



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF SMALL HYDRO POWER GENERATION
SYSTEM WITH SIMPLE GEOMETRICAL DESIGN FOR
SMALL WATER RESOURCES**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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DECLARATION

I hereby, declared this report entitled “Development of Small Hydro Power Generation System with Simple Geometrical Design for Small Water Resources” is the results of my own research except as cited in references.

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APPROVAL

This report submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:



(Ir. Dr Mohd Farriz Bin Basar)

ABSTRACT

Nowadays, the hydro power generation is getting popular among the rural residential or any residential place that are near to the water resources. It is one of the causes that may lead to many kind of innovation to the hydropower system. The objective of this project is to develop a simple geometrical design of a pico hydro that would be portable and friendly user. Besides that, the project is use to investigate the ability of the different type of generator by implementing different measurement of water flow rate and level of head. There are some method has been use to develop the pico hydro such as using different type of motor to obtain the optimum output of the pico hydro. Other than that, the prototype are tested with level of head of five meter and flow rate of the water which about 2 Liter/s. Next, the prototype also tested using 3 type base design which to improve the stability of the prototype during the operation. After a few test, the experimental result shows that the motor could generate optimum power up to 100W of potential energy by only using five meter of water head and 2 Liter/s of water flow rate. As for the result, the prototype are able to generate about 153 watts and 1.9 ampere of current. It lead to the 80 percent of efficiency percentage. As a conclusion, the prototype achieve the optimum output power and can be commercialize to solve the rural residential electrical power source.

ABSTRAK

Pada masa kini, penjanaan kuasa hidro semakin popular di kalangan kediaman luar bandar atau mana-mana tempat kediaman yang berhampiran dengan sumber air. Ini adalah salah satu punca yang boleh menyebabkan banyak inovasi dapat dibuat untuk sistem tenaga hidro. Objektif projek ini adalah untuk membangunkan reka bentuk geometri yang mudah bagi pico-hydro yang boleh menjadi satu produk mesra pengguna dan mudah alih. Selain itu, projek ini digunakan untuk menyiasat keupayaan jenis penjana yang berlainan dengan melaksanakan pengukuran kadar aliran air dan tahap ketinggian air yang berbeza. Terdapat beberapa kaedah yang telah digunakan untuk membangunkan pico hydro seperti menggunakan jenis motor yang berbeza untuk mendapatkan keluaran yang optimum dari pico hydro. Selain itu, prototaip ini diuji dengan lima meter tahap ketinggian air dan 2 Liter/s kadar aliran air. Seterusnya, prototaip ini juga diuji dengan menggunakan 3 jenis reka bentuk asas untuk meningkatkan kestabilan prototaip semasa beroperasi. Selepas beberapa ujian, hasil menunjukkan bahawa motor dapat menjana kuasa optimum sebanyak 100W hanya dengan menggunakan lima meter ketinggian air dan 2 Liter/s kadar aliran air. Sebagai hasilnya, prototaip ini dapat menjana kira-kira 153 watt dan 1.9 ampere dalam satu masa. Ia merujuk kepada 80 peratus kecekapan. Sebagai kesimpulan, prototaip dapat mencapai kuasa keluaran optimum dan boleh dikomersialkan untuk menyelesaikan sumber tenaga elektrik kediaman luar bandar.

DEDICATION

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TABLE OF CONTENT

Declaration	I
Approval	II
Abstract	III
Abstrak	IV
Dedication	V
Acknowledgement	VI
Table of content	VII
List of figure	XI
List of table	XIII
CHAPTER 1: INTRODUCTION	1
1.0 Introduction	1
1.1 Small hydro	4
1.2 Water turbine	5
1.3 Research gap	7
1.4 Objective	8
1.5 Scope of project	8
CHAPTER 2: LITERATURE REVIEW	10
2.0 Introduction	10
2.1 History of hydroelectric power	11
2.1.1 Small hydro in Malaysia	12
2.1.2 Introduction of pico-hydro	13
2.2 Pico-hydro component system	14
2.2.1 Penstock	15
2.2.2 Turbine	16
2.2.3 Generator	17

2.2.4	Battery	18
2.2.5	Inverter	19
2.2.6	Distribution system	19
2.2.7	Electrical load	20
2.3	Planning for pico-hydro system	21
2.3.1	Estimation of power	22
2.3.2	Measurement of head	23
2.3.3	Water flow rate	23
2.3.4	Selection of generator	24
2.3.5	Turbine type selection	25
2.3.6	Inverter	27
2.4	Floating system	27
2.5	Theoretical	28
2.6	Previous study	29
2.6.1	Case study 1: application of hydro generation in rural areas	29
2.6.2	Case study 2: portability of hydro power generation	31
2.6.3	Case study 3: Rural Electrification in Malaysia	32
CHAPTER 3: METHODOLOGY		34
3.0	Introduction	34
3.1	Flow chart	35
3.2	K-chart	37
3.3	Overview performance analysis technique	38
3.3.1	Framework	39
3.4	Instrumentation	40

3.4.1	Motor	40
3.4.2	Tachometer	41
3.4.3	Water flow rate meter	42
3.5	Design and development	43
3.5.1	Design	43
3.5.2	Hardware development	44
3.6	Testing procedure	46
3.7	Testing table	47
CHAPTER 4: RESULT		49
4.0	Introduction	49
4.1	Prototype	49
4.1.1	Floating	49
4.1.2	Simulation (modeling)	51
4.2	Experimental result (Simulation)	54
4.2.1	Potential energy	54
4.2.2	Electrical energy	55
4.2.3	Graph analysis	57
4.3	Field test	60
4.3.1	Fish pond	60
4.3.2	Water waste flow	61
4.3.3	Prototype installation & operation	63
CHAPTER 5: CONCLUSION		64
5.0	Introduction	64
5.1	Summary of research	64
5.2	Future work	65

REFERENCES	66
APPENDICES A	71
APPENDICES B	72
GANT CHART	78

LIST OF FIGURE

1.1	The component of hydro power	2
1.2	Cross flow turbine system operation	3
1.3	Operation of well turbine	3
1.4	The specification of head and flow of the water	4
1.5	The classification of water turbine	6
1.6	Water turbine application range	7
2.1	Sungai Mentawak Mini-Hydro Power Station	13
2.2	Pipeline with and without surge tank	15
2.3	Pipeline and penstock of a pico hydro	16
2.4	Impulse turbine bucket diagram	17
2.5	The efficiency curve of turbine	17
2.6	The flow of energy distribution from the resource	20
2.7	Pico-Hydro Power Development Flow	21
2.8	Micro hydro turbine system	23
2.9	Turbine selection chart	26
2.10	A cylinder shows the direction buoyant force and gravity act on it	28
2.11	The object is submerged into the water and the water level increase	28
2.12	1kW pico hydro in Laos	30
2.13	Design of pico hydro turbine and its components	31
2.14	Electricity demand in Malaysia	33
2.15	Electrification programme in Sarawak	33
3.1	The flow chart of the project	35
3.2	K-chart	37
3.3	Overview Performance Analysis Technique	38
3.4	Flow of the experiment and analysis	39
3.5	Direct Drive Motor DC96-01218E	41

3.6	Golden motor	41
3.7	Digital Tachometer	42
3.8	Water flow rate meter	42
3.9	SolidWorks logo	43
3.10	Final design of prototype	44
3.11	Upgraded turbine holder using aluminum material	45
3.12	Installation of the motor on the new designed bas	45
3.13	The final assembly of the prototype	46
4.1	Prototype floating system	50
4.2	Prototype is running the operation without load	50
4.3	Final pattern of the prototype	50
4.4	Modeling circuit to observe the potential energy	51
4.5	The increment of head increase the generated output	51
4.6	The resistor is assume as the energy conversion	52
4.7	The different output generated after energy conversion	52
4.8	The power input and power generated	53
4.9	The power generated with different value parameter	53
4.10	Reading value of potential and electrical energy graph	57
4.11	Output generated when varying the head graph	57
4.12	Output generated when varying water flow rate graph	58
4.13	The efficiency of the prototype graph	59
4.14	Generated output with different speed of motor graph	59
4.15	Fish pond for catfish breeding	60
4.16	Water waste flow out through the pipe	61
4.17	Water waste pipe line	62
4.18	Water waste pipeline into the generator	62
4.19	Valve to control water flow into the turbine	62
4.20	Pipeline connect the generator and intake turbine	63
4.21	The system operating	63

LIST OF TABLE

2.1	Classification of turbine	26
2.2	The classification of hydro generation	32
3.1	The component for testing procedure	46
3.2	Mechanical Parameter	47
3.3	Electrical Parameter	48
3.4	Power and Efficiency	48
4.1	Reference voltage for modeling simulation	54
4.2	The output generated by varying the value of head	54
4.3	The output generated by varying value of water flow rate	55
4.4	The output power generated after energy conversion	55
4.5	The output generated after varying the parameter	56
4.6	Power generated with different speed of motor	56

LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

P_{in}	-	Power Input (Watt)
P_{out}	-	Power Output (Watt)
η	-	Efficiency
H	-	Head of water (meter)
Q	-	Rate of water flow (Liter/second)
G	-	Gravitational force (9.81 m/s ²)
AC	-	Alternating current
DC	-	Direct current
AG	-	Asynchronous generator
SG	-	Synchronous generator
ASG	-	Asynchronous self-excited generator
B	-	Buoyant force
ρ	-	Density of fluid
V_f	-	Volume of water displaced
T	-	Torque
R	-	Radius

CHAPTER 1

INTRODUCTION

1.0 Introduction

Nowadays, renewable energy is the most prominent energy that has been used to generate power. It can be classified into several categories such as biofuel, biomass, geothermal, hydropower, solar energy, tidal power, wave power and wind power. By using renewable energy, it is one of the initiatives to reduce pollution and global warming. Besides that, it helps rural areas people get access to electrification [1]. Based on the research that has been done, 16% of the world population by 2030 will not get access to the electrical supply [2].

One of the renewable energy sources that is widely used is hydro power. The fact states that 16.3% of the electrical source is generated from hydropower [3]. It uses the flow of water to move the blades of the turbine, which are connected to the generator by the shaft [4]. The inexpensive nature of renewable sources plays an important role in generating power supply in the future, especially in developing countries [5]. Therefore, hydro power is the most effective way of power generation. Other than that, it creates a reservoir, which means it may increase the variety of recreational activities such as fishing, swimming, and boating. Other than that, the reservoir may provide seasonal stability of energy supply in which the water that has been stored is used to generate electricity [6].

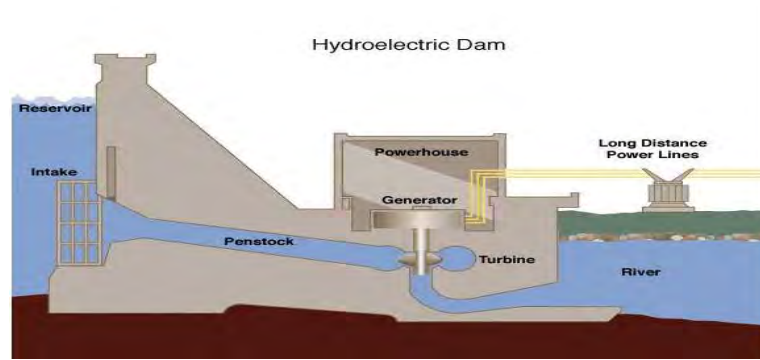


Figure 1.1: The component of hydro power [7]

Hydro power is the most efficient technology that convert the mechanical movement of the turbine into electrical energy. As shown in Figure 1.1, it is some of the component need to be present to convert the mechanical movement. It be classified to several type such as pico hydro, micro hydro, mini hydro, small hydro and large hydro by referring to their output power generated [8]. It was divided based on the capacity that can be generated from the hydro. For an example a pico hydro power generator usually can generate the power to the maximum capacity of five kilowatt [9]. Meanwhile the micro hydro can generate power to the maximum capacity of 100kW [10].

The power generated is caused by the flow of the water into the turbine which act as a prime mover of the system [11]. The angle of the blade that was attached to the turbine form a kinetic energy to move the rotor of the generator. The turbine also can be classified into three common type which is impulse turbine, reaction turbine and gravity turbine. Figure 1.2 shows the example of cross flow turbine operation.

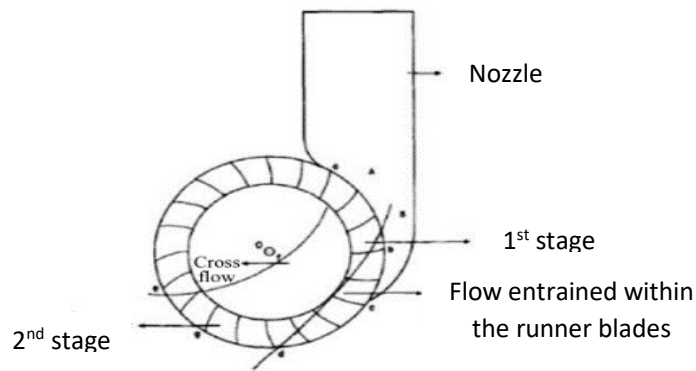


Figure 1.2: Cross flow turbine system operation [9]

Impulse turbine is a system that require the fast-moving water to flow through the turbine and it usually it will operate in optimum when the head is above 10m [8]. Other than that, the reaction turbine also one of the famous system that has been use in power generation. Reaction turbine perform well even the head is less than 10 m in which the low head water can be utilize easily [12]. Compared to impulse turbine, the reaction turbine is much more expensive due to the complexity of the design [13]. Figure 1.3 show the operation of the well turbine to drive the internal shaft. Sadly, wells turbine is rarely use since it has low efficiency and create high noise during the operation [14].

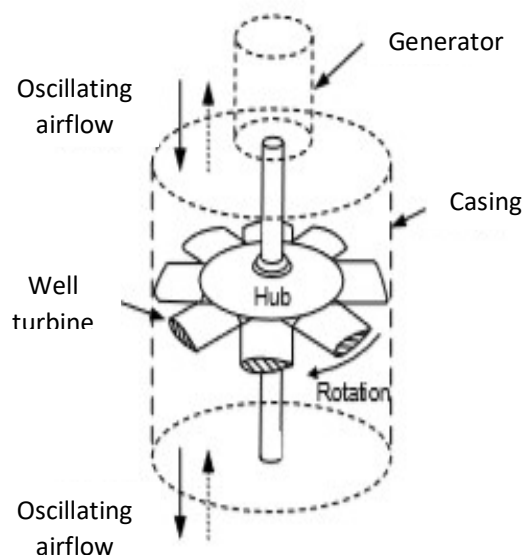


Figure 1.3: Operation of well turbine [14]

The hydro power generation has been introduced since 19th century. It gives a lot of advantages to the human kind such as power electricity demand, clean water supply and etc. Most of the inventor or innovator of this technology focus on major supply such as power plant station. It seems there is lack of invention on small capacity of power generation that could give a lot of advantages too.

1.1 Small hydro

Small hydro is a system that able to generate power up to 100kW [15]. Small hydro also consist of other miniature hydro system such as mini hydro, micro hydro and pico hydro. Pico hydro is one of the smallest power generation system which is the cheapest and require less effort compared to the bigger power generation plant [8]. Pico hydro has the capability of generating power up the fluorescent light bulbs and TV or radio for approximately 50 homes around it [9]. Pico hydro stands the fundamental of the hydropower generation. For an example, in Thailand the farming village installed their pump as a turbine for their pico hydro system [16]. There is two parameter that need to be considered in order to obtain the optimum output of the generator.

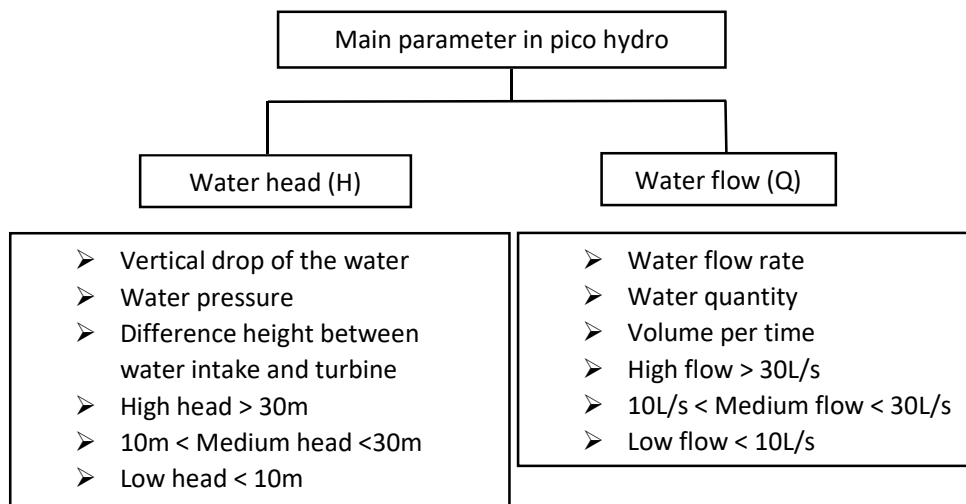


Figure 1.4: The specification of head and flow of the water [13]

The water head can be describe as the pressure of the water that in vertical axis toward the water drop from the surface of the water. It was formed through the existence of height. It is also the distance between the height and the water intake into the turbine. In the other word, it is also can be related to the attraction of the gravity. The classification of the parameter of pico hydro are shown as in Figure 1.4. Besides that, the water flow also act as a main factor to the power generation. The water flow is a rate where the water intake is taken in order to create a kinetic movement to the turbine. Pico hydro power plant is an excellent alternative to provide a low cost, small, easy installation and low cost maintenance which give a lot of advantage to the consumer.

1.2 Water turbine

Water turbine is a rotating device that convert the mechanical movement to the electrical parameter. In the past century, it was built to perform the mechanical power work before it is widely used for mechanical energy conversion. It is well known as the prime mover of the generator that exist in the dams to generate electricity. The flow of the water into the turbine give an assist to the movement of the turbine. It is aligned with the movement of the water. Basically, most of the water machine is reaction machine which it rely on the pressure of the head that acted on it to produce a movement. The turbine need a fully loaded water supply during their energy transfer.

The main theory of the operation of the turbine is the directed flowing water toward the blades of the turbine creating a force on the blades. The angle of the attached blade helps the turbine to move in such a high speed. Besides that, it also control the flow of the intake water so that the water pumped into the turbine can be spell out.

The structure of the turbine could be small or large in circular. The bucket or blades attached around it are able to produce a lot of torque to drive the auxiliary generator. Generally, the water turbine has more blades to the central of the shaft. It is because,

the rotation of will affect the next blade to get contact with the force act on it. But the speed of the rotation still depend on the speed of the water intake into the turbine.

As mention earlier, the parameter of the hydro is an important factor to push the hydro to generate the optimum power which is include the head of the water that related to the attraction of the gravity. The water turbine can be divided into three main group which is impulse turbine, reaction turbine and gravity turbine. The impulse turbine is a technology that driven in a high velocity of the water flow to create a force to the turbine blades. Meanwhile, the reaction turbine are fully immersed in the water which are surrounded by the pressure to form a force to the surface of the blades. The gravity turbine just process the fundamental of the gravity pull where the weight of the water entering the upper part of turbine create a force to the blade and drop to the bottom of surface. Figure 1.5 below shows that the classification of turbine according to the level of head.

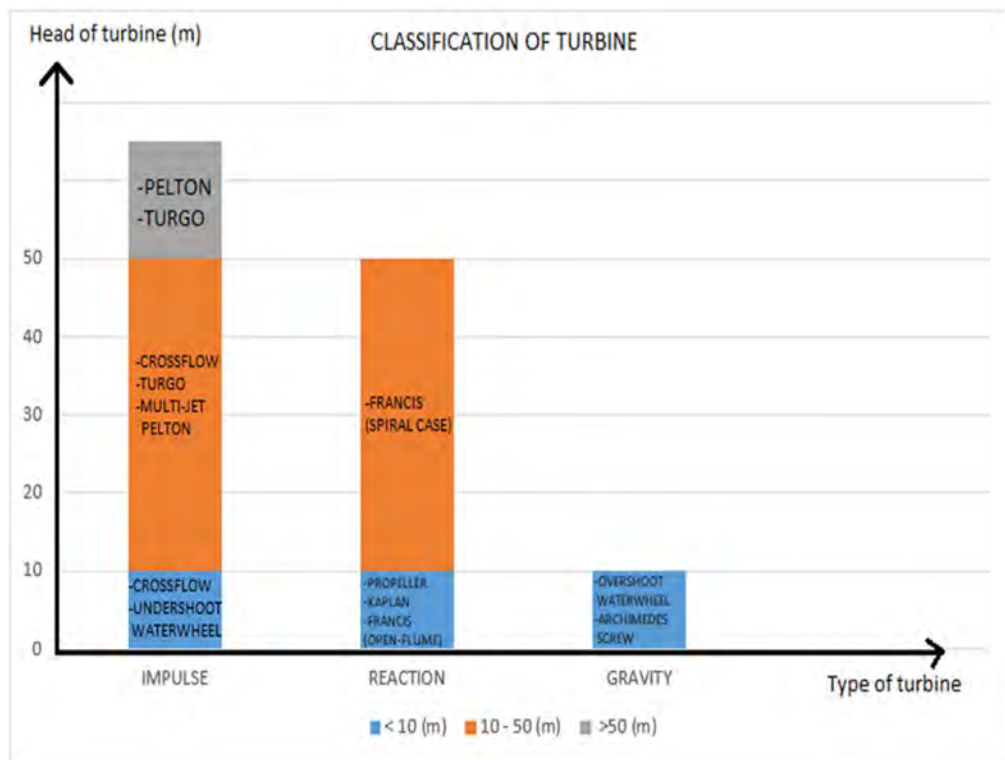


Figure 1.5: The classification of water turbine

1.3 Research Gap

The main focus of the project is utilize the potential energy of the waterways, small waterfall and drain system for a sustainable energy source. The flow of the water has the possibility to convert the small potential energy to a useful power generation without affecting the daily activities and the habitat. This is also the alternative to preserve the generation and in the same way the power can be generated. Besides that, it is best way for the consumer to save up their dollar bills on their power utilization charge. It is also portable which can be use in any kind of situation. For an example, camping beside the waterfall require the source of light from the spotlight. Therefore, the invention may be a lot of advantage to the camper in the future.

Nowadays, most of the power generation is focus on the high power which the capacity is up to 30 MW. This could be so expensive and complicated in term of the installation and maintenance. It is also costly to build and require the large are of water supply. The large hydro power commonly use high and medium head turbine such as Pelton, Turgor, Francis, Propeller and Crossflow which describe the expenses that need to be use. From figure 1.6 below, it show the typical range of a turbine according to the rate of flow and head of the water.

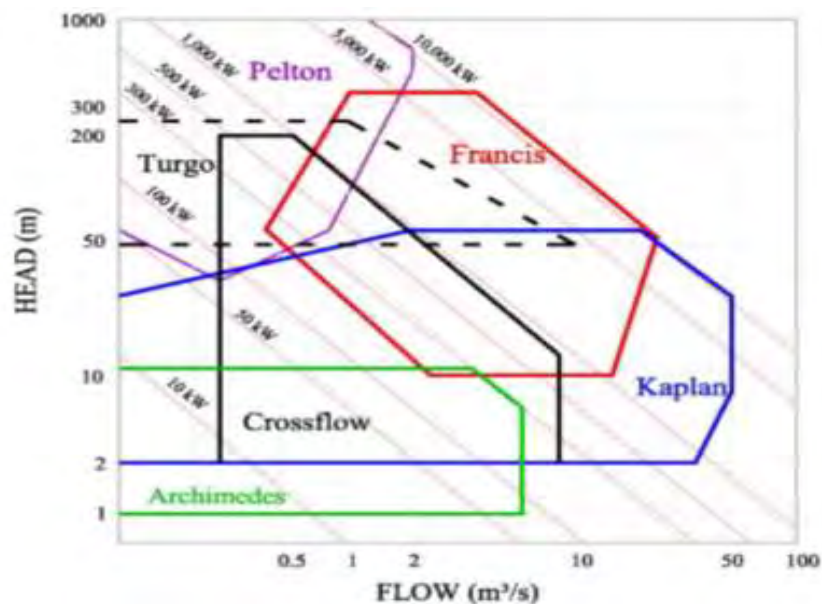


Figure 1.6: Water turbine application range [2]

1.4 Objective

The objective of the project is:

- To design a simple and low cost pico hydropower for small water resources.
- To investigate the performance of different type of generator base on the different flow rate and head.
- To make a comparison on the theoretical and experimental result of the pico hydropower.

1.5 Scope of project

The scope of the project is a section where the boundary or limitation in developing a system. It is important because in order to obtain the output in experimental test of the prototype, boundary has to be made to justify the output of the experiment on a certain level. On the first scope of the project, the level of head is set to be 5m to achieve the output of 100W. In addition, the rate of the water flow also need to be set to 2L/s. These two prospect are related to the law of physic which the pressure applied and the attraction of gravity will assist the movement of the water. This is really obvious when these two aspect is increasing, the output would be at the highest point.

Other than that, the portability and the lightness of the prototype would be one of the aspect that need to be consider. It is because the aim of the project that to provide the consumer a product that could ease their daily life in generating electrical power. Next, in term of saving the nature, the product are set to be float on the water. By applied this invention, the nature habitat of water life could be preserve.

The other scope of project is designing the prototype using a designing software called SolidWorks 2015. The software has the technology of predicting the total weight of