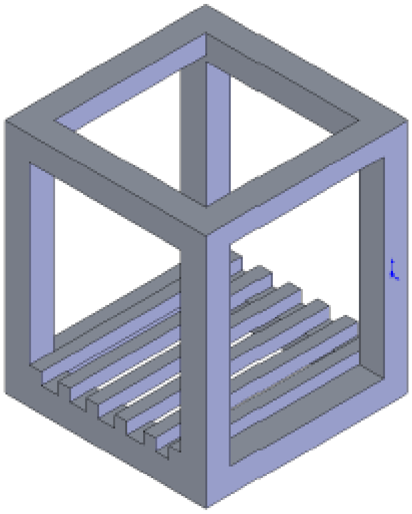


Figure 3.10: Original design for test rig

3.7.1 Improved design 1

This design in figure 3.11 is added with 2 extra supportive structures to make it more stable on each side. Now, when the turbine vibrates, the forces will be distributed evenly to each side of the stand, which has a wider base now. Pressure formula is : force/area. So when the surface area is increased, the pressure resulting from the weight and vibration will be greatly reduced. Thus, the stability of the stand is increased now. However, the stand will be very heavy now. If adding the turbine’s weight, it will be very hard to move it to shift it to other place. A mobile stand should be designed.

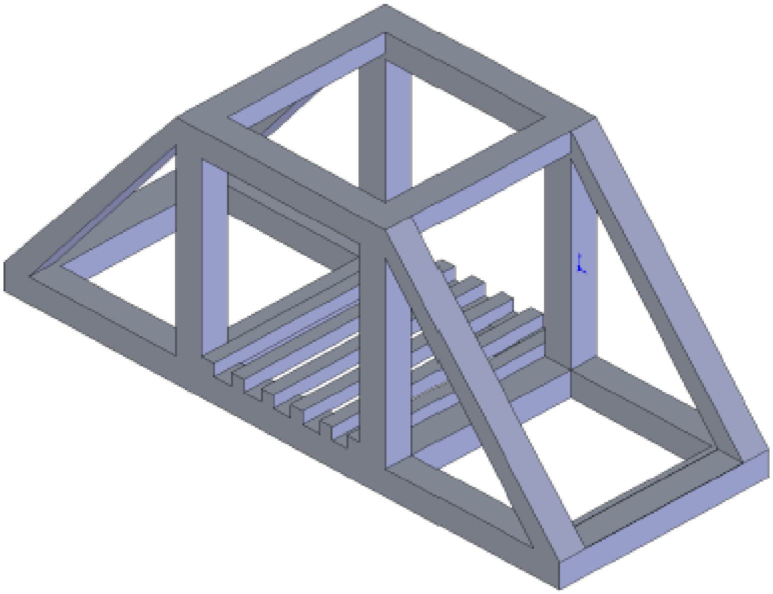


Figure 3.11: Improved design 1

3.7.2 Improved design 2

This design is now stable, and also mobile. As we can see, there is a supportive structures added to the leg of the stand to make it to distribute the load evenly when it is being moved. Now, the stand and the turbine can be moved easily without facing any problems that been faced previously. An important consideration to be taken is the tires of the stand. It should enable the user to make turn so that it will be easier to operated. The tires must be strong enough to withstand a very high load. This is because the entire load now will be pressured to the tires. So heavy duty tires such as the trolley tires should be used.

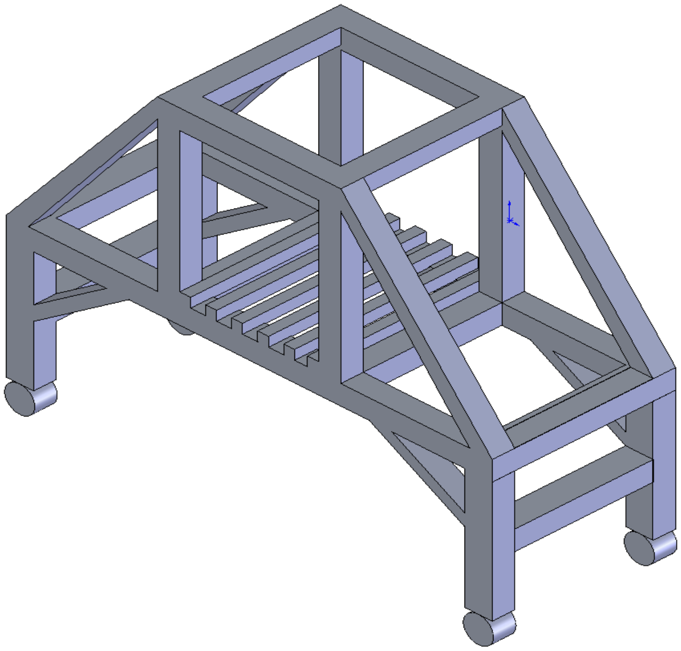


Figure 3.12: Improved design 2

3.7.3 Finalized design

Figure 3.13 shows that the turbine will be placed on top of the stand and water will be pumped out from the tank and shoot into the turbine using a pump. The used water from the turbine will again flow in to the tank. This ensures there is a constant supply of water and there is a sufficient head for the turbine blade to rotate. The stand is placed as close as possible to the tank to ensure water from the turbine does not splash out of the tank.

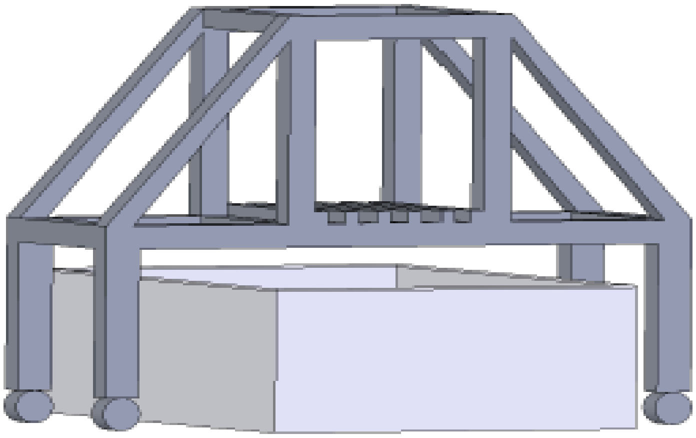


Figure 3.13: Finalized design

3.8 Final design and dimensions of test rig

In figure 3.14 , it shows the top, front and side view of the test rig. And a isometric view of it is also shown. Figure 3.15 shows the top view, figure 3.16 shows the front view and figure 3.17 shows the side view. From these figures, dimensions of the test rig can be seen clearly.

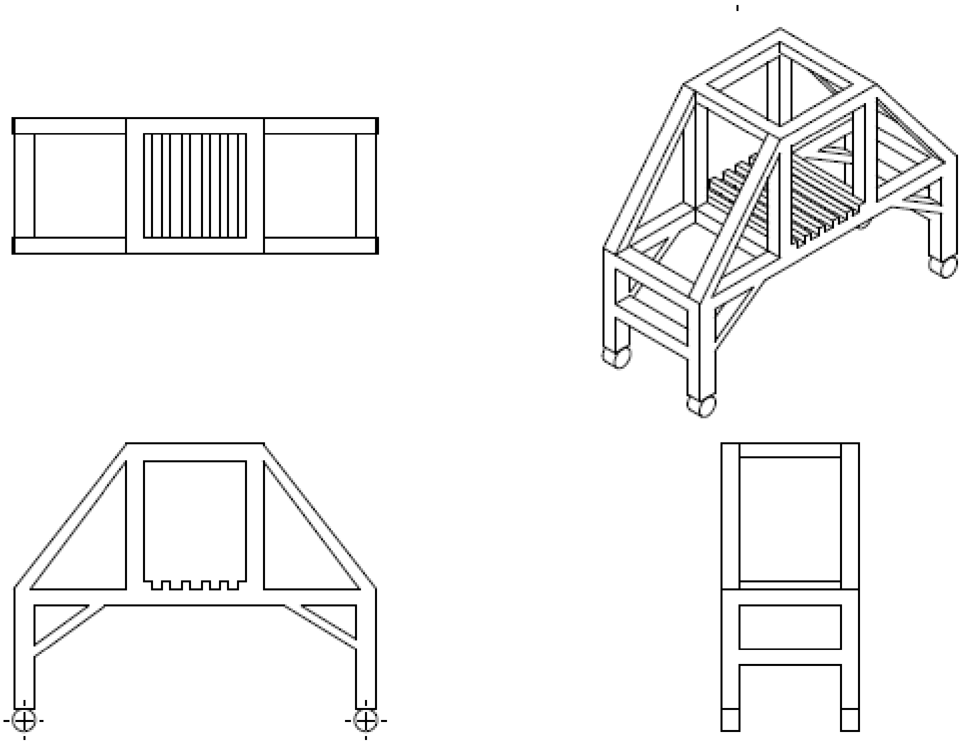


Figure3.14: 3-D annotational view

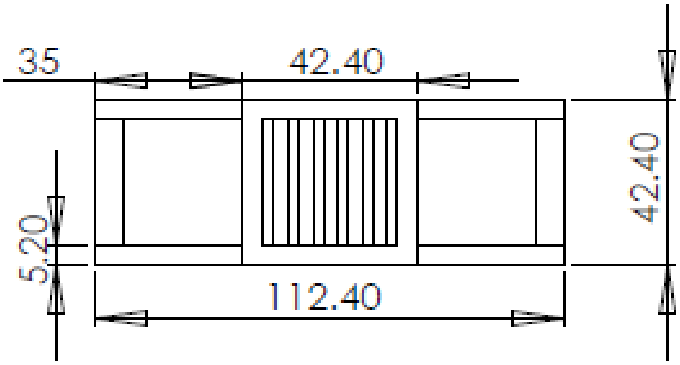


Figure 3.15: Top view

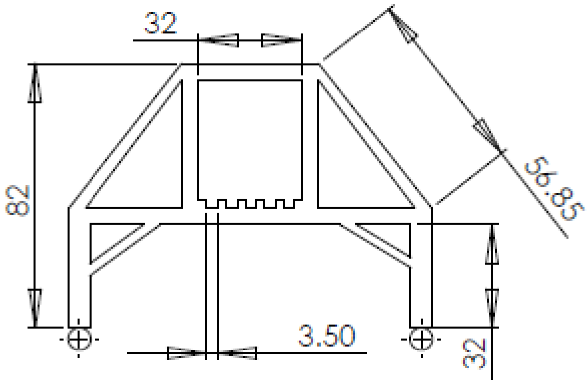


Figure 3.16: Front view

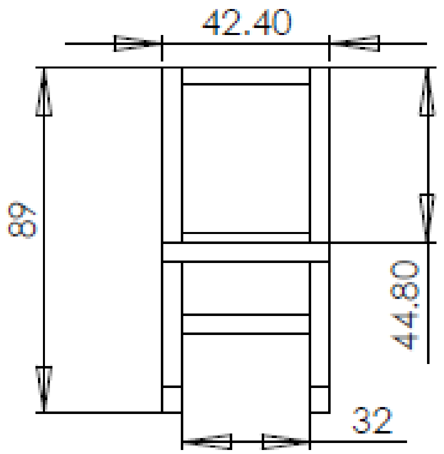


Figure 3.17: Side view

Table 3.3: Bill of materials

BILL OF MATERIALS			
PARTS	MATERIAL	DIMENSION	NO.
STAND	MILD STEEL HOLLOW BAR	52X52X396 52X52X372 52X52X274 52X52X568.5 52X52X320 52X52X424 52X52X1124 20X20X424	4 2 4 4 4 2 2 6
TURBINE RUNNER COVER	MILD STEEL ROD	18X50	4

3.9 FABRICATION

There are several fabrication methods that have been applied in the fabrication of the solar turbine such as:

- Cutting
- Welding
- Surface finish
- Turning(lathe)
- Assembly of turbine parts
- Project Testing

3.9.1 Cutting

Figure 3.20 shows the process of cutting involved in the fabrication of turbine stand where the process of cutting the material which are mild steel hollow bar and mild steel rod into the desired size. The machines which are used during the cutting process are bend saw and disc cutter.

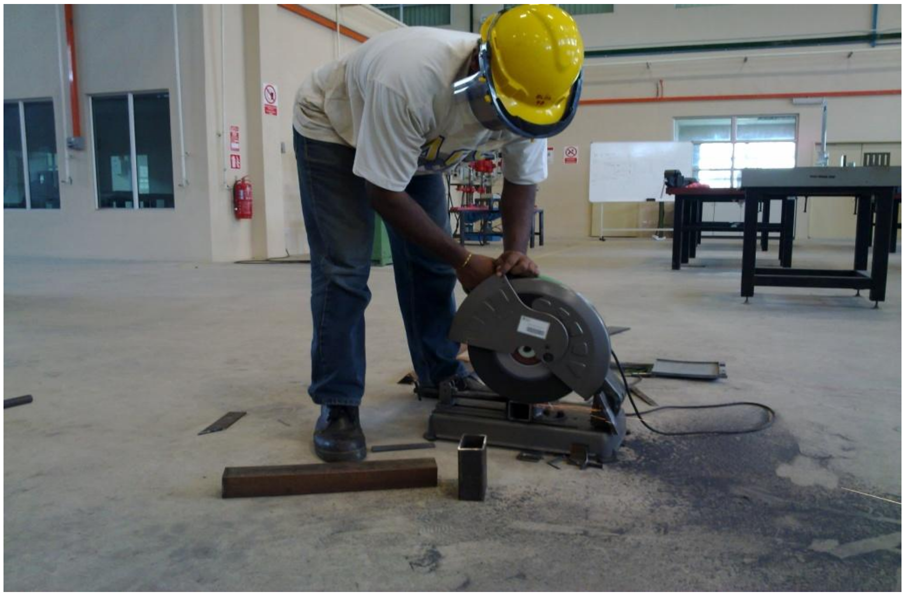


Figure 3.20: Cutting the hollow mild steel metal bar using disc cutter.

Figure 3.21: Cutting the mild steel rod using bend saw machine.

3.9.2 Welding

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the actual work and an electrode (stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod with the purpose of simply carrying the current between the tip and the work. Welding is used to join the hollow mild steel bar which has been cut into proper dimensions to form the stand and join the mild steel rod on the turbine runner cover. Figure 3.22 shows the welding done on the test rig while the figure 3.23 shows the welding done on the turbine runner cover.

Figure 3.22: Welding the stand using arc welding

Figure 3.23: The mild steel rod have been welded on the turbine runner cover.

3.9.3 Turning-lathe

Figure 3.24: Lathe machine

Lathe machine is used reduce the diameter of the shaft into the desired diameter so that the bearing could be inserted into it. Figure 3.24 shows the lathe machine used to reduce the diameter of shaft.

Figure 3.25: This shows the reduced diameter of the shaft and it’s threading

3.9.4 Finishing surfaces.

The surface finish is not only functioning as to beautify the test-rig, but also to improve the safety and quality of it. The surface finish is grinding, filing, remove rust using sand paper and spraying. Spraying ensures the mild steel does not rust when exposed to water. It ensures the test rig lasts longer while being exposed to water. Figure 3.26 shows the process of grinding, figure 3.27 shows the filing process, figure 3.28 shows the process of removing rust and figure 3.29 shows the spraying process.

Figure 3.26: Grinding is being done to flatten the extra bits of welding.

Figure 3.27: Filing is done to remove the sharp edges to make the test rig convenient to the user.

Figure 3.28:Rust is being removed using sand paper to ensure a better surface appearance is achieved.

Figure 3.29: The finished test rig is being sprayed to ensure it does not rust.

3.9.5 Assembly of turbine parts

24mm hexagon nut and bolts and 12mm hexagon nut and bolts are used as fasteners to join the turbine parts together. The nut and bolts used are shown in figure 3.30. There are all 7 different parts in the turbine assembly. The turbine is assembled manually but the bearing was inserted into the shaft using a press machine to avoid the malfunction of the bearing. The shaft is also inserted into the turbine runner cover using a press machine to avoid damage of the shaft. There was no threading on the shaft to hold the runner blade, so turning has been used to produce thread on the shaft and the 24 mm nut was used to fasten it. The bearing was placed to ensure the shaft does not vibrate during rotating. However the bearing was smaller than the shaft and there was no place to hold the bearing from moving. So, the shaft has been reduced in diameter using turning-lathe process and bearing was inserted. After inserting the bearing, the bearing-shaft diameter was measured and a design comprising four 5mm diameter mild steel rod was welded on the turbine runner cover to restrict the bearing from moving and shaft chattering could be avoided. This ensures a better result is obtained while carrying out the test.

Figure 3.30: Nuts and Bolts

3.9.6`Project Testing

After the turbine parts were assembled, the turbine were placed into the test rig. The turbine fits the head of the test rig perfectly. This could reduce the vibration of the turbine. The flow straightener is directly above the space designed for the water to flow out from the turbine. This ensures the used water falls back into the pump’s tank and reused by the pump to turn the turbine. The tank can be placed perfectly under the test rig and this could makes sure the water does not splashes out during the water is being discharged from the turbine to the tank. This can be shown in figure 3.31.

After turning-lathe process has been carried out, the bearing was pressed into the shaft. The bearing fits into the shaft without any difficulty. This ensures the bearing will work in good condition. The 24 mm nut fits the treading done on the shaft perfectly. So, it need not be forced into the shaft and it could be opened back if wanted as it is shown in figure 3.32 and figure 3.33.

After the mild steel rod has been welded into the turbine runner cover, the shaft-bearing was fitted into it. The shaft will then be pressed into the cover. It fits the cover perfectly and the bearing was held stiffly from moving. This ensures the shaft does not vibrate or chatter while rotating as it is shown in figure 3.34.

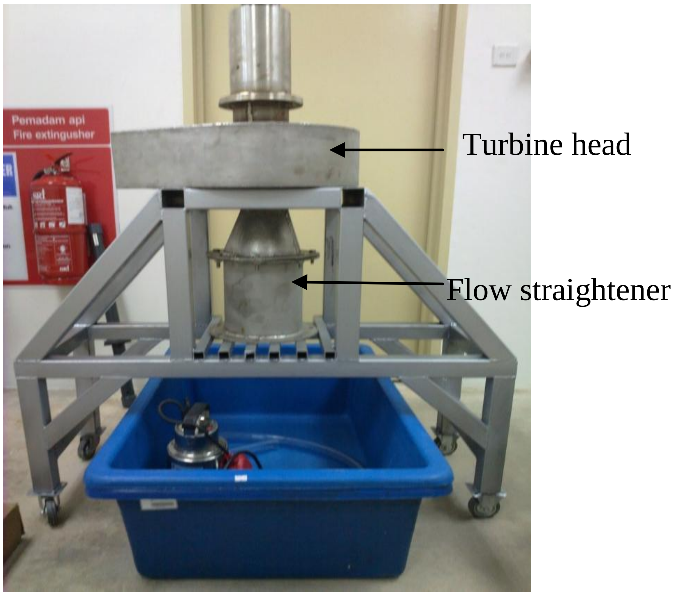


Figure 3.31: The test-rig could withstand the weight of the turbine.

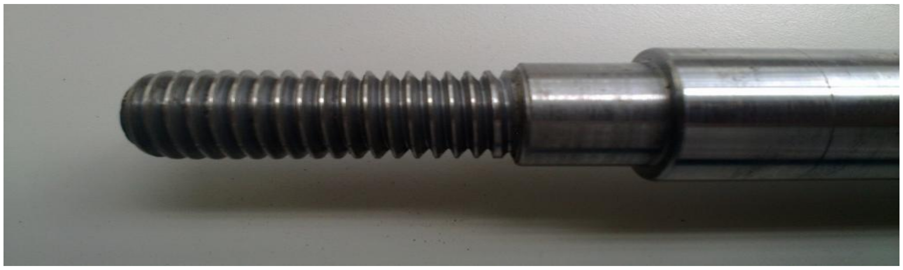


Figure 3.32: The 24mm nut could perfectly slide into the threading

Figure 3.33: The bearing fits perfectly into the shaft after it’s diameter has been reduced using turning-lathe process.

Figure 3.34: The shaft-bearing fits perfectly into the turbine runner cover. The bearing was held stiffly and this avoids the shaft from vibrating while rotating.

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT AND DISCUSSION

4.1.1 Test rig

The result for the project is aimed for this chapter including the fabrication process of the test rig, the turbine's specifications and the problem with the designs. The result will be used to find the ways to solve the problems and make some improvements to the entire design. After made some improvements, the comparison of the latest result and the result before the improvements for the project was run to archive the target.

Most of the turbine's parts are made by using stainless steel. The reason why the steel is mostly used is because of it better properties which are fair corrosion resistance, high technical stability, high temperature resistance and strong. The test rig is made up of hollow mild steel bar because it is easy to cut into the desired shape and also strong to carry the heavy load on it. The test rig will support the turbine so it will be stable and able to withstand the load, pressure and the process effects such as vibrations.

The turbine is assembled and placed into the test rig. The test rig is able to be moved while carrying a very heavy load. The water discharged from the turbine falls without facing any difficulty passing through the test rig to the tank. The design has achieved it's objective and fulfilled all it's purposes. From the result after drawing, sketching selection, generate and evaluate the concept selection, the Concept 4 was the best design for this project to be fabricate and it was done. During carrying out the project, the pump will suck the water from tank and supply to the turbine via a rubber hosing. When the water level in the turbine reaches a certain level, the runner blade will start to rotate. This eventually will turn the shaft and the shaft will be connected to an alternator using beltings. Now, kinetic energy from the turbine will be converted into mechanical energy by the alternator. Current will now be produced an the amount of current produced can be measured using ammeter while the rotational speed of shaft using tachometer. Figure 4.1 shows the front view of the test rig, figure 4.2 shows the side view of the test rig, figure 4.3 shows the turbine placed on top of the test rig while figure 4.4 shows the side design of the design assembly.

Figure 4.1: Front view of test rig

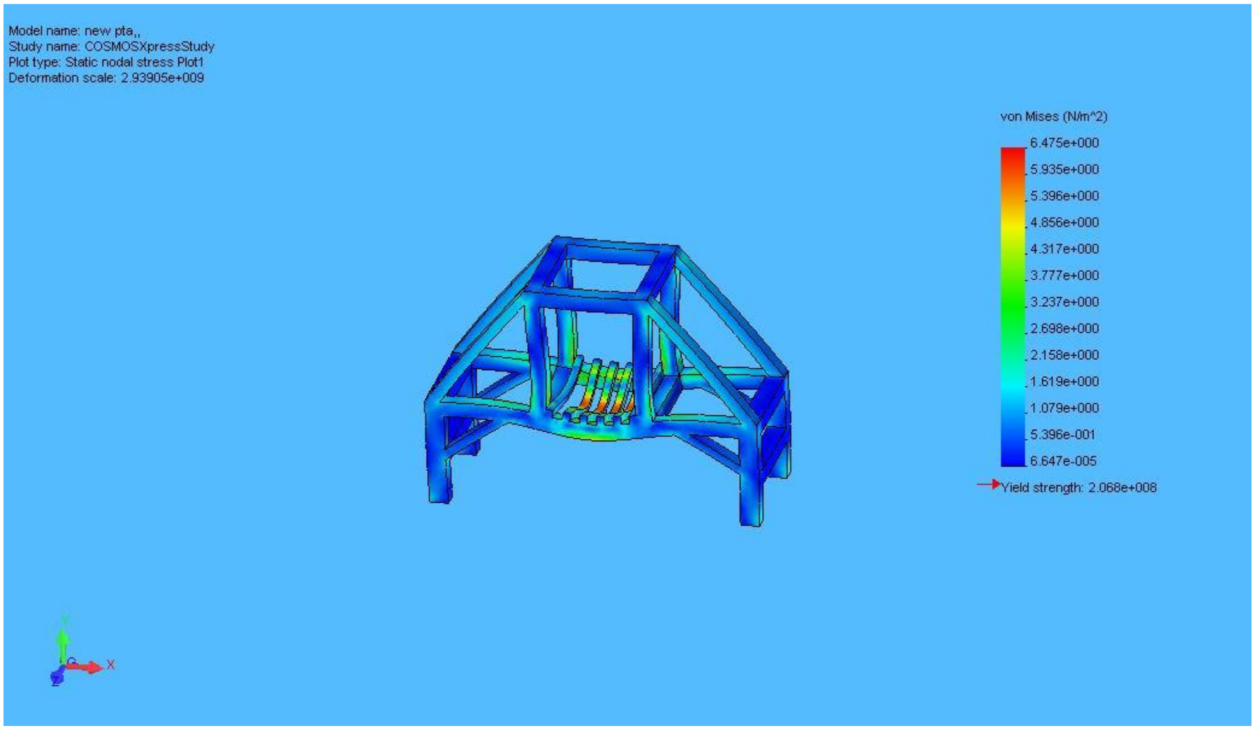
Figure 4.2: Side view of test rig.

Figure 4.3: Turbine is placed on top of the test rig.

Figure 4.4: Side of the design assembly.

4.1.2 A SIMPLE SIMULATION USING SOLIDWORK

The effect of load and stress distribution is analyzed using Solidwork’s cosmos express study software and is shown in figure 4.8. The parts which will be exposed to stress and pressure is identified using this software. From this software also we came to know that this test-rig will not collapse easily because it has a uniform distribution of forces which makes it very stable.



Model name: new pta,,
Study name: COSMOSXpressStudy
Plot type: Static nodal stress Plot1
Deformation scale: 2.93905e+009

Figure 4.8: Simulation of test-rig

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The micro-hydroturbine was successfully built and it is able to withstand the turbine. The turbine’s major parts has been assembled. The remaining parts of the turbine will further will produced and assembled and finally the project testing will be carried which is calculating the electricity generated. My duties given by Mr. Akramin in this micro-hydroturbine project have been completed.

5.2 RECOMMENDATIONS

The test rig has been made mobile so that it could be easily moved with heavy load on it. However, there is no specific handle to the test-rig. In future, there should be a handle attached to the test-rig to increase the users comfort of using the test-rig. Moreover, now the design comprises a separate tank to contain water in it. But it will be more convenient is a self-attached tank is produced together with the test-rig. Since the turbine is very heavy, a mechanism that could lift and place the turbine in the test rig must be designed so that the user won’t face difficulty in lifting the turbine.

The pump we are using now is Omnia 230 V 200W pump with 80 L/min flow rate. However, the turbine’s runner blade is very heavy and the pump’s power may not able to supply enough water power required to turn the blade. In this case, a pump with higher power must be used. In future, the blade should be designed such that it has a lower weight so that it could be easily tuned by the flowing water. There is no proper design to hold the shaft from being in contact with the turbine wall. A better design to the shaft to be hold firm must be designed to ensure a better performance of the turbine.

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APPENDICES

Flow-straightener

Flow-straightener

Shaft-cover

Turbine blade

Turbine-runner cover

Shaft

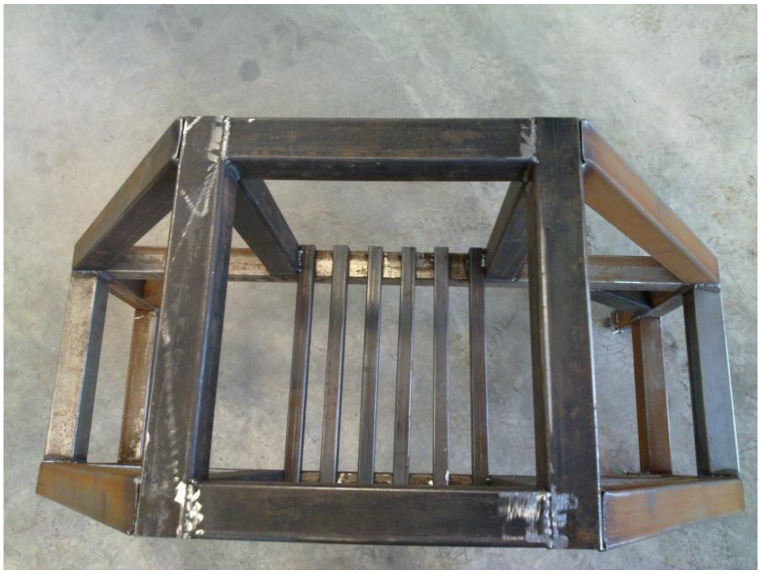
Turbine body

Hollow mild-steel bar

Measure the perpendicularity using l-square

Front-view of test-rig

Side-view of test-rig



Top-view of test rig

Final product