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TO STUDY, DESIGN & DEVELOP A SMALL SCALE PROTOTYPE OF MICRO HYDRO SYSTEM WITH AUTOMATIC VALVE CONTROL

Tie Chin Ho

Bachelor of Electrical Engineering (Industrial Power)

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“I hereby declare that I have read through this report entitle “To Study, Design & Develop A Small Scale Prototype Of Micro Hydro System With Automatic Valve Control” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature :

Supervisor’s name : Khairul Anwar Bin Ibrahim

Date : 11 June 2012

TO STUDY, DESIGN & DEVELOP A SMALL SCALE PROTOTYPE OF MICRO HYDRO SYSTEM WITH AUTOMATIC VALVE CONTROL

TIE CHIN HO

A report submitted in partial fulfillment of the requirements for the degree

of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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2012

I declare that this report entitle "*To Study, Design & Develop a Small Scale Prototype of Micro Hydro System with Automatic Valve Control*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Tie Chin Ho

Date : 11 June 2012

To My Beloved Mother and Father

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ABSTRACT

Micro hydropower system is one of the most environmental friendly energy conversion methods. Unlike large scale hydropower plant, it will not bring big impact to the environment [3]. Micro hydro power plant (MHPP) can continuously supply electrical power and can help to supply much needed electricity to small communities and villages which transmission line is expensive to reach there. Loads that connected to generator need uniform, stable and uninterrupted supply energy. However, characteristic of micro hydro power plant change with the consumption. So, the output supply voltage MHPP need to be controlled in order to maintain the output supply voltage at the rated voltage [3]. This project is to study micro hydro power plant and finally design & develop a small scale prototype of micro hydro system with automatic valve control.The fundamentals and parameters of the micro hydropower plant are being studied in this project. The micro hydropower plant consists of penstock, pipeline, turbine and generator. Electric motor is used to act as governor in order to regulate the flow rate to maintain the output supply of the generator at the rated voltage. One prototype with the automatic valve is built and testing is carried out. The maximum efficiency of this prototype is 6.6% and the automatic valve take 10 to 18 seconds to regulate the flow rate of the water.

ABSTRAK

Sistem mikro hidro adalah sejenis penukaran tenaga mesra alam sekitar. Tidak seperti loji hidro yang besar, ia tidak membawa kesan yang besar kepada alam sekitar. Sistem mikro hidro boleh menghasil kuasa elektrik secara berterusan dan menghasil elektrik kepada komuniti yang kecil atau kampung-kampung di mana talian penghantaran mahal di bina. Beban yang disambung kepada penjana elektrik memerlukan bekalan elektrik yang seragam, stabil dan tidak diganggu. Akan tetapi, ciri-ciri loji kuasa mikro hidro berubah dengan perubahan penggunaan elektrik. Jadi, voltan yang dihasilkan oleh system mikro hidro hendaklah dikawal supaya sentiasa berada pada voltan diberi nilai. Projek ini adalah untuk mengaji loji elektrik mikro hidro dan akhirnya mereka dan membina suatu prototaip mikro hidro yang mempuyai injap automatic. Asas dan parameter sistem mikro hidro telah dikenali dalam projek ini. Loji mikro hidro terdiri daripada penstock, talian paip, turbin dan penjana elektrik. Akan tetapi, ciri-ciri loji kuasa mikro hidro berubah dengan perubahan penggunaan elektrik. Jadi, motor elektrik telah digunakan untuk bertindak sebagai gabenor yang akan mengawal aliran air, seterusnya mengawal hasil voltan dari penjana elektrik kekal pada voltan tertentu. Satu prototaip mikro hidro telah dibuat dalam projek ini. Analisis terhadap sistem ini telah diadakan. Kecekapan maksimum prototaip ini adalah 6.6% dan injap automatik memerlukan 10-18 saat untuk mengawal kadar aliran air untuk menghasilkan voltan yang diperlukan.

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INTRODUCTION

1.1 Project Background

Renewable energy has become a hot issue now in nowadays due to climate change concerns, coupled with high oil prices increasing government support. Renewable energy is energy which comes from natural resources such as sunlight, wind, water, tides, and geothermal heat, which can naturally replenished [1].

Water has been used as an energy source for thousands of years, since ancient civilizations using water to drive mills through the use of water wheels. Technology has been improved from time to time, and the potential for water as a power source continues to be important. Large-scale example such as the Three Gorges Dam in China is used to power large-scale projects [2].

Modern times are calling for a clean, efficient renewable energy source. One of the possible solutions is the implementation of micro hydro power systems. Micro hydropower systems used in harvesting the kinetic energy of steaming waters that produce electrical energy on a small scale. Micro hydro power systems are able to generate electricity by using the movement of water from small streams to rotate a turbine in order to spin a shaft which used to power an alternator to generate electricity [2].

1.2 Problem Statement

Normally, micro hydro system is designed with the fixed flow water to push the turbine of the alternator. However, this design will cause problem when few situation happen:

- When the load in system increases, the speed of alternator will drop, causing the voltage and frequency of the power supply to also drop.
- During raining day, the flow or pressure of water to the turbine will increase. This cause the voltage and frequency of the alternator will increase. This will damage the device in the system as well. Current solution is to switch on the dumping load when higher voltage produced is noticed.

1.3 Project Objective

- To study, to design a micro hydro system and the parameter that need to be considered to make the system to success.
- To develop a small scale prototype of micro hydro system with automatic valve control.
- To carry out simulation on the automatic valve system.

1.4 Scope of The Project

- Develop a small scale prototype of micro hydro system with automatic valve control which can control the flow rate of the water that entering to the turbine.
- The system should supply 12V alternating current (ac) constantly even though the load of the generator is varying.

CHAPTER 2

LITERATURE REVIEW

2.1 Micro Hydropower

Micro hydropower is a renewable energy which harvests the kinetic energy from streaming waters, then converts to electrical energy on a small scale. Generally, a moving stream of water turns turbine blades which are connected to a shaft that spins a generator to produce electricity [4]. It is a green energy with zero carbon emission during the operation.

MHPP convert potential energy from falling water into electric energy. Water is channelized from a higher level to a lower level which the resulting potential energy of water is used to do work. The water head is used to move a mechanical component (turbine) then that movement involves the conversion of the potential energy of the water into kinetic energy to spin the turbine. The turbine is connected to a shaft that spins a generator [5].

MHPP operate in isolated mode and supplying the electricity in the local rural area where the population is very small and the extension of grid system is a high cost investment for transmission line [6].Micro hydropower plants can be defined as hydro power plant with capacity less than 100 kilowatts (kW) [6].

2.2 Potential of MHPP in West Malaysia

Malaysia is a tropical country with average rainfall of 2540 millimetre (mm) in Peninsula and blessed with richly supplied streams and rivers flowing from the highland areas [7]. Some researches had been done and found out that West Malaysia has the potential to implement micro hydropower plant to generate electricity with total estimated available power is 20407.3 kW [7] . Table 2.1 show about potential micro hydropower plant side by state:

Table 2.1: Micro Hydro Potential Sites by State[7]

Bil	State	No. of Sites	Total estimated available power (kW)
1	Johor	12	1687.9
2	Negeri Sembilan	17	848
3	Malacca	0	0
4	Selangor	2	343.8
5	Pahang	26	4835.1
6	Perak	34	9945.9
7	Kedah	5	496.7
8	Penang	0	0
9	Perlis	0	0
10	Kelantan	10	1420
11	Terengganu	3	829.9
			20407.3

2.3 Operation Principles Of Micro Hydropower Generation

Basically, micro hydropower generation is converting one form of energy to electrical energy. The most common convertion of energy at micro hydropower plant is as shown in Figure 2.1:

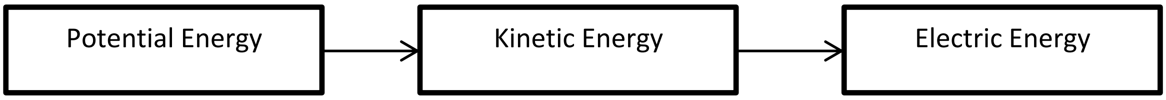

Figure 2.1: Energy conversion of micro hydropower generation

The potential energy is the energy stored in the water due to its position. When the water flows from higher position to lower position, the energy is converted from the potential energy to kinetic energy. When the water hit the turbine and spins the generator, the generator converts the kinetic energy to electric energy. The equation of the energy conversion is as per Equation 2.1:

$$E \text{ (energy release in joules)} = mgh \text{ [4]} \quad (2.1)$$

m = mass of the water
g = gravitational acceleration = $9.81 m/s^2$
h = vertical distance h, or the head

Head, *h is* defined as the elevation difference between the water source and the turbine. The mass of the water, m also can be defined as water density, *r* times its volume *v,* where the water density is 1000 kg/m^3. When substituted to Eq. 2.1, the energy release equals to as Equation 2.2:

$$E \text{ (joules)} = vrgh \text{[4]} \quad (2.2)$$

Power, P is defined as energy per second ($P = E$/s), the energy of water entering the hydroelectric turbine is as per Equation 2.3:

$$P \text{ (J/s)} = rvgh/s \text{ W (J/s = W) [4]} \tag{2.3}$$

R = 1000 kg/m^3
v/s = flow rate, Q

Flow is the volumetric measure of moving water, in cubic meter per second. One method which can measure water flow is called the *container method,* in which water is collected in a bucket for certain duration of time. The amount of collected water in the container is divided by the time it takes to fill the bucket [4]. So, energy contain in the flow of water is as per Equation 2.4

$$P_{net} = e \times Q \times 9.8 \times h \text{ kW [4]} \tag{2.4}$$

Where, e = efficiency

For practical purposes, the formula applied becomes as in Equation 2.5

$$P_{net} = 0.5 \times Q \times 10 \times h \text{ kW [4]} \tag{2.5}$$

where the efficiency, e is 50%.

2.4 Elements of Micro Hydropower Plant

The scheme of a micro hydropower plant is shown in Figure 2.2 can be summarised as follows [8]:

- Water is taken from the river by through an intake at a weir.
- Before water flow to the turbine, the water passes through a forebay tank where the water is slowed down sufficiently for suspended particles to be filtered out.
- Penstock will convey the water from the forebay tank to the turbine, which is enclosed in the powerhouse together with the generator and control equipment.
- Finally, the water will release back to the river.

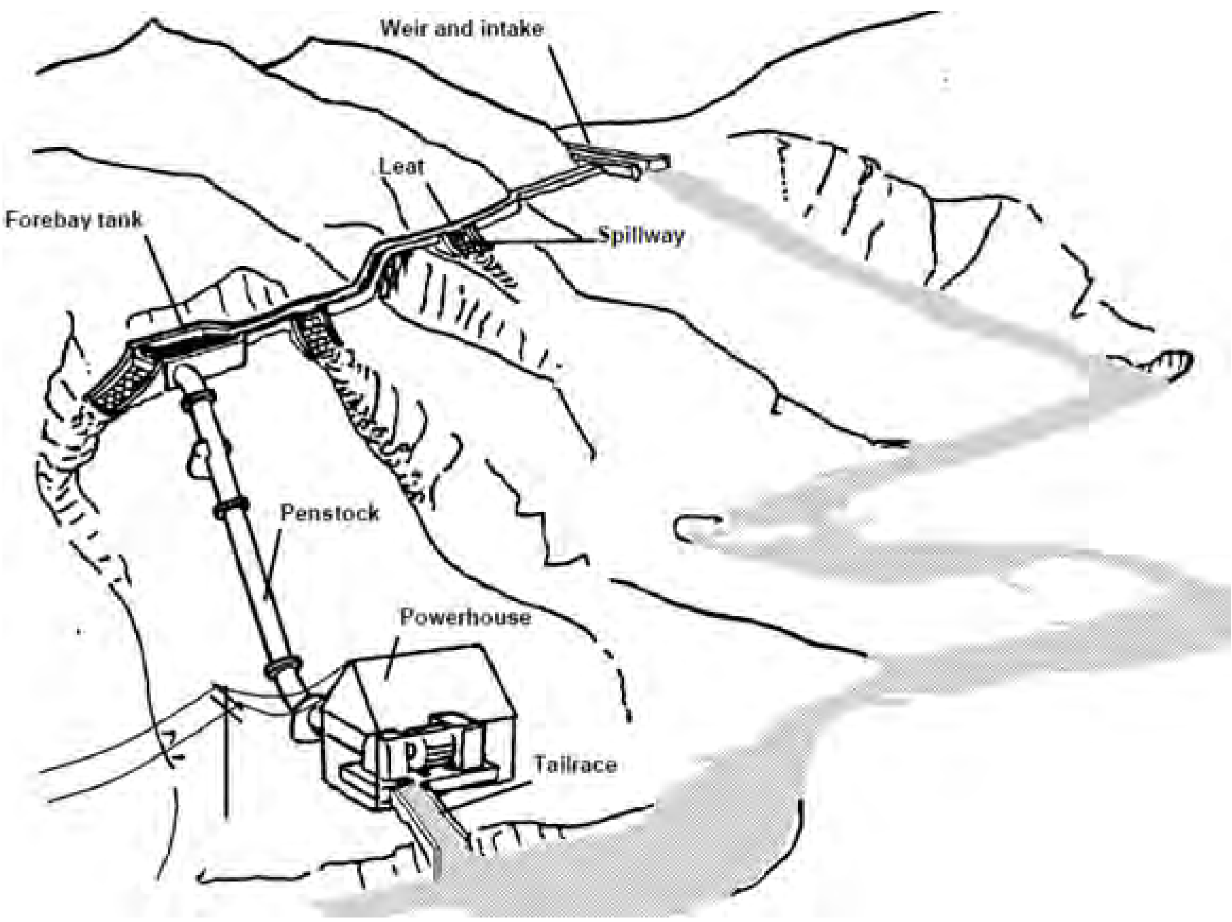

Figure 2.2: Basic scheme of a micro hydropower plant

2.4.1 Site Layouts

In practice, sites for micro hydropower plant vary greatly depend on the landscape. They might need to build at mountain area where there are fast-flowing mountain streams or lowland areas with wide rivers. The four most common layouts for a micro hydropower plant are shown in Figure 2.3:

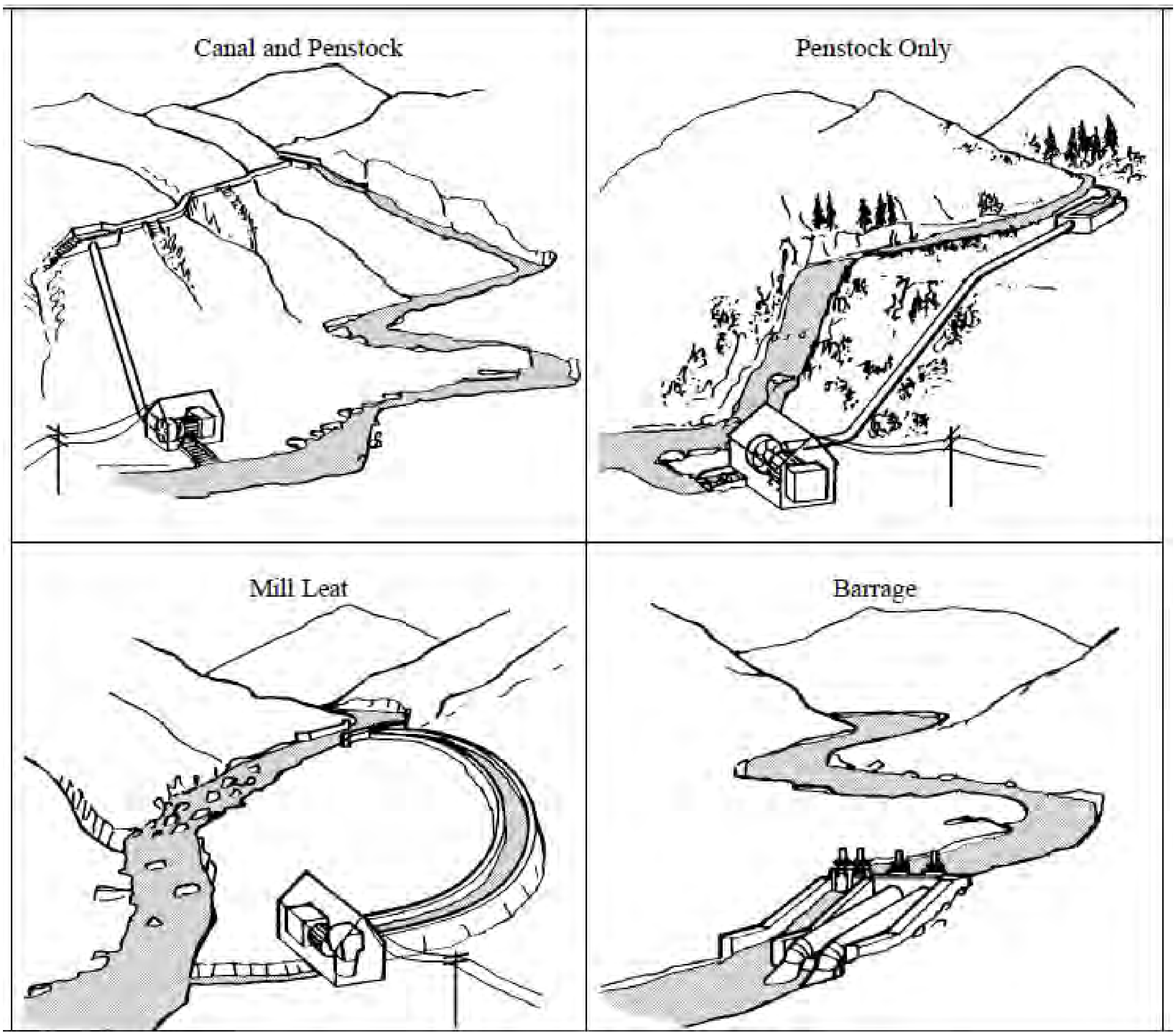

Figure 2.3: Four most common layouts for MHPP

2.4.2 Types of Micro Hydropower Plants' Turbines

Turbines are used to convert the energy contained in a continuous flow of fluid into rotational mechanical energy of a shaft. In micro hydropower plant, turbines are used to connect with the shaft of the generator to spin to generate electricity. There are few types of turbines use in micro hydropower plant, which are impulse-type turbine, reaction-type turbine and submersible-propeller turbines [4].

For impulse-type turbine, which is shown in Figure 2.4, water strikes the turbine runner and pushes it to rotate like the water mills. These types of water-propelled electrical generators work best in sites with high head. The best known impulse-type propeller is called *Pelton propeller* [4]. Impulse-type propeller will be used as turbine in this project.

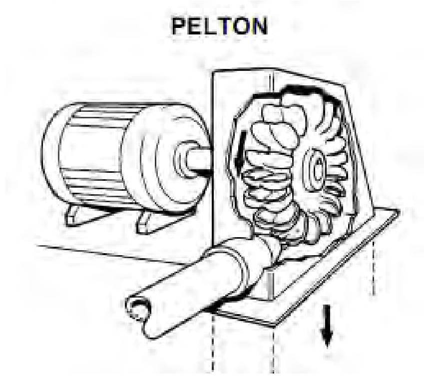

Figure 2.4: Pelton Propeller[8]

Reaction-type turbine is suitable used at water source that have low head but high flow rate. The runner of reaction-type turbine is immersed in water, where the water exits the housing through the turbine, turning the generator as it drops through the runner blades. The best known impulse-type propeller is called *Francis propeller* [4] which is shown at Figure 2.5.