POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

JABATAN KEJURUTERAAN MEKANIKAL

SESI 1 2021/2022

REPORT: LAMINAR FLOW WATER TURBINE

NAMA	NO PENDAFTARAN
MUHAMMAD BATRISHAH BIN MOHD RODI	08DKM19F1191
MUHAMMAD NAJEEB BIN ZOLKFELE	08DKM19F1187
MUHAMMAD HAFIZ BIN LUKMAN	08DKM19F1185

ABSTRACT

Laminar Flow Water Turbine change from mechanical rotational force into electrical life force.The Mechanical interface which consists of a laminar flow provision, water pump, and a suitable coupling transmits life force to an electric generator.The ouput of this generator is linked to battery matrix of framework.Preparation of Laminar Flow Water Generator.

Our group project is the result of an idea from our observations.The objective used is the interests of consumers that have been stated because of the problems in indigenous areas where there is usually no more or enough electricity supply.The method used to complete this project was through a questionnaire to 33 respondents consisting of 48.5% women and 51.5% men through questionnaire observation and reference.Objectives were selected based on frequent research in the area and this study was conducted in river areas throughout Malaysia.In this study our group has identified problems and came up with our idea to implement this project and our group project has a limited use limit that can only be used in a suitable place from our observations.in conclusion, the study from the observations of our group found that the service of electricity supply to the indigenous people who are in the interior of the forest or hilly areas is very important for them. In fact, this makes this problem the cause of our project idea was created to implement in more detail.

Keywords: laminar flow, electricity, battery, water, turbine

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Every student studying at the Polytechnic, Ministry. Malaysian Higher Education is required to make a final project that takes 2 semesters to enable the student to be awarded a diploma. With this, this final project is very important because it can find out the ability of the student to make a project that has been directed.

The introduction of our project is Laminar flowing water turbine machine that can generate electricity with the help of natural river water flow or from pumps produced by us. This laminar can have a positive effect on the user without noise

1.2 BACKGROUND OF THE PROJECT

According to what we can collect, this product is proposed to be produced is due to the factor of consumers who are less able to have an electric generator that can be taken anywhere. In this case, the idea for this project was produced. but from the price factor may be the product We can get response and there may be a shortage due to the price.However that does not mean that we will use substandard materials, We will use suitable and quality materials in terms of price and in terms of how many products We can supply electricity. Our products are suitable for low voltage applications such as smartphones, laptops, battery chargers and those that suit the voltage supplied.

1.3 PROBLEM STATEMENT

The problem we face is the Orang Asli people who live in forests far from Malay villages, in hills and rivers. The thing is about the area having to pay, they can't supply adequate and comfortable electricity and may charge a little to those above having to pay the electricity bill. Also, the problem we often hear about is that most gasoline generators emit smoke that can cause environmental pollution

1.4 OBJECTIVE

Providing facilities or solutions to the indigenous people to get a second electricity with pump rocks generated by us or from natural sources such as rivers or rainwater to some extent helps them bring this laminar -like electricity supply to a suitable place. In addition, this product is a special turbine water flow laminar for electronic products. Voltages such as cell phones, powerbanks, laptops and such ranges

1.5 RESEARCH QUESTION

The cost of making Laminar Turbine uses minimal cost. It is also useful during times of electrical outages. In addition, it is environmentally friendly because it does not use fuel but only uses water.

1.6 SCOPE OF THE PROJECT

The outline of a water turbine consists of a turbine interface with a generator and 12 battery voltages. As we noticed from the generator giving DC 12V output D.C. this is generally inconsistent there are some variations of this DC result that can not be given to the battery stock, it may weaken the battery life. So keep in mind the ultimate goal is to get a stable DC result and further to avoid back current to the board as no charge controller stack has been used to help us allow a fixed voltage of 12V DC to the battery and in turn it acts as a blocking diode and ensures regulation engine.

Uniform water flow so as to control the age results to be consistent.The preferred point of view of this guideline is that the edge of the rotor can recognize water from any compass.Since this machine has vertical pivot symmetry, it does not require yaw control requirement so that its rotor can capture life force. Double reason and shaft hub amplifiers are generally expected and in addition the transmission of ground surface force results due to the quality of the vertical shaft. As such, this allows for less demanding access and convenience of services.The manufacturing cost of an air rotor must be reduced compared to the edge cost of a traditional rotor.Field control prerequisites that do not appear for synchronous activity cangenerate additional cost investment funds.The proportion of tip speed and power coefficient are much better than that of an S-rotor but still below the quality for a flat, two-blade rotating propeller rotor.

Coordinating heating applications Mechanical movements derived from water force can be used to move heat pumps or to make heating from the contact of strong materials, or by stirring different water or liquids, or in different cases, by using diffusive pumps or various types mixed with prohibition openings that produce heat from the grate and turbulence as the fluid works through it. This warmth can then be removed in materials that have a high heat limit, such as water, rocks, eutectic salts, etc.,

A home heating framework that uses water -controlled pumps and prohibition openings to determine the coordinate warmth for work, without first generating energy has also been produced.

Electricity Generation Applications:

Hydropower can be used as part of a shared utility application to power synchronous A.C. electric generators. In such applications, the life force is driven specifically to regulate the control through a voltage ventura transformer.

This unit can be coordinated with existing hydroelectric systems and used as part of the "water saver" method of the task. At the moment the water is blowing, an amount of electricity equivalent to that of a creature can decrease the age of the hydroelectric plant in the system transmitted by this unit. Along this line, water turbines supply part of the system stack typically made by hydroelectric generators. Under these circumstances, part of the water that will be used by the hydroelectric power plant to supply the pile is spared in the repository and can be accessed for later use when the water is not blowing.

1.7 SIGNIFICANCE OF THE PROJECT

People

The importance of our project to the people is:

I. Reducing production costs in this covid 19 era
II. In addition, it can facilitate traders on the side of the road because there is no need to buy oil and other2.
III. Next, be able to provide electricity to residents living in mountainous areas or forests far from rural areas.

Environment

I. Able to reduce environmental pollution because our project only uses fuel from water and not like petrol or diesel.
II. In addition, our project uses more second -hand goods than goods sold in the store. This can have an impact on goods that are good but not used and had to be discarded. But we by using this very minimal cost can provide our customers with goods which is good at an affordable price

Countries

I. Able to reduce the purchase of diesel or petrol from abroad, with this the country's finances will be better maintained.
II. In addition, to be able to maintain the health of the population in this time covid 19 because it does not use fuel such as 1.7.2 .this will result in the government not having to spend high medical costs and can focus on covid 19 patients.

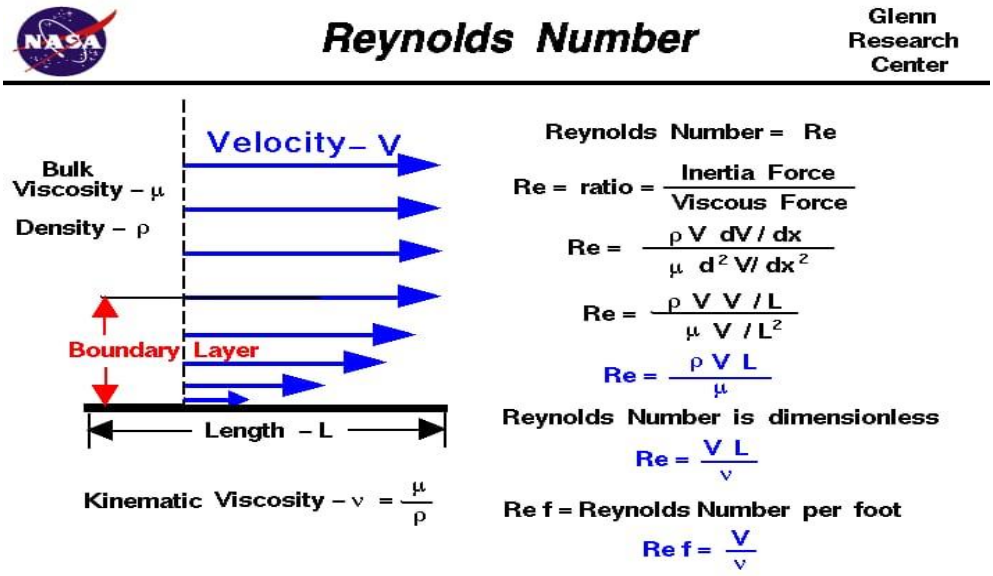
1.8 DEFINITION OF TERM/OPERATION

Formula

$$Re = \frac{\rho u L}{\mu}$$

Re = reynolds number
ρ = density of the fluid
u = flow speed
L = characteristic linear dimension
μ = dynamic viscosity of the fluid

For such systems, laminar flow occurs when the Reynolds number is below a critical value of approximately 2,040, though the transition range is typically between 1,800 and 2,100.



1.9 SUMMARY

The conclusion we can make in this chapter 1 is that this our project may be able to help the residents and also ease the burden of the government as it can reduce the purchase of diesel fuel for the flags. Apart from that, it can also reduce the interpretation of electricity in every house or more precisely in aboriginal residential area

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Laminar Flow Water Turbine is a change of energy for comparison for the rotational force Mechanical has converted electricity. The force interface and the mechanical process are comprised of the provision of a Laminar water host flow, a generator we use a used ac motor and a plug. All these parts will transmit kinetic energy to mechanical energy and produce electrical energy. The generator will be connected with wires to produce even electricity. Our project is only 500mm x 300mm x 300mm in size.In this Chapter, we get to know how laminar turbines act and occur. Here too, we have made a detailed study of how our project is designed and runs theoretically and according to science. First, Turbine flow is characterized by fluid particles that follow a narrow route through the layers, with each layer flowing smoothly across neighboring layers with little or no mixing in fluid dynamics. these have scientific and technical laws such as the law of conservation of energy, the law of faraday and the principle of electromagnetism. These have scientific and technical laws such as the law of conservation of energy, the law of faraday and the principle of electromagnetism.

The lower the reynold number the higher the concentration of a fluid i.e. water.

$$Re = \frac{\rho \cdot V \cdot L}{\mu} \; or \; Re = \frac{V \cdot L}{\nu}$$

Re = Reynolds number
ρ = Density
$V = Velocity$
L = Length
μ = Bulk viscosity
ν = Kinematic viscosity

Figure 2.1.1 shows picture about laminar nozzle

Figure 2.1.2 shows picture about laminar nozzle

2.2 COMPREHENSIVE WRITING

Laminar flow is one of our projects. Laminar flow is a type of fluid flow (gas or liquid) in which the fluid travels smoothly or in a normal path, in contrast to turbulent flow, in which the fluid undergoes irregular fluctuations and mixing. And the following displays a brief commentary on the meaning of flow laminar. Laminar flow is a type of liquid or gas flow in which liquid flows through a channel regularly or smoothly. This is in contrast to turbulent flow, in which liquids through irregular mixing and fluctuations. Pressure, speed and other properties in solution remain constant in laminar flow. Initially Laminar flow is a flow regime characterized by high momentum propagation and low momentum convection. When a fluid flows through a closed channel such as a pipe or between two flat plates, one of two types of flow can occur depending on the velocity and viscosity of the fluid: laminar flow or turbulent flow. Laminar flow occurs at lower velocities, below the threshold at which the flow becomes turbulent. The velocity is determined by a dimensionless parameter characterizing the flow called the Reynolds number, which also depends on the viscosity and density of the fluid and the dimensions of the channel. Turbulent flow is an irregular flow regime characterized by eddies or small packets of fluid particles, resulting in lateral mixing. Moreover, in non - scientific terms, laminar flow is smooth, while turbulent flow is coarse. Faraday's law says that a change in the magnetic environment of a closed coil (loop) of wire causes a voltage, or emf (electromotive force), to be produced in the coil.

Next we went to the part of our generator that had a magnet fitted along the shaft and the rotor shaft. A generator that converts kinetic energy into electrical energy uses the laws of electromagnetism. Multi -function attractive structure, draft, centrifugal heavy turbine use attractive offer and shock structure such as turbine with turbine magnet and attractive watch magnet. With this the detailed law we apply is Faraday’s law and Ampère’s circuital law. Faraday’s law is that changing the intensity of a magnetic field, moving a magnet toward or away from a coil, moving a coil into or out of a magnetic field, or rotating a coil in a field can all create changes in the magnetic environment.

The induced emf is equal to the rate of negative change of magnetic flux multiplied by the number of turns in the coil:

$$E = -\frac{N\Delta\phi}{\Delta t}$$

Where:

E = emf (V)

N = number of turns in the coil

Φ = magnetic flux (weber, Wb)

t = time (s)

Figure 2.2.a shows picture about formula faraday law

In addition, we also use other laws of electromagnetism such as the law of the Ampère circuit. Ampère's law of the circuit was taken under the name André-Marie Ampère, in 1860. Ampère can be formulated as Ampère's law of force, which describes the force of attraction or repulsion along two current-carrying wires The magnetic field creates a force in one direction on one side of the loop and in the opposite direction on the other side of the loop when the wire is a loop. The coil spins as a result of the torque created. The coil will oscillate back and forth if direct current is provided, but it will not make complete rotations - this is why DC motors employ commutators. Motors that run on alternating current (AC motors) do not have this difficulty.

The magnetic field puts attraction on a straight wire that carries a current. The intensity of the magnetic field can be calculated using the laws of the Ampère circuit as follows:

$$B = \frac{\mu_0 I}{2\pi r}$$

Where:

B = magnetic field (T)

μ0 = magnetic permeability of air, T-m/A

I = current (A)

r = distance from the wire (m)

Figure 2.2.b shows picture about formula faraday law

The pointer or needle of the Galvanometer, which is essentially an extremely sensitive centre zero'ed moving-coil ammeter, will deflect away from its centre position in one direction only when the magnet illustrated below is pushed "towards" the coil. Because there is no actual movement of the magnetic field when the magnet stops moving and is maintained stationary with respect to the coil, the needle of the galvanometer returns to zero.

When the magnet is pushed “away” from the coil in the opposite direction, the galvanometer needle turns in the opposite direction from the first, indicating a polarity shift. The galvanometer needle will then turn left or right, positive or negative, relative to the directional motion of the magnet by moving it forward and backward toward the coil.

The basic premise of how an electric generator works, just like our project, is to create a constant induced voltage that alternates between a positive polarity and a negative polarity, producing an alternating output voltage in an ac motor or so-called generator

Finally, this is the theory we introduce our project laminar flow water turbine by using water to move the shaft in the generator that has a magnetic produces electricity of 6votls suitable for charging phones, laptops and power bank

2.2.1 Design

The prototype of the project that we have produced is a laminar turbine flow which is a device that uses water energy to move the turbine and produce kinetic energy, and produce electric energy. the water flow becomes sharper or straighter by using the laminar flow method. with this method we can produce a stronger force to drive the turbine to rotate faster in order to get better results.

And this is a sketch of our project:

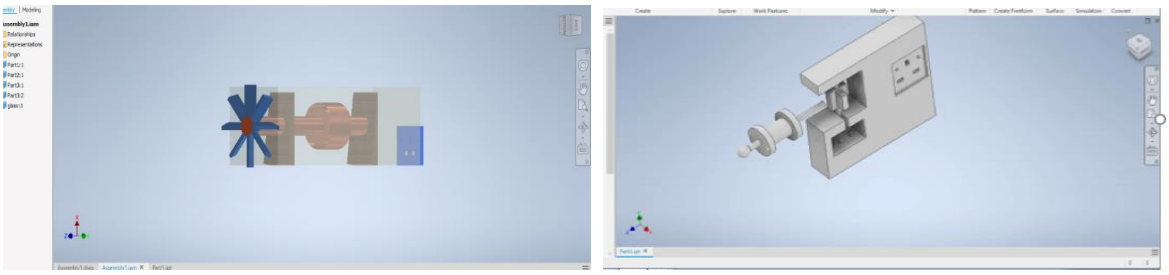


Figure 3.1.2 shows above right are sketches of our full product produced. while, on the top left is a picture of the prototype we produced in this semester. This method is designed in the form of 3D sketches using a standard computer application Inventor.

2.2.2 DESIGN STUDY

We used the electromagnetic turbine method to work to generate electricity. Inside the turbine generator, the water fluid will move like a concentration of water that has pushed the edge arrangement mounted on the rotor shaft. This fluid constraint on the side of the shaft rotates and rotates the rotor shaft of the generator which has been wound with. The generator will in turn convert mechanical energy with rotor dynamic energy into electrical energy. The magnets that are in the generator will be rotated together with the coated wire in the opposite direction. and it will produce an even amount of electrical energy. The wires installed along the generator will carry the flow of electricity generated and directly to our electricity production division.

2.3 SUMMARY

Our project protype has worked well because it is not too difficult to create (build) and use. This is because we have already used various theories of physics and engineering that have been discovered by previous researchers. These People have helped us in the present day to produce many more things that help us move forward. In conclusion, our project has been able to be used by beginners, especially indigenous people who live far inland who are short of electricity. I hope our country can produce research and innovative such as laminar, turbine and electromagnetic to drive progress for our country.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

To solve existing problems with the resulting product, we need to have its own methodology by way of describing all the activities that done. The use of methodology must be systematically structured for our project can produce important aspects. In this chapter, we will explain how our project the Laminar Flow Water Turbine was designed and manufactured

This Laminar Flow Turbine is designed by us based on research and thorough discussions between our group members and supervisors. Laminar Construction This Flow Water Turbine considers various aspects and theories that are innovative. The design produced is environmentally friendly, lightweight, easy to carry and convenient produced. The selection of each component is based on agar research and testing this project can be used on buyers or the community. In addition, we also prioritize safety and comfort on our projects.

This Project Search is used to solve common problems in the environment in our society. After discussing with the supervisor, we a group discusses how this product is produced Project Presentation 2, involves several things namely project introduction, scope, objectives, statements problems, literacy studies, methodologies, computer aided drawings and others. but in project 2 we found that the material cost to make a laminar flow water turbine is too high, so we decided to make a prototype for our project in Sem 5. this prototype is different from the original because the material used is of poor quality and requires strong force to pushing the turbine to rotate, it is likely that this prototype can only be used in waterfall areas and is less proactive if used at home.

3.2 PROJECT DESIGN

This project uses research methods to compare students who has the best project ideas and designs. This method is designed in 2D sketch form and sketch using a computer application called Inventor

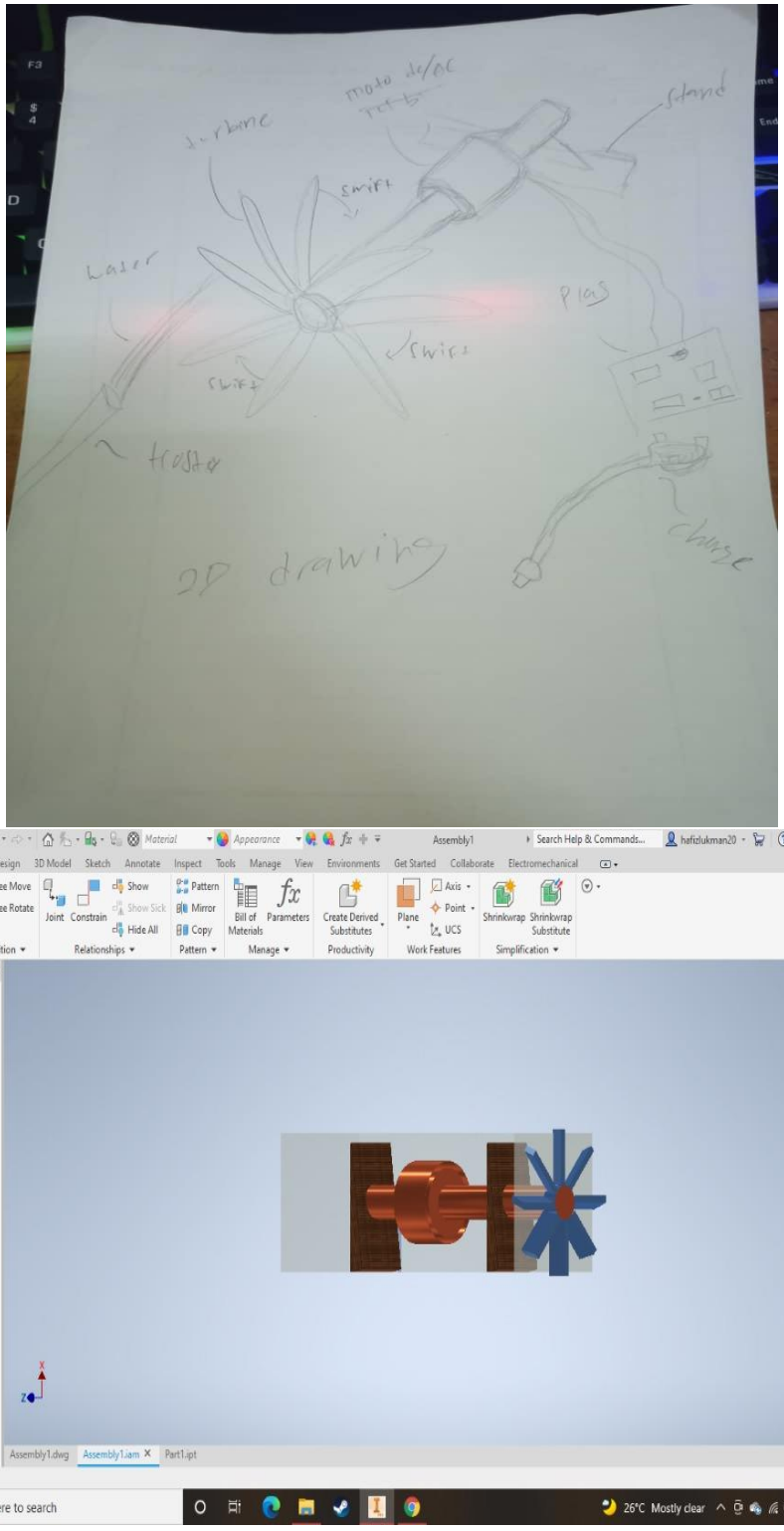


Figure 3.2.a shows project sketch

3.2.1 METHOD

To make this project a success, a few steps need to be done and are also necessary adhered to to ensure that the project to be undertaken is smooth and successful. With the existence of this flow chart encourages a more orderly use of time as well systematic because it can follow all instructions so accurately and perfectly. Among the steps that need to be followed are as follows

STEP -STEP FLOWCHART PRODUCING A LAMINAR FLOW TURBINE: -

1. More research in the meaning of laminar and turbine
2. Estimated cost in each of the Major Division Projects
3. Make a sketch of the Project design
4. Complete 3D and 2D project design
5. List to budget for frames, pumps, laminar hosts, generators and turbines
6. Presentation of proposals
7. Measure and cut frames and timber
8. Fabrication connections and installation
9. Frame and woodworking connections
10. Manufacturing process
11. Run the test
12. Inspection and updates

3.2.2 Proposed Material/Tool/Equimpment

Materials and equipment for laminar flow prototype

LIST	ITEM	PRICE
1	TURBINE WHEEL • Disk • plastic spoon • bearing holder	 RM 5.00 RM2.00 RM1.50
2	GENERATOR • USED AC MOTOR • 0.032mm Polyurethane Insulated Enamel Coated Wire • Bearing • Shaft • Magnet • Rope • Rotor • Used Iron metal for frame • Slip rings and brusher	 RM 0.00 RM5.00 RM3.10 RM 3.00 RM 5.60 RM1.00 RM 3.00 RM 0.00 Rm 3.00
3.	SECTION FOR CONTINUATION • Bolt and nut • Screw • hot glue stick • wired electrical	 RM0.50 RM 1.00 RM 1.00 RM 0.70
4.	Plug Extension Cord outlet	RM 4.60 RM 6.00
5	Nozzle • Bjiax 1.5inch External Thread Opening Water Flow Inlet Nozzle • Airbrush Nozzle E3D V6 Compatible 0.4mm host	 RM 5 RM 9.00 RM 5.00
6	Acrylic sheet	RM 30
		TOTAL : RM 95

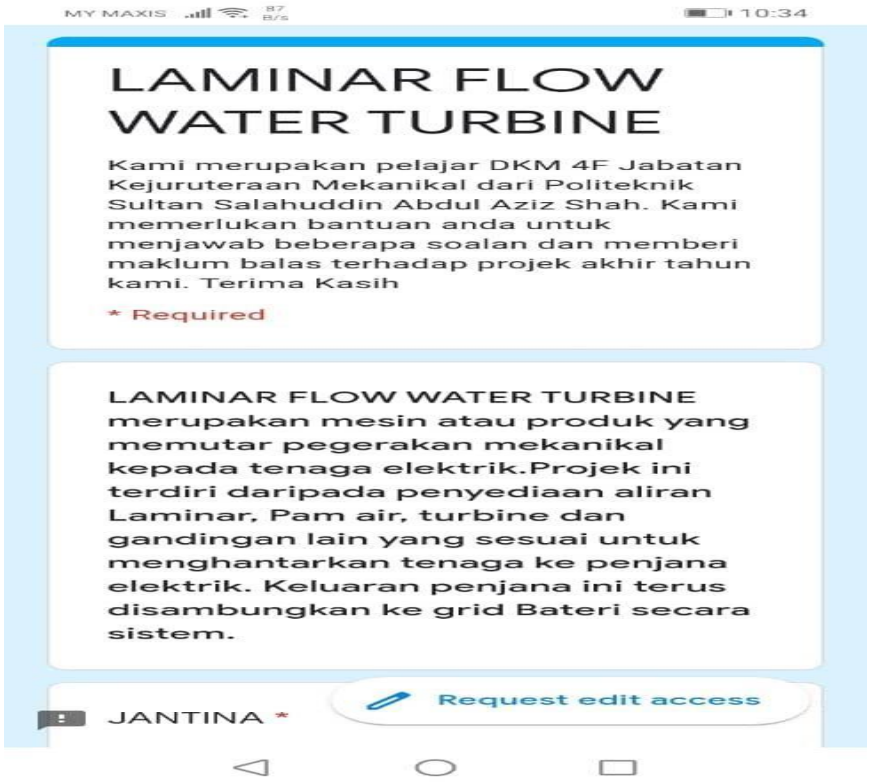
Table 3.2.2.1 shows Equipment and prices for our projects

3.4 METHODS OF DATA PRODUCTION

The collection of data required in this project is collected through websites, references from books and from data collection. Data collection from questionnaire results made through "Google Form". Each information obtained

is also analyzed in advance to be in accordance with the methods carried out

In the process of analyzing this, the collected data will be analyzed and the results to be achieved are displayed in the form of pie charts, crossbar graphs and tables.
we found while we were in Sem 4 project 1. laminar flow water turbine is too expensive and



will cause the selling price to increase, this will reduce consumers to buy our goods. Therefore, we decided to minimize production or material cost by replacing our project to prototype.

3.5 SUMMARY

In arranging, thinking about plans, methods of data collection, contemplating instruments, strategy of examining and investigating information that are made efficiently in considering techniques to know facts and data to support rebellious research and learn more clearly in this study.In the initial stage, project design, data collection methods, project instruments, data techniques and data analysis methods are systematically created in the project methodology to know the facts and information to support the project instruments and to illustrate more clearly in the project.Once an information check is done, it is imperative to formulate or conclude on the same to hypothesize whether the laminar project was successful or failed.

CHAPTER 4

RESULT OF DATA ANALYSIS

4.1 INTRODUCTION

At the end of this project, our Project managed to produce our generator to produce electricity even though it only produced a prototype. In addition, according to the analysis we have studied based on our products, our products are not all users or areas that are suitable for full daily use. And we think that suitable users are users who live in hills, rivers and in forests or suburbs. , because there are areas where it is difficult to get the same level of electricity as the people in the city with good facilities. And the advantages of this product, this laminar flow water turbine can help a little to the users mentioned above such as can supply electricity and also helps when in their area they experience frequent power outages.

4.2 PROJECT FINDINGS AND OUTCOME OF TEST

For this laminar flow water turbine project, we managed to produce to generate electricity by using only water. But we are only able to produce a porotype. We are also only able to produce 6 volts of electricity. Our laminar flow water turbines can charge voltage electrical appliances such as power banks and Battery capacity and voltage rating Usually, they use cells with a nominal voltage of 3.7 volts (V) and a capacity ranging from 1500 to 5000 milliampere-hours (mAh). However, cells with other voltages are also available on the market, e.g., 3.6V, 3.8V or 3.85V.

Maximum electrical output	**average output voltage**
6 volts	3.1-3.7 volts

Figure 4.2.1.a shows maximum and electrical output

Figure 4.2.1.b A prototype of our project has been produced

Figure 4.2.1.c shows the power bank we have connected to our project has been able to charge

Figure 4.2.1.d shows A multi -meter has been connected to our electrical production wire and the output produced is 6 volts

4.3 DISCUSSION

The interpretation that can be obtained from our product, which is a laminar flow water turbine, will definitely get response and less response from the public because the product is not a product to meet the needs but this product is a product that can meet the needs of every user when there is an unexpected Kris. this can work also without the natural flow of river water, it can also work by using a water pump using the same water i.e. the water will be shot towards the laminar and the stagnant water will be sucked back into the pump continuously. This product can supply electricity to consumers who own this product.

4.3.1 COMPARATIVE STUDY

This laminar flow water turbine can replace the existing product on the market which is a generator that uses petrol to produce electricity and the use of this generator is often used by night market traders and so on. a place with the noise of the generator machine and lead to noise pollution. This does not provide comfort to some users and this generator machine is not suitable for use in residential areas, this will have a negative impact on users and residents close to users.

4.4 SUMMARY

This laminar flow water turbine product can to some extent have a positive effect on the public as well because this product is not expected to be too heavy, easy to carry anywhere according to the appropriate area as well as to take camping. This product also does not emit noisy noise like the product which is on the market and can be said this product is an environmentally friendly product. Our products can be considered for use by the appropriate population on a large scale or on a small scale first. We hope that our products get a good response from all parties

4.4.1 RECOMMENDATIONS

We accept all ideas for improvements to our products to make our products more sophisticated or work better while being able to provide convenience to the public.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This laminar flow water turbine product can to some extent have a positive effect also on the public because this product is not expected to be too heavy, easy to carry anywhere according to the appropriate area as well as to take camping. noisy like the products on the market and it can be said that this product is an environmentally friendly product.

5.2 CONCLUSION

With the help of our product, the laminar flow water turbine, it can facilitate and reduce worries for the indigenous people and also for consumers who use this product in suitable places such as rivers or waterfalls and hilly places.

5.3 RECOMMENDATION

We accept all ideas for improvements to our products to make our products more sophisticated or more functional as well as able to provide convenience to the public.

5.4 PROJECT LIMITATION

The limits of our project can be stated can only be used in hilly areas close to rivers or waterfalls. Users who can be used are residents living in the river area and also travelers or visitors who vacation in the river. The speed of water required to move or turn Our turbine fans have a minimum of 81 flow rates.

5.5 SUMMARY

From what is studied in this Chapter, this Chapter describes all the data and initial income of the study for this product and this data can also be collected from the cooperation of the public. Each product reasonable and should make assessments and seek important data to ensure that the product can be used safely and functioning smoothly and well as desired by each product manufacturer

REFERENCE

1. Streeter, V.L. (1951-1966) Fluid Mechanics, Section 3.3 (4th edition). McGraw-Hill

2. ^ Jump up to:a b Geankoplis, Christie John (2003). Transport Processes and Separation Process Principles. Prentice Hall Professional Technical Reference. ISBN 978-0-13-101367-4. Archived from the original on 2015-05-01.

3. ^ Noakes, Cath; Sleigh, Andrew (January 2009). "Real Fluids". An Introduction to Fluid Mechanics. University of Leeds. Archived from the original on 21 October 2010. Retrieved 23 November 2010.

4. ^ Avila, K.; Moxey, D.; de Lozar, A.; Avila, M.; Barkley, D.; Hof, B. (July 2011). "The Onset of Turbulence in Pipe Flow". Science. 333 (6039): 192–196. Bibcode:2011Sci...333..192A. doi:10.1126/science.1203223. PMID 21737736. S2CID 22560587.

5. ^ Nave, R. (2005). "Laminar Flow". HyperPhysics. Georgia State University. Archived from the original on 19 February 2011. Retrieved 23 November 2010.

6. ^ Anderson, J. D. (1997). A History of Aerodynamics and Its Impact on Flying Machines. Cambridge University Press. ISBN 0-521-66955-3.

7. ^ Rogers, D. F. (1992). Laminar flow analysis. Cambridge University Press. ISBN 0-521-41152-1.

8. ^ sovereign578. "Laminar Flow in Nature". YouTube. Retrieved 17 December 2019.

9. ^ Faith, Robert E.; Hessler, Jack R. (2006). "10. Housing and Environment". In Suckow, Mark A.; Weisbroth, Steven H.; Franklin, Craig L. (eds.). The Laboratory Rat (2 ed.). Amsterdam Boston: American College of Laboratory Animal Medicine (AP). p. 304/pp. 304–337/xvi+912. ISBN 978-0-08-045432-0. OCLC 162569241. ISBN 9780120749034 ISBN 0120749033

10. ^ Trávníček, J.; Mandel, L. (1979). "Gnotobiotic techniques". Folia Microbiologica. Czechoslovak Society for Microbiology (Springer). 24 (1): 6–10. doi:10.1007/bf02927240. ISSN 0015-5632. PMID 374207. S2CID 6421827.