Development of Mini Hydro Generation Concept Trainer

Norbaiti Adzlina binti Basharudin¹ and Meor Ahmad Zainal bin Meor Muhamud²

¹Department of Electrical Engineering, Politechnic Sultan Abdul Halim Muadzam Shah, Bandar Darul Aman, 06000 Jitra, Kedah.
²Email: norbaiti.adzlina@gmail.com

Abstract: Development of Hydro Generation Concept Trainer was created to show the basic concept of Hydro Power Plant which is a part of the Power System curriculum taught in Malaysian polytechnics. This trainer was designed to model hydroelectric power plant which converts energy derived from flowing water into electricity. This project was made based on Bill Kelsey’s hydro concept whereby fast flowing water is used to spin a turbine which will then spin a metal shaft forming the equivalent of an electrical generator that produce electricity. The electromagnet in the generator will generate the electrical voltage and current in the stationary coils of wire inside them. This trainer uses only direct current (DC) which differs from most hydro generation trainers using alternating current (AC). Moreover, this low cost trainer successfully utilizes a battery as a capacitor bank, replacing the costly capacitor bank used to store electricity in an actual hydro power plant.

1. Introduction
Development of Hydro Generation Concept Trainer is a similar for mini that use for student easy to learn and handle it at study place or lab without going outdoor to any place to learn something. This trainer is a kit that equipment is complete like a real hydroelectric. This trainer also is make for lecturer easier to teach student in the laboratory, whereby this trainer easy to carry and handle it. Development of Hydro Generation Concept Trainer is a machine that produce power that come from mechanical energy that convert from kinetic energy. This trainer using water to turn a wheel and move the blade or rotor to reduce a power, this is because it’s have friction at the rotor. Hydro Generation Concept Trainer used generator to generate power from turbine to make some power. This trainer also provide voltmeter and amp meter for student and lecturer to make observation and also gets some reference from volt meter and amp meter. Lecturer can used this trainer as lab work or practical work.

The basic of hydro is that water had been piped from certain higher level to lower level, which will cause pressure difference. The water pressure difference will be used to move turbine movement conversion of potential energy of water into mechanical energy. After that, the turbine will convert water pressure into mechanical shaft power, which is used to drive an electric city generator, a grinding mill or some other useful device.

2. Literature reviews
Basically, previous research was done review about project Hydro Generation Concept Trainer and Bill Kelsey micro water turbine. Electrical energy that has been generated using natural water or flowing water. A power sources is use to spin a turbine, forming the equivalent of an electrical generator that produce. When water move a turbine, the turbine spins, and electromagnet in the turbine generate an electrical current in the stationary coils of wire in the turbine generate electric current in the stationary
coil of wire inside them. So, in literature review, most research done about the type of turbine that been use concept generation electric power as shown below.

| Item          | High Head | Medium Head          | Low Head     |
|---------------|-----------|----------------------|--------------|
| Turbine impulse | Pelton    | Cross-Flow Multi-jet Pelton | Cross-Flow |
| Turbine reaction | -        | Francis              | -            |

2.1. Turbine by Iqbal Potential Speed Turbine

The impulse turbine is a water turbine that works by changing all available water energy (which consists of potential energy + pressure + speed) into kinetic energy to rotate the turbine, thus producing kinetic energy. The potential energy of water is converted into kinetic energy in the nozzle. Water exits the nozzle that has high speed hit the turbine blade. After hitting the blade, the flow velocity changes so that there is a change in momentum (impulse). As a result, the turbine ignition will spin. The impulse turbine is the same pressure turbine because the water flow coming out of the nozzle the pressure is the same as the surrounding atmospheric pressure. All high-energy places and pressure when entering the turbine road blade are converted to energy speed. Examples of impulse turbines are Pelton turbines [1].

The reaction turbine is a turbine that works to convert all available water energy into kinetic energy. This type of turbine is the most widely used turbine. The blade in the reaction turbine has a special profile that causes a decrease in water pressure through the blade. This pressure difference gives the blade a force so that the runner (rotating turbine part) can rotate. Turbines that work based on this principle are grouped as reaction turbines. Runner turbines react fully immersed in water and are in the turbine house [2].

Water turbines convert the potential energy of water into mechanical energy. Mechanical energy is converted into an electric generator into electricity. Based on the working principle of the turbine in converting the potential energy of water into mechanical energy [3]. So, refer from Turbine by Iqbal Potential Speed Turbine, some enhancement was made for this project, the basic turbine component must use to make the turbine rotate in full speed to archive the current that will generate.

2.2. Turbine Motor System by Bill Kelsey

Refer from previous research by Bill Kelsey, turbine is built mine completely by trial and error. He ordered a Harris Hydro turbine from a retailer for 15 feet (4.6 m) of vertical drop. The first Rube Goldberg setup was a 275-gallon (1,040 l) flat tank with the side cut out of it, so that water coming off the top of the rock and timber dam passed through a homemade filter and into two, 2-inch pipelines laid side by side in the brook [4].

The Harris Hydro generator was one of the first in the field. Installing systems for decades, lo-power engineering has set up many off-grid homesteads. For smaller streams of 2 to 250 GPM and 25 to 300 feet of head this versatile unit can produce up to 1500 Watts. Available in 12/24 or 48 Volts DC. Permanent magnet alternator has an output optimizing circuit, mounted on cast Aluminum base with a 4 inch cast bronze runner [5].

The turbine has a unique design in that its efficiency is achieved by the tilting of the power blades during the rotating cycle. The blades rotate half a revolution for each full rotation of the central shaft. This configuration allows each blade to contribute a unidirectional force to the central shaft, for virtually the entire rotational cycle. In this way they can efficiently utilize the kinetic energy of the moving water. The central shaft works the generator via a gearbox to produce emission free renewable energy. Electrical power is generated at a voltage of 690V [6]. After done research from the project of Bill Kelsey, we have upgraded our project to the trainer that can use to teach student easily. We also make it with full protection for student to more safety.
2.3. Turbine Francis
The Francis turbine is one of the reaction turbines. The turbine is installed between the high-pressure water source at the entrance and the low-pressure water at the exit. Turbine Francis uses a guide blade. Steering blade directs incoming water tangentially [7]. French turbine works by using a more pressure process. When the water enters the road wheel, a portion of the high energy falling has been worked in the guide blade is changed as the speed of the water entering. The remaining high-energy fall is utilized in the road blade, in the presence of a suction pipe allowing high energy to fall on the road to the maximum possible extent. Turbines surrounded by directional blades are all immersed in water. Water entering the turbine is flowed through filling water from the top of the turbine (Schact) or through a house in the form of a spiral (snail house). All road wheels always work [8].

The power produced by the turbine is regulated by changing the opening position of the guide blade. Opening the guide blade can be done by hand or with a regulator from the oil press (governor oil pressure), thus the capacity of the water entering the turbine wheel can be enlarged or reduced. On the outside of the road wheels there is low pressure (less than 1 atmosphere) and high flow speeds. In the suction pipe the flow velocity will decrease and the pressure will rise again so that the water can be flowed out through the water channel under pressure like the surrounding [9].

The choice type of turbine can be determined based on the advantages and disadvantages of the types of turbines, especially for a very specific design. In the initial stage, the selection of the type of turbine can be calculated by considering the special parameters that affect the turbine operating system.

2.4. Generator
In general, DC generators are made by using a permanent magnet with 4-pole rotors, digital voltage regulators, overload protection, excitation starters, rectifiers, bearings and generator or chassis houses, and rotor parts. The DC generator consists of two parts, namely the stator, which is the silent DC engine part, and the rotor part, which is the rotating DC engine part. Stator parts consist of: motor frame, stator winding, charcoal brush, bearing and terminal box. While the rotor part consists of: commutator, rotor winding, rotor fan and rotor shaft [10].

So, after complete literature review, we decided to build Mini Hydro Generation Concept Trainer in smaller size and compact. We want user (students and lecturers) understand clearly about hydro generation. Concept in our research, motor that been use is so big and user can’t handle it, because the motor is not user friendly and it was so dangerous for user which is didn’t have experience. So, we build a user-friendly Hydro Generation Concept Trainer using small motor and this trainer also easy to carry. So, our target to build small Hydro Generation concept Trainer as easy for student to analyze and make observation in reality. We also want to reduce costing to build this trainer, so if the trainer broken, the costing is cheaper to do maintenance.

3. Methodology
In Mini Hydro Generation Concept Trainer show how this project is implement and how to manage it smoothly. This project was divided into two part, there are Mechanical Part and Electrical Part.

This methodology in figure 1 and figure 2 shows the whole step by step to build Mini Hydro Generation Concept Trainer. Firstly, mechanical parts were done, start with project frame. Then make a turbine using method crossflow and dam for water flow method. Next, for electrical parts, need to learn the term of wiring DC system before make a wiring for all electrical equipment. More research was review about the wiring in DC to know the type of bulb that support DC wiring.
Figure 1. Block diagram of Mini Hydro Generation Concept Trainer

Figure 2. Flowchart of Mini Hydro Generation Concept Trainer
3.1. Part 1: Mechanical Part

3.1.1. Phase 1: Build Frame of Mini Hydro Generation Concept Trainer
First step, build frame using steel, need to measure the actual size of steel and cut it follow the measurements. Second step, cut and welding steel follow the measurements and finishing up with welding to combine every steel become frame. This task was guided by others experience people that have welding skills. Third step, build reservoir. Trying to reduce cost by using recycle air conditioner gas tank as project reservoir. Then, cut upper air conditioner gas tank - need to cut the upper side of an air conditioner gas tank and welding it with steel plate. Fifth step, band steel - need to cut steel plate to make a suitable place for flow water pump. Then, banded steel plate 90°c become ‘U’ shape. Next, combination all parts, welding all parts together. There are frame from steel, water tank and place for flow water pump. After that, put 4 wheels on frame. Cut steel and welding together as a stand. Then welding each wheels at side at the bottom of the frame. Next, complete welding stand wheel on frame. To make project frame compactly, after finish welding part, smoothly used grinding machine with flexible disc to remove rust. Now, project frame cleans from rust. Painted project frame with silver colour spray. While painting, cover project tank with waste paper to prevent silver colour spray affected water tank. Next, painted project water tank. After finish painted frame, place it under the about 2 hours. After dry completely, take of waste paper from water tank and spray it with blue metallic colour. After finish painted both parts, start make a hole on base wheel using electrical drill machine. Next, installing 4 wheels on base wheel and fight it with screw.

3.1.2. Phase 2: Build Turbine of Mini Hydro Generation Concept Trainer
Now, frame parts was done. So next step, to build project turbine using crossflow method. First step, steel plate is measured about 4 inch and cut in into slice to make blades for turbine. Second step, cutting steel plate, need to measure steel plate to make a frame for turbine. Third step, build blade, need to combine blades with frame turbine and welding together with sub shaft motorcycle. Project turbine method need to be done is crossflow. Next, put silicone around outside turbine. Remove frame and combine together as reservoir turbine to make sure water flow not leaking. After silicone dry almost 1 hours, put water on turbine to make sure the result is well and not leaking.
After project turbine was successful, start painting spray with silver colour. Then, start install turbine in Mini Hydro Generation Trainer frame.

3.1.3. Phase 3: Install Water Pump in Mini Hydro Generation Concept Trainer
For this stage, need to install water pump in Mini Hydro Generation Concept Trainer frame. First step, reduce noise from water pump by cutting a gasket as follow measurement 22.5 cm to reduce noise from water pump. Second step, make a hole for water turbine by measuring actual size of hole for water pump to make it suitable for water turbine. Third step, make a grid holes at the back of water pump, make a set of grid holes at the back of water pump to reduce heat. So, water pump will always in cool conditions. Then, start install water pump on frame and tighten it with screw and nut to make sure the water pump is not vibrate on a frame. Last step, tighten up water pump by installing water pump in the frame and tighten up with nut and screw to make it stable when the operation is on.

3.1.4. Phase 4: Piping Process
After finish installment mechanical part, need to start piping process and prepare all equipment. First step is taping all accessories pipes using white tape to make sure no leaking issue. Second step, connection between tanks to water pump by measuring and cut pipes follow measurements given to connect between tank and water pump. Then, for neatness, install the pipe with glue. Third step, connection between water pump to turbine by installing water tap in between water pump and turbine. Finally, installing nozzle. For finishing, need to install nozzle to make sure water flow smooth directly to turbine and glue on the top of nozzle to present leaking. Finally, installing nozzle. For finishing, we
need to install nozzle to make sure water flow smooth directly to turbine and glue on the top of nozzle to prevent leaking.

3.2. Part 2: Electrical Part

3.2.1. Phase 1: Install a Junction Box to the Frame
A junction box to frame must be installed. The cover of junction box will have switch, dimmer, meter display volt and amp. First step, installing a junction box by screwing junction box to the project frame. Second step, measuring size of accessories component - need to punctuation the junction box refer from measuring size of accessories component. Third step, making holes at the cover of the junction box.

3.2.2. Phase 2 : Connecting Extension Wires to the Water Pump and controlling dimmer
Wiring was made from water pump and controlling the speed using dimmer. Firstly, change the original wires from water pump with flexible wires to the junction box. Secondly, cut the water pump wires and removed it. Redo new wiring connection extension wires for neutral and earth connector only. Thirdly, connecting the life wire as supply and water pump to the one way switch with a dimmer together. Then after all the wires connected correctly, install it to the cover of junction box. Lastly, installing a plug top at the supply wires to connect to the plug as a supply.

3.2.3. Phase 3 : Making a Wiring on Generator and Connecting to the Battery as Charger
Do a connection together between pulley turbine and pulley generator. After connected, make a wiring from generator to the battery as charger. Firstly, connect together the pulley turbine with pulley generator using belting. Secondly, using shrink tube. Extend the wire generator with two core cable using black tape. Thirdly, make a wiring from generator to the volt meter and amp meter to see the output of voltage and current of the generator. Lastly, make wiring from volt meter and amp meter to the battery.

3.2.4. Phase 4 : Making a Wiring Output (Lamp) as Indicator Battery
For this parts, make a wiring from lamp to the battery as indicator for battery. Firstly, measuring to put lamp holder and one way switch on board. Using the actual measurement, cut all the pieces out. Secondly, install the one way switch with the lamp on the board. After finish installation section, make a wiring from lamp to the switch one way separately with one lamp to others and combine it together and connect to the battery.

4. Result & discussion
Users (students or lecturers) must connect the plug top of Mini Hydro Generation Concept Trainer to the socket and turn on the supply shown in figure 3. Secondly, turn on switch water pump. Then, users can see the water pump will turn on. Next, fully open the water tap to see the water flow through the water tap. Users can make observation base on what happen. The increase speed of water pump, the increase speed of turbine will spin and the result when the turbine speed increase, the more voltage will get from the generator it will losses 0.4% because of belting belt spin. Result in this trainer shown, when the speed of water pump increase, the output voltage of generator increase, the current will show as millie Amp is also increase.
Figure 3. Mini Hydro Generation Concept Trainer

Below is the procedure how to use Mini Hydro Generation Concept Trainer:

- Connect incoming supply to socket that use 230V supply.
- Switch on the water pump switch
- Adjust speed water pump by using dimmer switch that connect to the water pump
- Look the display voltage meter and ampere meter for the output supply generator
- Open water tap to see water flow through the turbine
- Switch on lamp A and lamp B to display the output

5. Conclusion
This project, Mini Hydro Generation Concept Trainer was successfully built. This trainer can enhance the knowledge and experience of applying and adapting the skills learned and gained for curriculum syllabus Power system in Polytechnic Sultan Abd Halim Mu'adzam Shah.

After done research and analyzing data during this project, Mini Hydro Generation Concept Trainer was built at least a very basic one. From this project also, more knowledge gained about alternative fuels and how hydroelectricity works such as generator usually used at the night market.

For testing phase, learned how to use a generator system specifically. It is best to hold the generator at a downward angle so the water will hit the turbine correctly. While doing the hypothesis, the proved incorrect, however, it turns out that the amount of electricity each system generated varied slightly. Regarding the research about hydroelectricity, many things was found out. It is not as easy as the concept explanation to access hydropower. After learnt about hydropower, notify that the power used comes from a dam. Hydroelectricity, in working process, it is a very good clean source of power that everyone can use. However, many lands was destroyed to build the dam and some agricultural lands is used to divert the streams. There is a significant impact to the fish and small animals and their habitats.

The use of hydropower is worldwide and very useful. This is the reason why Mini Hydro Generation Concept was built. Hydropower is a very good source of energy. In conclusion, believed that hydroelectricity is clean and powerful source of electricity. Project objective was archived to help students understand the concept of hydro generator that to build a small trainer for them for education use. Besides that, students got opportunity to look closely how hydro operations, in order to understand about dam concept in Mini Hydro Generation Concept Trainer. Furthermore, students learnt the concept of hydroelectric more clearly. Finally, this trainer was built to reduce cost.

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