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MICRO HYDRO TURBINE (DESIGN AND FABRICATION)

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MICRO HYDRO TURBINE (DESIGN AND FABRICATION)

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This report is submitted to Faculty of Engineering University Malaysia Sarawak
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Dedicated to my loving family, friends and especially, Elly

Nadya

Thank you for all the support and encouragement

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ABSTRACT

Micro hydro turbine is an alternative for rural electrical power generation where the some areas in Malaysia are beyond the reach of power grid. This type of turbine is much cheaper than the full scale hydro turbine. Generating electrical power from 200W to maximum 10MW makes this type of small turbine the option to install in rural areas that in located near highly located places where abundant storage of water supply is available. However, this micro hydro turbine design actually needs special manufacturing process which is casing that is not widely available in Malaysia and some of the major components especially the Pelton bucket have to be imported. This project is focused on the redesigning and fabricating newer design of micro hydro turbine which will be constructed in an alternative way. Therefore, several of the problems of existing machine need to solve. Several parameters are discussed and analysed in order to build the new micro hydro turbine in term of cost, material selection and manufacturing selection.

ABSTRAK

Penjana hidro elektrik berskala kecil merupakan suatu pilihan alternatif dalam menyediakan kemudahan bekalan elektrik ke kawasan-kawasan terpencil yang jauh daripada kawasan liputan bekalan elektrik. Penjana jenis ini jauh lebih murah daripada penjana hidro elektrik jenis skala penuh. Penjana jenis ini yang menghasilkan tenaga elektrik dari 200W hingga 10 MW maksimum menyebabkan ia dipilih untuk dipasang di kawasan terpencil yang berdekatan tanah tinggi yang sememangnya mempunyai sumber bekalan air yang amat banyak. Penjana jenis ini melibatkan cara pembuatannya iaitu dengan kaedah tuangan yang seperti diketahui, kaedah ini tidak banyak terdapat Malaysia dan ada di antara komponen penting penjana ini iaitu 'Pelton Bucket' terpaksa ditempah dari luar negara. Fokus projek ini ialah untuk merekabentuk dan membina penjana hidro elektrik mikro baru yang dapat dihasilkan dengan kaedah alternatif. Dengan ini, beberapa masalah yang terdapat pada rekaan harus diatasi dan diselesaikan. Beberapa perkara akan dibincangkan sebelum membina penjana mikro ini iaitu kos, pemilihan bahan binaan dan kaedah pembuatan.

TABLE OF CONTENT

ACKNOWLEDEMENT	ii
ABSTRACT	iii
ABSTRAK	iv
CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	x
NOMENCLATURE	xiii

CONTENT	PAGES
----------------	--------------

CHAPTER 1: INTRODUCTION

1.1	Background	1 - 2
1.2	Micro Hydro Turbine	2 - 6
1.3	Pelton Turbine	6 - 7
1.4	The Objective of the Project	7 - 8

CHAPTER 2 : LITERATURE REVIEW

2.1	Introduction	9 - 10
2.2	Basic Theory of Movement	10 - 13
2.3	The Typical Design of the Pelton Turbine Component	13 - 16
2.4	The Comparison of Other Type of Turbine	
	2.4.1 Turgo Turbine	17 - 18

2.4.2	Crossflow Turbine	18 - 21
2.4.3	Francis Turbine	21 - 22
2.4.4	Propeller or Kaplan Turbine	22 - 24
2.5	Summary	24

CHAPTER 3 : METHODOLOGY

3.1	Introduction	25
3.2	The Design Stage	25
3.3	Defining Problems	26 - 27
3.4	Gathering Information	27
	3.4.1 Study on the machine	27
	3.4.2 The turbine that are going to be design	27 - 28
3.5	Concept Generation	29
3.6	Evaluation of Design	
	3.6.1 Design description	29 - 30
	3.6.2 Pelton Bucket Analysis	30 - 32
	3.6.3 Drive System Analysis	33 - 34
	3.6.4 Design Concept	
	3.6.4.1 Concept 1	35
	3.6.4.1 Concept 2	36
	3.6.5 Evaluation of concept	37 - 38
3.7	Decision making	38
3.8	Product Architecture and Configuration Design	38
	3.8.1 Material selection	39
	3.8.1.1 Steel	39 - 44

3.8.2	Bearing Selection	44 - 45
3.8.3	Welding Selection	45 - 47
3.9	Part Arrangement and Important Dimensions	47 - 51
3.10	Parametric Design	
3.10.1	Specification	52
3.10.2	Part by Part Feature	52 - 55
3.11	Fabrication Stage	55 - 58
3.12	Design Amendment	59 - 63
3.13	Conclusion	64

CHAPTER 4 : RESULTS AND DISCUSSIONS

4.1	Introduction	65
4.2	Micro Hydro Turbine Test	
4.2.1	Observation and Analysis of Deflection Characteristics	65 - 66
4.2.1.1	Observation Results	67 - 69
4.2.1.2	Analysis from Observation	69 - 70
4.2.2	Experiment of Power Generation	71 - 73
4.2.2.1	Experimental Result	74 - 78
4.2.2.2	Data Analysis	78 - 79
4.2.2.3	Discussion of the Test Result	79 - 80
4.3	Conclusion	80 - 81

CHAPTER 5 : CONCLUSION AND RECOMMENDATION

5.1	Introduction	82
-----	--------------	----

5.2	Achievements	82 - 83
5.3	Limitation	83 - 84
5.4	Recommendation for Future Work	85 - 86
5.5	Conclusion	86

REFERENCES	87 - 88
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APPENDIX I	I
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APPENDIX II	II
--------------------	----

LIST OF TABLES

TABLES		PAGES
3.1	Pugh concept generation matrix	37
3.2	Various steel alloys identification SAE-AISI numbers and chemical composition	41 - 42
3.3	Typical applications for plain steels	42 - 43
3.4	General properties of steel	43 - 44
3.5	Type of bearing	44 - 45
3.6	Specification of the proposed design	52
3.7	Part by part Description	52 - 55
4.1	Flow rate calculation	74
4.2	Recorded values for no load in chain drive mode	74
4.3	Recorded values for load engaged in chain drive mode	75
4.4	Recorded values for no load in pulley drive mode	75
4.5	Recorded values for load engaged in pulley drive mode	75

2.14	Propeller or Kaplan turbine	23
2.15	The position of component of the propeller or Kaplan turbine	23
3.1	Existing design of Pelton bucket	31
3.2	The shape of the existing Pelton bucket design	31
3.3	Concept 1	35
3.4	Concept 2	36
3.5	Interrelation of design, materials and processing	39
3.6	Classification of welding processes	46
3.7	The reaction of the turbine when jet of water hits the buckets	47
3.8	The assembly of the 16 Pelton buckets	49
3.9 (a) and (b)	The dimension nomenclature and its position	50
3.10	The working flow diagram of typical micro hydro Pelton turbine	51
3.11	The 2 Cs design of the existing Pelton bucket design on plan view	56
3.12	The complete design of the Pelton micro-hydro turbine	58
3.13	The final 12 Pelton buckets attached to the wheel assembly which will be fabricate.	60
3.14	The final Pelton bucket design	60
3.15	The final nozzle design	61
3.16	Comparison of earlier bucket design with revised bucket design showing the deflector fin circled in red	62
3.17	Comparison of earlier design of the nozzle with the deflector is circled in red and the revised design	62
3.18	The final design of the micro hydro turbine prototype	63
4.1	The observation testing components arrangement	66

4.2	Bottom view	67
4.3	Side view	68
4.4	Top view at $\frac{3}{4}$ of tap water valve opened	68
4.5	Top view at approximately $\frac{1}{3}$ of tap water valve opened	69
4.6	The angle of water deflection	70
4.7	The equipments arrangement for the power generation test	71
4.8	The circuit of connecting the alternator to the load	72
4.9	The prototype with chain drive system	73
4.10	The prototype with pulley drive system	73
4.11	The alternator speed recorded at no load and with load condition for chain drive mode	76
4.12	The alternator speed recorded at no load and with load condition for pulley drive mode	76
4.13	The alternator speed at 75 bar at no load and with load condition for both drive mode	77
4.14	The value of voltage recorded in both drive modes at 40, 50 and 75 bar	77
4.15	The value of electric current recorded in both drive modes at 40, 50 and 75 bar	78

NOMENCLATURE

U	Bucket speed
C	Water jet speed
W	Relative fluid velocity of water
E	Weight of flow
η_H	Energy transferred / Energy available in jet
g	Specific gravity
D_{runner}	Diameter of the runner
H_{net}	Vertical height from water source outlet to nozzle
d_{jet}	dimension of the nozzle opening
Q	Water flow rate

CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, many countries have taken an interest in renewable power technology. But some of the possibilities are in research stage for commercialization for public. Probably the most successful renewable energy source that is used widely in the world is hydro turbine electricity power. This type of renewable energy source is being used widely in Malaysia.

Many of the full scale type hydro turbine electricity power plants manage to supply electricity to several cities. The typical hydro turbine power plant can produce more than 10MW of electric power where 1MW of electric power is enough to power up 20000 50W light bulbs. With this tremendous advantage, the hydro electric power plant is probably the most suitable power source for countries that have mountainous terrain such as Malaysia.

The main problem with these renewable power sources is the high initial cost that burden small or poor countries. The cost of extending the electricity power grid to rural and isolated areas is also becoming more and more expensive due to the increase of metal price worldwide. The more feasible approach on low cost hydro

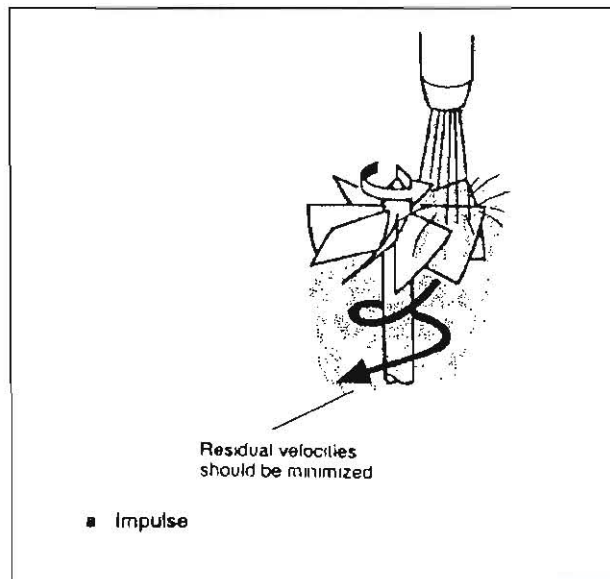
turbine power plant must be done to make these power plants to be available to anyone and anywhere possible.

The introduction to a smaller size hydro turbine that ranges up from 200 W to 10 MW of electric power have been done in several third world countries to power up isolated rural or small towns that are 100 miles away from the nearest power grid. These small hydro would provide the generation of electric power and even mechanical power to small factories.

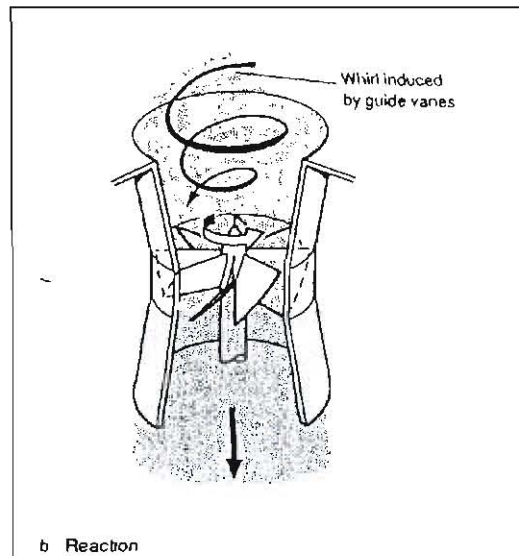
1.2 Micro Hydro Turbine

The introduction of micro hydro turbine has been made in several third world countries such as India and Peru. These micro hydro turbine ranges from 200W to 300kW. These small power plants have been installed in various rural areas in these countries and proven to be successful. Some of these power plants have been made locally to decrease the cost, but it depends on the local expertise in fabricating the micro hydro turbine as the cost of imported system is very high and will change due to the currency exchange.

Micro hydro turbine is divided into 2 major types that are impulse turbine and reaction turbine. Impulse turbines are Pelton, Turgo and Crossflow (also known as Banki, Mitchell or Ossberger turbine) while the reaction turbine are Francis and Kaplan turbines. Figure 1.1 shows the Impulse and Reaction turbine.



(a)



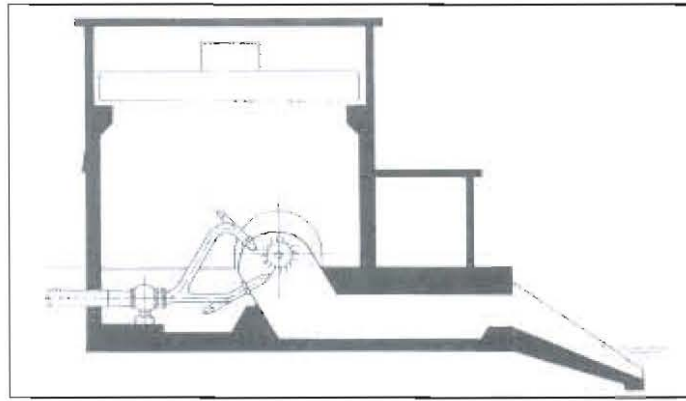
(b)

Figure 1.1 (a): Impulse turbine and (b): Reaction turbine (Harvey *et. al*, 1993)

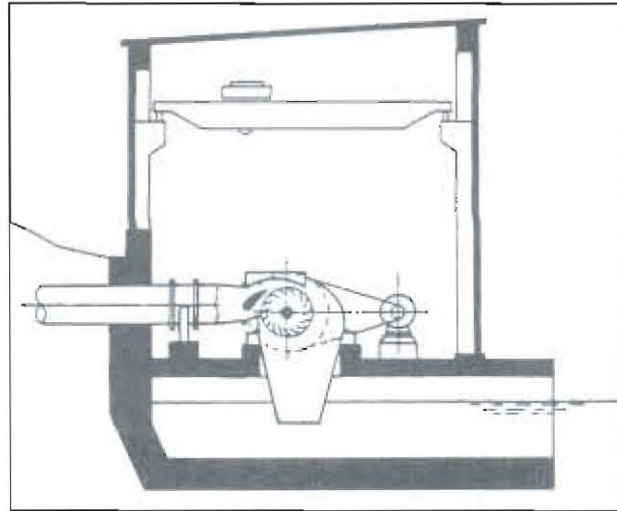
In comparison of reaction turbine, the impulse turbine is more tolerant to debris such as sand. It also allows access to the moving parts, in other word maintenance is easier. It is also easier to fabricate. The impulse turbine is also less subjected to cavitation and has more constant efficiency if the flow control devices are installed such as nozzles, control valve, guide vanes and others. The major upset

for the impulse turbine compared to reaction turbine is that this type of turbine is not suitable for a low head to power ratio. This head to power ratio is referring to the gross height of the flow source for example a river to the power output of the hydro turbine system. It means that the head must be sufficiently high enough to produce the desired power output. This disadvantage is improved by the used of the crossflow, Turgo and multiple nozzle Pelton turbine that runs better in medium head to power ratio.

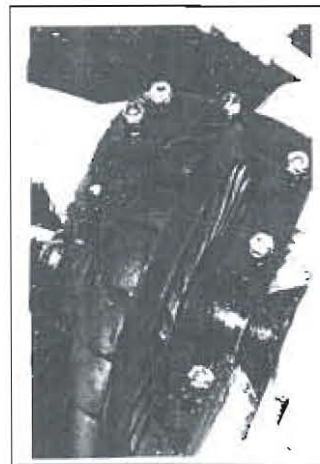
Meanwhile, comparing impulse turbine, the reaction turbine able to run in higher rotational speed that the impulse turbine in same head and flow conditions. This means that the reaction turbine will run in higher rpm than impulse turbine in the same pressure of water flow. This type of turbine is suitable running in low and medium head. This type of turbine is also can be connected directly to the generator without the installments of the speed increasing gearbox. The major disadvantage of reaction turbine is the difficulty of fabrication of its profile blade. This disadvantage leads to the decreasing interest of the developing countries to construct this design in their micro hydro turbine project.



(a)

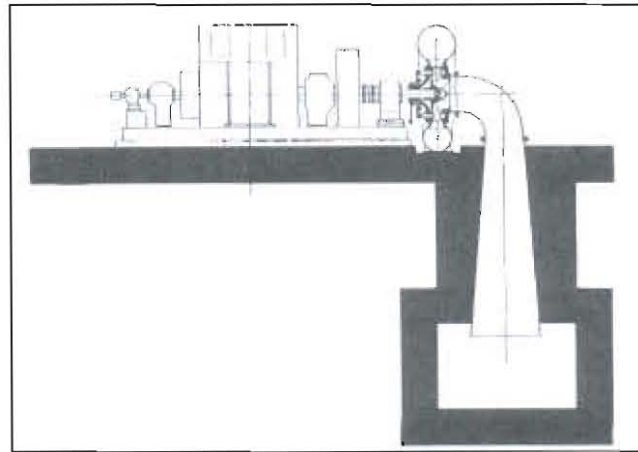


(b)

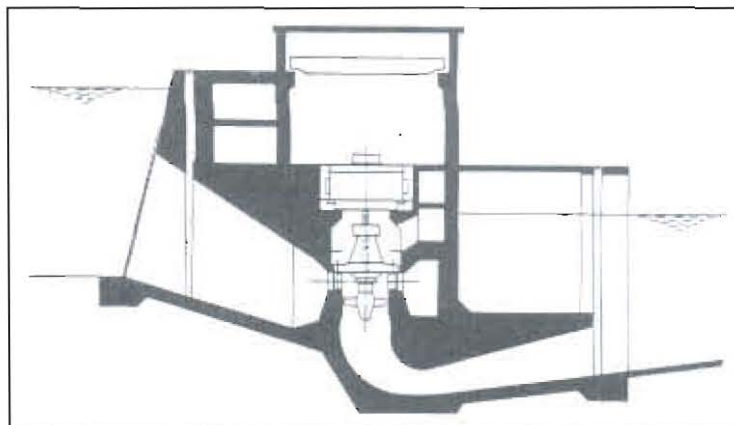


(c)

Figure 1.2: Types of impulse turbine (a) Pelton, (b) Crossflow, (Taylor and Strongman, 1984) and (c) Turgo turbine (Harvey *et. al*, 1993)



(a)



(b)

Figure 1.3: Types of reaction turbine (a) Francis and (b) Kaplan turbine

(Taylor and Strongman, 1984)

1.3 Pelton Turbine

The Pelton turbine was invented by Lester Pelton in 1870s. He obtained his Pelton wheel patent in 1880. Basically, the idea of the Pelton turbine or wheel was based on the working principal of water wheel. The invention of the Pelton turbine was the effort of Lester Pelton to increase the water wheel efficiency of producing power. This idea was inflicted by the demand of new power source since in the time

of the gold rush in California, the mills and the machine was powered by woods or coals. The idea was to fully optimize the water power in a faster river flow that the water wheel is incapable to produce optimum power output. This is the reason why the Pelton wheel or nowadays known as Pelton turbine was a success.

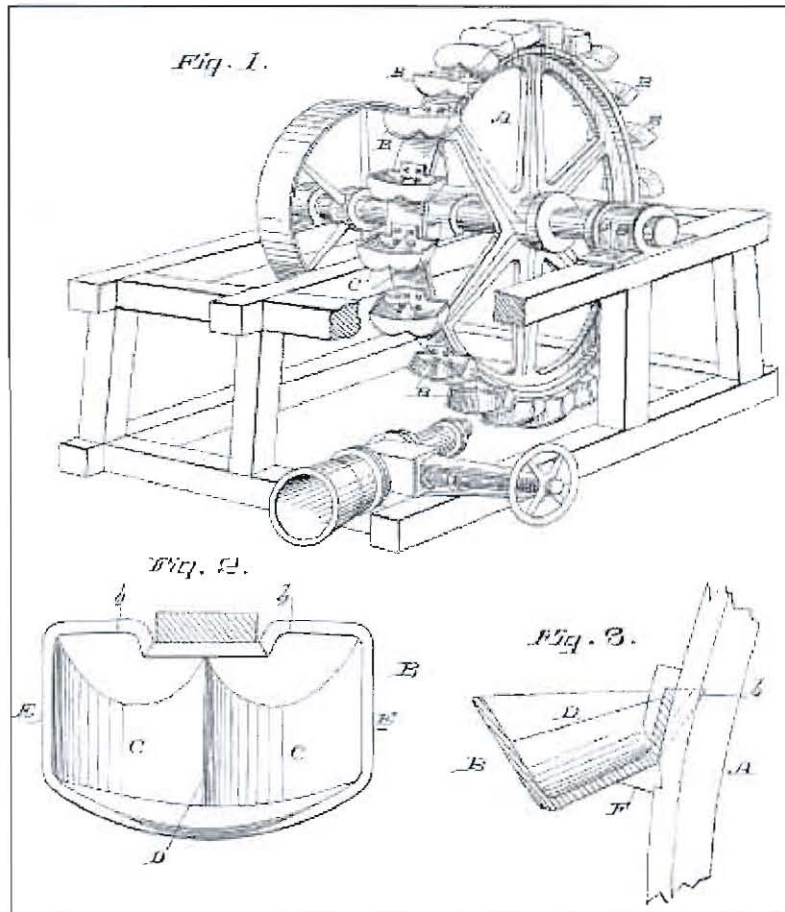


Figure 1.4: The 1889 patent issued by Lester Pelton of improved water wheel
 (<http://inventors.about.com/library/inventors>, n.d.)

1.4 The Objective of the Project

In this final year project, the author studied the construction of the micro hydro turbine based on Pelton turbine. The author also studied the design of

available Pelton turbine from the beginning to the final construction. The objectives of the project are as follows.

1. To construct a 200 W micro hydro turbine that can be installed at rural area where the power grid is unavailable
2. To construct the most cost wise and simple construction of the micro hydro turbine that can be made by any workshop.

The scope of this project is to be able to construct a micro hydro turbine prototype that will able to produce 200 W of power with relative efficiency.