Technoeconomic Analysis of Prototype Hydropower Plant Development in Nigeria

Mojisola A. Bolarinwa, Abdulrahman A. Adeyemi, and Oluwasolamidotun E. Kassim

***Abstract* — Epileptic power supply in Nigeria has caused hindrances to her growth. Electricity is required for technological advancement and economic growth, as business transactions and most activities depend on its availability. This work was aimed at developing a prototype hydropower plant for use in riverine area(s) for electricity generation. Using Autodesk inventor software, the required turbine was designed and thereafter fabricated and assembled appropriately with all necessary components. Stress analyses (Von Mises, first, and third principal stresses) were also conducted to determine the turbine load bearing capacity. The e system was fitted into the edge of a stream (with minimum debris and cataract to prevent and reduce the blades from wear and tear) and arranged such that the blades were at an appropriate angle of attack to capture the water's kinetic energy. The turbine possessed eight blades, designed and fabricated to function in a river with low volume. On assembling the turbine with frame, gears, ball bearing and shaft, a pico-hydropower plant was developed. Stress analyses indicated Von Mises; first; and third principal stresses to respectively be: (0.00000498617; -0.00316625; and -0.0259764) MPa for minimum values and (0.0382339; 0.0452009; and 0.00873272) MPa for maximum values, indicating that the turbine can withstand operating conditions like pressure, force and friction. On testing, voltage readings were 0.90, 0.93, 0.96, 0.98 and 1.00 volts respectively. It was found to be portable and economical. The locally developed hydropower plant will be useful for solving electrification problems in rural areas, farm settlements and off-grid homes.**

***Keywords* — Capacity, Electricity, Hydropower, Kinetic Energy, Stress Analysis, Turbine.**

I. Introduction

Most developed nations cannot function without electricity, this makes electricity a very important utility for the growth of a nation. The demand for electricity has been growing exponentially with the growth of the human population [1]. There thus arose the need to explore various ways in which power may be generated without harming the environment, and in essence, renewable energy. Renewable energy, otherwise called clean energy, is the energy source that is spontaneously replenished, comes from natural means and does not harm nature in the end [2], [3]. Fortunately, renewable energy types do not undergo depletion [3]. Based on the primary source of the energy in question, renewable energy normally comes in different forms. For instance, solar energy is realized by trapping the radiant energy from sunlight and converting it into heat, electricity, or hot water [3], [4]. Wind power is produced when sunlight hits the earth's surface, causing a difference in temperature across different regions of the earth surface, bringing about the movement of air molecules in the atmosphere [5]. Hydroelectric power, as an energy form can be obtained by using the kinetic energy of water to turn a turbine, which in turn generates electricity based on the mechanical movement of the turbine blades, fostered by generator in most cases [3] [6]. While almost a quarter of World's total electricity generation comes from renewable energies, hydropower is known to be the biggest source of renewable energy, claiming more than 60% of renewable energy generation [3]. It is also continuous and predictable for proper management. Power generation must be efficient to reduce power loss due to heat, hysteresis and all other forms of energy loss which makes power generation uneconomical. Hydropower is one of the most efficient and most suitable sources of renewable energy [7]. It dated as far back as the period when it was only useful for grinding purposes [8]. Although early AC could not travel above 1,000 ft radii, it was later found to be transmittable over long range, by stepping it up [9]. Hydropower is power produced by converting potential energy in a river into kinetic energy by using a turbine which is then converted into electrical energy using a generator. This power is harnessed from fast running water or energy from waterfall. The quantity of electricity that can be generated is determined by the number of head (the difference in height from the turbines in the power plant to the water surface) and the volume of water flow created by the water reservoir [10]. Exception however comes in when crossflow turbine is utilized, designed to accommodate larger water flows with lower heads [11]. A typical hydropower plant includes a dam or reservoir, penstocks (a gate or sluice that regulates water flow or also a pipe that delivers water to the turbine) [12], a powerhouse and an electrical power substation. The reservoir stores water and creates the head while penstocks carry water from the reservoir to turbines inside the powerhouse; the water rotates the turbines, which drive generators that produce electricity [13]. Hydropower is a clean source of energy which only utilizes the water's kinetic energy after which the water can be used for other purposes. For this reason, there has been an increase in the importance of utilizing water bodies for hydropower at minimal cost relative to other methods [14]. Large hydropower plants can affect river ecology and limitation of biodiversity due to the construction of large dams [15]. Dams also prevent fishes from swimming upstream or downstream to reproduce [16]. It also results to social effects, such as displacement of

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residents to pave way for the reservoir construction [17]. Therefore, it is important to consider smaller hydro systems, like a micro power plant [18]. The quantity of electricity possibly generated by a hydropower plant largely depends on the flow rate of the river being used, as well as the head, in addition to cost, turbine efficiency and depth [19]. Also, technology available determines the resulting hydropower plant [20]. Existing technology include: (1) Run of River (RoR) [21], (2) Pumped storage [22], [23] (3) Dammed reservoir [12]. Talking of capacity, it is the amount of energy generated by a plant that determines the size of the hydropower plant [24]. Hydropower plants, based on technology can be: (1) Large: Capacity greater than 10 MW. (2) Small: Capacity ranging between 1 and 10 MW. (3) Mini: Capacity of 100 KW to 1 MW. (4) Micro: Capacity of 5 Kilowatt to 100 KW. (5) Pico: Capacity less than 5 KW. The Pico type is easy and cheap to establish (no dam is needed) and has a high efficiency rate [3]. It also does not depend on non-renewable energy sources, and most times use the run of river (ROR) technology. Its electricity output can be as high as 5 KW [3], [25]. Turbines for the hydropower systems can be classified as: (1) Impulse and reaction turbine. Examples include Pelton, Turgo and Cross-flow turbines [26]. (2) Axial and Radial turbine. Examples include Kaplan, propeller and Francis turbines [27], [28]. (3) Ceramic turbines [29]. The Pico hydropower system of electrification has been widely adopted in Malaysia, Thailand, and Rwanda among others in recent times [3]. Geothermal energy, in its own case, is realized from the trapped heat energy under the earth and likely radioactive decay [3]. This heat often leads to volcanic eruptions and geysers when released naturally at once. However, it can be arrested and utilized to generate geothermal energy, aided by the steam coming from the heated water coming from below the surface and rising to the top to operate a turbine [3]. Others are biomass, hydrogen, fuel cells, hydrogen fusion, and ocean tides [30]. No less than 26% of the entire electricity presently available worldwide comes from renewable energies [3]. This, according to IEA's estimate is likely to increase to about 30% by 2024. While one of the goals of the United Nations is to achieve clean energy, Nigeria, though a member, is still found wanting in terms of meeting up with increasing energy demands [3]. For instance, in the case of hydroelectricity, recent studies by experts show that only 24% of large and 4% of small possible hydropower generation in Nigeria have been embarked upon [3]. Nigeria has a population of about 162 million with 40% not having access to power supply. Unfortunately, those who have access to power supply remain without power 60% of the time [31]. They further stated that the erratic power supply cripples the industrial sector, thereby causing economic hardships. Lack of stable power supply also hinders agricultural growth due to inability to use irrigational lines to water crops and inability to store goods for long periods of time as these facilities operate with electricity [32].

The aim of this work was thus to develop a prototype of a small hydropower plant as a cost-effective means of generating electricity for rural and off-grid homes. Therefore, the objectives include: (1) Designing a hydro turbine. (2) Fabricating the turbine and acquiring other essential components. (3) Assembling the hydropower plant and subsequent testing. Justification for this work was based on the fact that by building a prototype of a hydropower plant, the dangers surrounding the construction of large dams are reduced to minimum. Also, global warming is reduced by providing an alternative to burning fossil fuels. This will also reduce epileptic power supply and provide electricity to off-grid homes.

A. Limitations

This work was restricted to low volume, low velocity rivers in Nigeria. It is expected to be carried out within a pollution free stream (free from plastics, wastes etc.) and the absence of cataracts.

II. Methodology

A. Project Setting

While the design and construction of the work took place in Faculty of Technology, University of Ibadan, Ibadan, Nigeria, the testing took place at Asejire River, boundary between Oyo and Osun States.

B. Material Components

In the choice of materials for the hydropower plant under construction, components selected were those that will enhance good quality product and function effectively at minimum cost.

C. Designing a Hydro-Turbine

A hydro-turbine was designed using design calculations to determine the number of blades, power, shaft diameter and stresses analyses of the turbine, as well as efficiency of the plant. Major considerations while designing a hydro-turbine include the flow rate and head.

D. Design Calculations

The diameter of the turbine is calculated using (1).

$$d = 40 \frac{\sqrt{H}}{n} \quad (1)$$

Number of blades is calculated using (2).

$$N = \frac{\pi d}{bs} \quad (2)$$

Hydropower is calculated using (3).

$$Q \times H \times \gamma \times \eta \quad (3)$$

Power generated from Run of River (RoR) is calculated using (4).

$$P = {}^{1}/_{2}\, \eta \rho Q v^2 \quad (4)$$

Gear ratio is calculated using (5).

$$\frac{driving\ gear}{driven\ gear} \quad (5)$$

Shaft diameter is calculated using (6).

$$\sqrt{\frac{112 \times p}{n}} \quad (6)$$

Revolutions per minute (RPM)is calculated using (7).

$$\frac{120 \times frequency}{no.of\ poles} \tag{7}$$

Torque produced is calculated using (8).

$$T = \frac{30\ P}{\pi n_{rpm}} \tag{8}$$

Electrical power is calculated using (9).

$$P_{out} = \frac{V^2}{R} = IV = I^2R \text{ and } V = IR \tag{9}$$

Von Mises stress is calculated using (10).

$$\tau v^2 = 3k^2 \tag{10}$$

The Von Mises yield criterion is commonly rewritten as (11).

$$\tau v \geq Sy \tag{11}$$

That is, if the Von Mises stress is greater than the simple tension yield limit stress, then the material is expected to yield. Principal stress is calculated using (12) and (13).

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \tag{12}$$

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \tag{13}$$

where

- Q= flow rate (litres per second)
- H = head meters
- ϒ = specific weight
- g = acceleration due to gravity
- P = power (watts)
- η = mechanical efficiency
- v = velocity
- d = diameter of turbine
- bs = circumferential blade spacing
- n = revolution per minute
- N = Number of blades
- τv = Von Mises stress
- Sy = simple tension yield stress
- σ_1 = maximum principal stresses
- σ_2 = minimum principal stresses
- τ_{xy} = shear stress

1) Conceptualization in designing the turbine

This came as required idea, creativity and imagination in developing approaches necessary to attain the design of this work, using Autodesk Inventor software.

2) Stresses analyses

Stress analyses (Von Mises; first principal and third principal stresses) were carried out to determine the load bearing capacity of the turbine. The Autodesk inventor software was used to simulate and analyze the effect of stress on the blades of the turbine.

A. Fabricating the Hydro-Turbine and Acquiring other Components

On accomplishing the final design using Autodesk inventor software, the turbine was thereafter fabricated, as well as the frame, while other components were purchased. The turbine blades were locally made, and with precision by designing them to assume impeller shapes.

B. Assembling the Hydropower Plant

After designing and fabricating the hydro-turbine, other component-materials were brought together with it. These were subsequently bolted onto one another in a sequential manner with the support of the component serving as the skeleton. Thereafter, necessary electrical fittings were properly made for power supply and lighting purposes.

C. Testing the Hydropower Plant

To increase the volume of water hitting the turbine blades, a suitable height was selected based on the topography of the area in which water flows towards the blades of the turbine from a height to create head (difference in height, measured vertically from the highest point on terrain to turbine blades). The whole system was fitted into the edge of a stream and then arranged such that the blades were at an appropriate angle of attack to capture the water's kinetic energy. To ascertain the efficiency of the hydro plant, testing was carried out at three different locations in the Asejire River, so that the best readings were selected for further computations.

III. Results and Discussion

A. Project Setting

Shown in Fig. 1 is the location of Faculty of Technology, University of Ibadan on the map. It is seen to stand along latitude 7º26' to 7º28' N and longitude 3º53' to 3º54' E. Also, shown in Fig. 2 is Asejire River, located on latitude 7º21' N and longitude 4º07' E. It is the major boundary between Oyo and Osun States.

B. Material Components

The material components selected for the plant construction are as shown in Table I.

TABLE I: Material Components for Hydropower Plant Construction

S/N	Material	Uses
1	Turbine	Converts kinetic to mechanical energy
2	Frame	Supports weight and accommodates all other components
3	Ball bearing	Supports radial loading, reduces friction
4	Gears	Increase speed and transmit torque
5	Bolts and Nuts	Serve as fasteners
6	Generator (DC Motor)	Converts mechanical to electrical energy
7	Shaft	Transmits torque to the generator
8	Paint	Prevents corrosion of frame
9	Voltmeter	Measures voltage
10	Wire	A conductor to transmit electricity generated
11	Spanner	Tightens bolts and nuts
12	Adhesive	Binding two different parts together
13	Bulb	For testing the hydropower plant

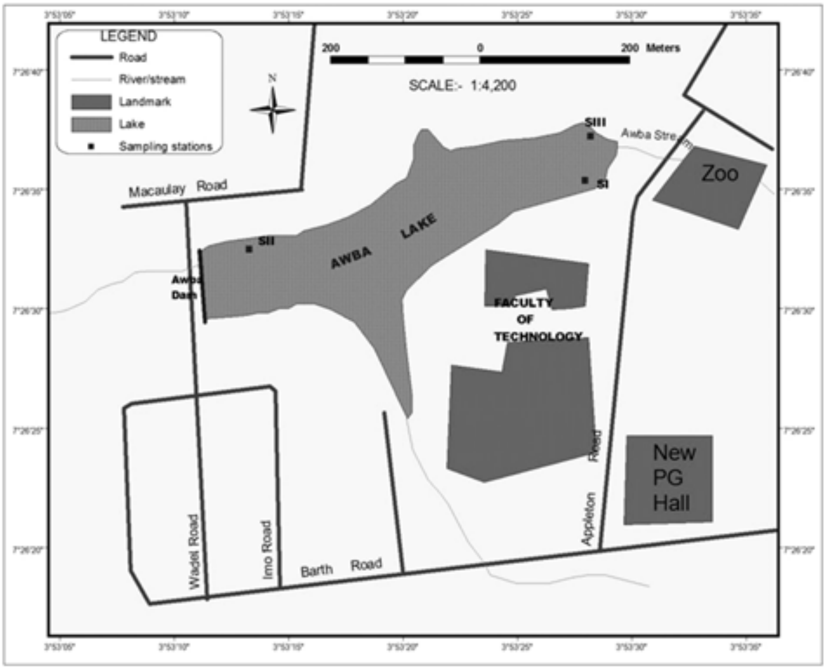

Fig. 1. Map showing Faculty of Technology, University of Ibadan, Ibadan, Oyo State, Nigeria [33].

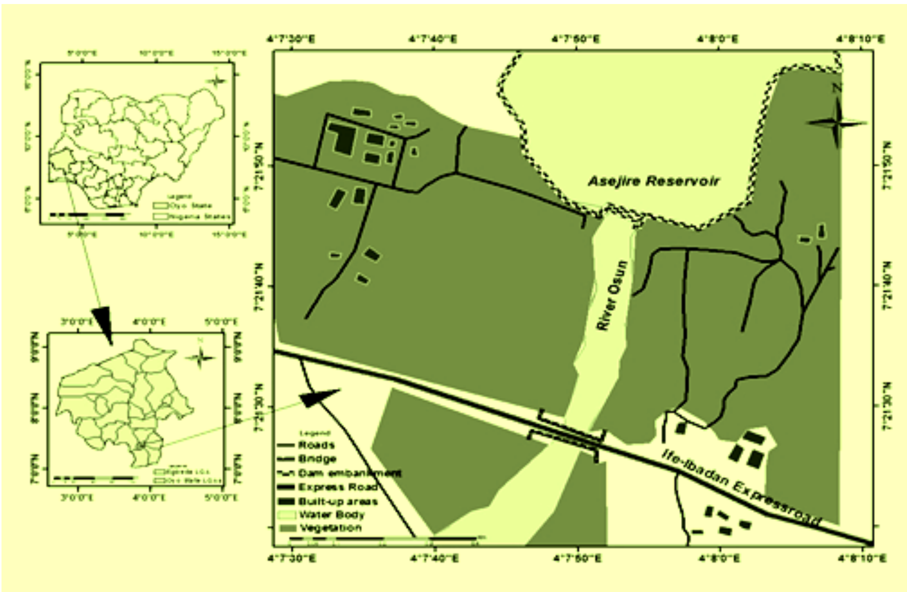

Fig. 2. Map showing Asejire River lying between the boundary of Oyo and Osun States [34].

From Table I, it could be seen that each selected material component (items 1 to 12) had unique roles to play in the hydropower plant being constructed.

C. Designing a Hydro-Turbine

1) Design Calculations

By adopting some of the aforementioned formulae and equations for design calculations, Table II was obtained.

TABLE II: CALCULATED DESIGN VALUES

Property	Value
Turbine diameter	0.218m
Number of blades for the turbine	8
Power obtainable	0.284 kW
Gear ratio	3
Shaft diameter	3.9 mm
Torque	1.36 Nm
Shear stress	0.001 MPa

As shown in Table II, the values obtained therein to a large extent guided parts fabrication and construction. For instance, the turbine from its design calculations will have eight heads. Also, the power rating of 0.284 Kw obtained (284 Watts) shows that the hydropower plant under construction, with close to 300 Watts of obtainable energy will be a Pico-hydropower plant.

2) Conceptualization in designing the turbine

As shown, Fig. 3 is the conceptual design for the turbine proposed for the hydropower plant under construction. This was done in order to achieve the design objective while satisfying the constraints. Therein, the eight (8) blades were joined together with fasteners, such as bolts and nuts.

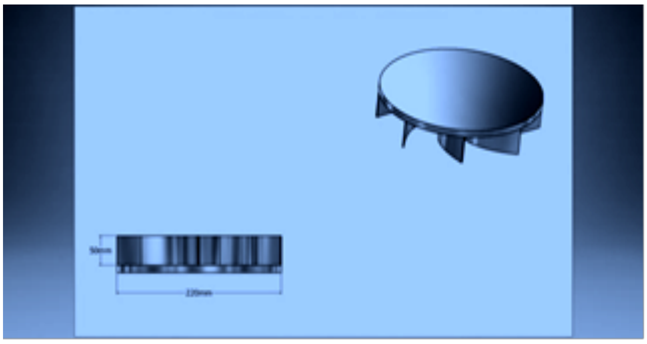

Fig. 3. Conceptual turbine design for the hydropower plant.

3) *Stresses Analyses*

Following the procedures under section II C, Fig. 4-7, Table III and Table IV were obtained.

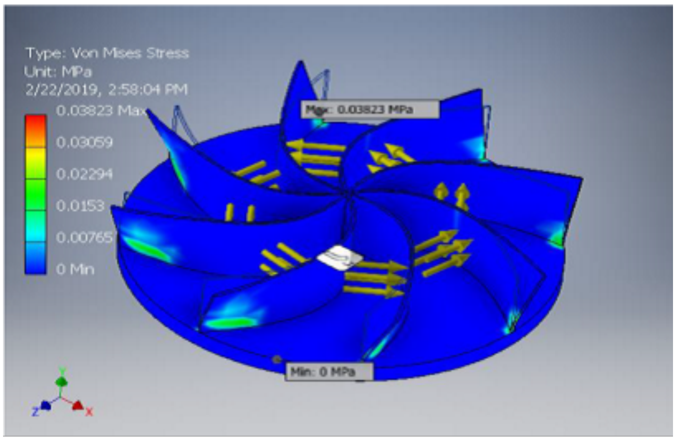

Fig. 4. Von Mises stress analysis of turbine.

Fig. 4 displays Von Misses stress analysis. Maximum stress is 0.03823MPa while the minimum is 0MPa, calculated using equations 10 and 11. Areas colored blue have low deformation while red indicates high deformation. It can be seen that the turbine can withstand the pressure acting on it.

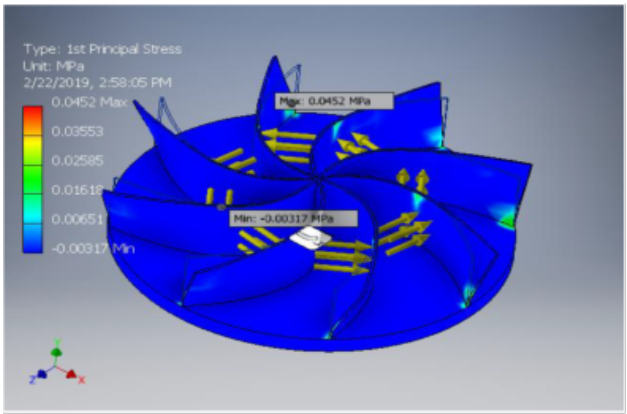

Fig. 5. The 1st principal stress of a turbine.

Fig. 5 displays the 1st principal stress; the maximum stress is 0.0452MPa while the minimum is -0.00317 MPa and can be calculated using equations 12 and 13. Areas coloured blue have low deformation while red indicates high deformation. It can be seen that the turbine can withstand the pressure applied on it.

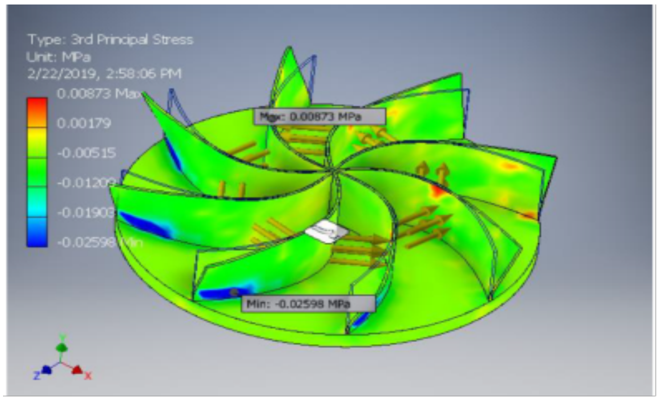

Fig. 6. The 3rd principal stress of a turbine.

Shown in Fig. 6 is the 3rd principal stress. The maximum stress is 0.00873MPa while the minimum is - 0.0259 MPa. Areas colored blue have low deformation while red indicates high deformation. It can be seen that the turbine can withstand the pressure on it.

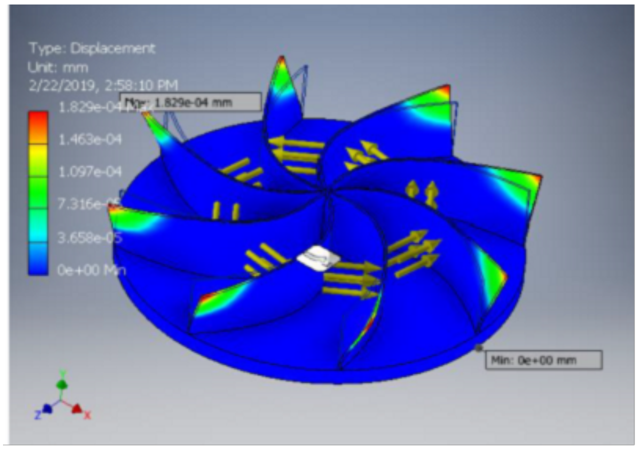

Fig. 7. Displacement of a turbine.

Fig. 7 indicated areas where surfaces get displaced under load or pressure. The maximum displacement occurred at the tip of the blades with a magnitude of 1.829×10^{-4} mm. The deflection is minimal and will not have serious effect on the efficiency of the turbine.

The values in Table III were obtained on using Autodesk Inventor to simulate and analyze the effect of stress on the blades of the turbine. Included are values for ultimate tensile strength (44961.7 psi) and shear modulus (3756.8 ksi), among others.

TABLE III: OPERATING CONDITIONS

Description	Property	Value
Stress	Yield Strength	39885.4 psi
	Ultimate Tensile Strength	44961.7 psi
	Young's Modulus	9993.1 ksi
	Shear Modulus	3756.8 ksi

As shown in Table IV, simulation of all three stresses showed that the turbine blades were able to withstand pressure on it.

TABLE IV: STRESSES ANALYSES SUMMARY

Name	Minimum (MPa)	Maximum (MPa)
Von Mises Stress	0.00000498617	0.0382339
1st Principal Stress	-0.00316625	0.0452009
3rd Principal Stress	-0.0259764	0.00873272

TABLE V: BILL OF ENGINEERING MATERIALS ANDEVALUATION (BEME) VERSUS COST

Item	Partnumber	Material	Colour	Quantity	Unit Cost(Naira)	Cost(Naira)
Frame	001	Cast iron	Black	13	1,000	13,000
Ball bearing	002	Cast iron	Silver	2	8,500	17,000
Bolts and Nuts	003	Carbon steel	Black	28	150	4200
Motor	004	Steel	Grey	1	8,000	8,000
Shaft	005	Plastic	White	1	700	700
Wire	006	Copper	Brown	1 yard	900	900
Turbine	007	Aluminum	Silver	(74×74)	5,500	5,500
Gear	008	Plastic	White	2	1,000	2,000
Adhesive	009	Epoxy Steel	-	1	2,500	2,500
Voltmeter	010	Plastic	Black	1	15,000	15,000
Spanner set	011	Steel	Silver	1	5,000	5,000
Bulb	012	Glass	White	1	500	500
Miscellaneous	-	-	-	-	30,000	30,000
Total	-	-	-	-	-	104,300

D. Fabricating the Hydro-Turbine and Acquiring other Components

As shown in Table V is the bill of engineering materials and evaluation (BEME), which include list of component items, materials from which they were made, colour and quantity required for the construction of hydropower plant on a small scale, as well as cost involved.

As shown in Fig. 8 is the fabricated turbine with eight (8) blades, made from aluminum material. The optimum number of blades for the turbine was calculated using (2).

Fig. 8 Aluminum turbine with 8 blades.

However, since the blades are made from aluminum material, there could be wear and tear due to friction, as a result of debris and cataracts present in the river under consideration.

Fig. 9 Drive shaft.

As shown in Fig. 9, the diameter used in construction of the turbine is 20 mm, since the minimum shaft diameter required to withstand the torque and torsion is 3.9 mm, according to the design calculations.

Fig. 10. Gears.

Fig. 10 shows the two gears, the white gear has 68 teeth while the black gear has 24 teeth. Therefore, the gear ratio is approximately 3, meaning that the speed increment is by a factor of three.

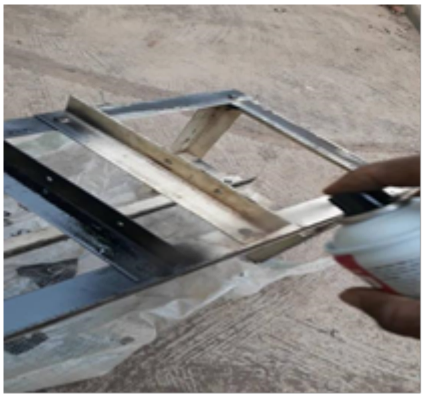

Fig. 11. Cast iron frame.

The frame holds together all other components. Cast iron was selected to build the supporting frame as indicated in Fig. 11. It was coated in black paint to prevent corrosion.

As shown in Fig. 12, a direct current generator was selected due to its availability and versatility.

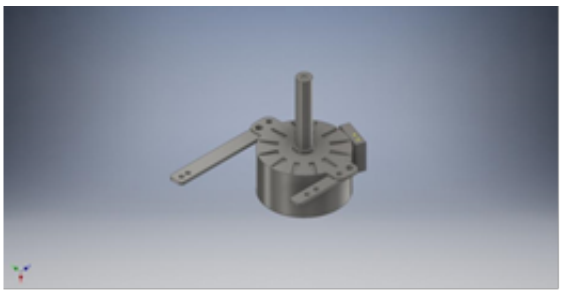

Fig. 12. A direct current motor.

E. Assembling the Hydropower Plant

Shown in Fig. 13 is the assembled prototype hydropower plant obtained by using all parameters and design calculations, and following the procedures described under Section II C. Therein, the turbine was assembled with an alternator that converts the rotational movement of the shaft to alternating current.

Fig. 13. Working prototype of the hydropower plant.

F. Testing the Hydropower Plant

As shown in Fig. 14. is the working prototype was placed in a body of water for testing. In addition to the voltage readings displayed on the voltmeter, the bulb connected to the system lighted after few seconds, especially during the first and the third testing.

The power values obtained are as presented in Table VI, Table VII, and Table VIII, calculated using (9) and a 96-ohm resistor.

Fig. 14. Working prototype in water.

TABLE VI: READINGS OBTAINED FROM FIRST LOCATION

S/N	Time(s)	Voltage(V)	Current (mA)	Power (mW)
1	0.00	0.25	2.0	0.5000
2	10.00	0.44	5.00	2.2000
3	20.00	0.66	7.00	4.6200
4	30.00	0.95	10.00	9.5000
5	40.00	0.99	10.00	9.9000

Table VI shows results obtained at the first location. The highest voltage measured at this location was 0.99 V. The greatest power output was 9.9mW.

TABLE VII: READINGS OBTAINED FROM SECOND LOCATION

S/N	Time(s)	Voltage(V)	Current (mA)	Power (mW)
1	0.00	0.64	6.60	4.2240
2	30.00	0.69	7.10	4.8990
3	60.00	0.74	7.70	5.6980
4	90.00	0.80	8.30	6.6400
5	120.00	0.88	9.10	8.0080

Table VI shows results obtained at a second location. The highest voltage measured at this location was 0.88 V. The greatest power output was 8.008 mW.

TABLE VIII: READINGS OBTAINED FROM THIRD LOCATION

S/N	Time(s)	Voltage(V)	Current (mA)	Power (mW)
1	0.00	0.90	9.36	8.4240
2	10.00	0.93	9.68	9.0024
3	20.00	0.96	10.00	9.6000
4	30.00	0.98	10.02	9.9960
5	40.00	1.00	10.04	10.0400

Table VIII shows results obtained at a third location. The highest voltage measured at this location was 1.00 V. The greatest power output was 10.04 mW.

The power generated can thus be stored in batteries for the powering of appliances such as bulbs, timers, farm security alarms and egg incubators.

To plot the graph in Fig. 15, Table VIII was used due to having the highest voltage readings and steady reading.

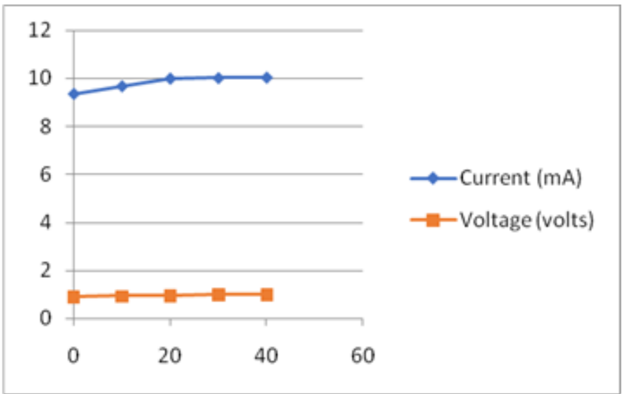

Fig. 15. Graph of current and voltage versus time (seconds).

It can be observed in Fig. 15 that the voltage increased with increasing current. Voltage is directly proportional to the current flowing across its ends.

G. Cost Comparison

The cost of procuring each material as used in the final design is shown in Table V. The total cost of component and fasteners used is N104, 300.

Comparing the cost of purchasing a Pico-hydropower turbine of model XJ14-0.3DCT4-Z of 300-watt power output (708 USD = (317,538 NGN using an official rate of 448.50 NGN to 1 USD and 523,920 NGN using black market rate of 740 NGN to 1 USD, without importation tax). The cost of purchasing a model XJ14-0.3DCT4-Z (708 USD/unit) is significantly higher than the pico-hydropower plant of 284 watt constructed (more than three (3) times higher).

Also, considering the cost of purchasing 10 litre fuels for a price of ₦180/litre, the total amount spent in a day is ₦1,800. In a week amount spent is ₦12,600 and this sums up to ₦655,200 in a year. It is an undeniable fact that renewable energy such as this Pico- hydropower plant pays off while considering a source for electrical power.

IV. Conclusion

A hydro turbine (impulse type) has been designed. In the course of its design, certain calculations were considered for determining the optimum design parameters in deciding the turbine category, power obtainable and ensuring an effective area for capturing the kinetic area from the water. Using the derived design, a turbine was fabricated, whose materials selection was such that will introduce resilience to the component and whose stress analyses determined its load bearing capacity. The turbine, when assembled with other essential components, a Pico-hydropower plant was developed and on testing, generated electricity that can be stored in batteries to power bulbs, fan and any home D.C appliance.

In terms of cost, using locally developed Pico-hydropower plant as a renewable energy source is quite cheaper than using premium motor spirit (petrol) as fuel for electric power generation. In addition, its local development is more economical than its shipment.

Appendix

TABLE IX: Physical Attribute of the Design

Property	Value
Density	0.0975437 lbmass/in^3
Mass	2.80273 lbmass
Area	0.1727m^2
Volume	0.00047085 m^3
Center of Gravity	x = 0.000000111472m y = 0.00832211m z = 0m
Material	Aluminum 6061

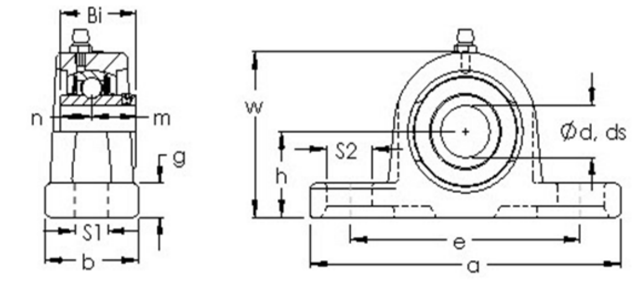

Fig. 16. Supporting Bearing.

TABLE X: Specification of Ball Bearing

Properties	Specification	Unit
Dynamic Load Rating (Cr)	12,000	N
Static Load Rating (CoR)	6,000	N
Shaft Dia. (Fw)	20	mm
Shaft Height (h)	33	mm
Housing Width (b)	38	mm
Mounting Hole Center-to-Center (e)	95	mm
Housing Length (a)	127	mm
Mounting Slot Length (S2)	19	mm
Mounting Slot Width (S1)	13	mm
Base Housing Thickness (g)	13	mm
Housing Height (w)	64	mm
Bearing Inner Race Width (Bi)	31	mm
Bearing Inner Race (n)	12	mm
Inner Bearing Race Width – Extended Side (m)	18	mm
Bolt Mounting Size	10	mm
Bearing Number	UCP 204	-
Housing Number	P204	-
Weight (g)	680	mm
Material	A housing of cast iron, steel chrome bearing	Grams

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