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DESIGN AND FABRICATION OF A NON-FOSSIL FUEL GENERATOR

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ABSTRACT

The non-fossil fuel generator is a flywheel energy storage system (FESS), which has attracted new research attention recently in applications like power quality, regenerative braking, and uninterruptible power supply (UPS). As a sustainable energy storage method, flywheel energy storage has become a direct substitute for batteries in UPS and other electrical applications. This project work, however, presents an overview of the applications of FESS in power systems and micro grids (MG) and also analyzes the design parameters to improve the energy density of the fuel-less generator. The aim is to improve its value and enhance its applications in numerous fields, such as renewable power generation. At the end of the project work, it was observed that the speed of the flywheel and generator pulley has a linear relationship. Varying the size of either the motor wheel or the flywheel that is connected to the generator will affect the amount of voltage produced and also the amount of work done on the system. Thus, increasing either of them will increase the speed of the generator and, thus, increase the voltage produced. This shows that the higher the speed, the more the voltage supplied, and vice versa. On testing the generator, the output voltage generated was 101V at a speed of 234rpm on the flywheel.

Keywords: Fuel-less, generator, flywheel, AC generator, pulley, energy.

INTRODUCTION

Power production and distribution have been essential to the development of many sectors of the economy, including finance, manufacturing, media, healthcare, and availability (Ulaby, 2009). Knight (2018) defined power as the rate at which work is completed; it follows that a nation's productivity will be significantly influenced by the availability of power from various sources. According to Hansan (2018), the bulk of Nigeria's issues can be linked to the unpredictable nature of the nation's power supply, which has caused several activities to come to a standstill. Research has unequivocally demonstrated that Nigeria loses up to 220 billion naira a year as a result of the inconsistent power supply in the nation, which poses a risk and lowers the ability of enterprises to boost production (James, 2019).

The use of non-fossil fuel-based energy solutions presents a viable alternative to address climate change issues brought on by conventional fossil fuel energy production techniques. Non-fossil fuel generators reduce greenhouse gas emissions and the ensuing global warming by doing away with carbon-based fuels. By supporting global efforts to fulfill emissions objectives outlined in the Paris Agreement, this strategy greatly enhances environmental sustainability.

Making such generators out of locally accessible materials would also be extremely valuable on many levels. It will encourages self-sustainability by lowering reliance on imports—a critical aspect for emerging nations. It promotes the use of regional resources and local industrial expansion, igniting the region's economy. Communities with low access to energy are likely to find locally manufactured generators to be more affordable. This novel method might also solve problems with energy security and dependability. These generators, which are made locally, are simple to maintain and offer a steady and dependable supply of electricity. In countries where energy grids are unstable or in remote locations where access to a centralized energy grid may be difficult, this option shows great promise.

MATERIALS AND METHODS

Materials

Description of Component Part

The generating unit, the power supply unit, the frame/transmission unit, and the power distribution unit make up the four main components of the flywheel-powered non-fossil fuel energy generator.

The power supply unit includes the electric motor, electrical lines, and the AC mains power supply socket.

The generating unit is made up of the 7.5 kW alternators and the 50 kg flywheel. The device is in charge of converting mechanical energy to electrical energy and the other way around.

The power distribution unit is present in order to supply the external loads with a certain quantity of electrical power. Electrical outlets and cabinets are included.

The frame and transmission unit comprises the flywheel, shafts, pulleys, bearings, and the casing and supports that hold the other parts.

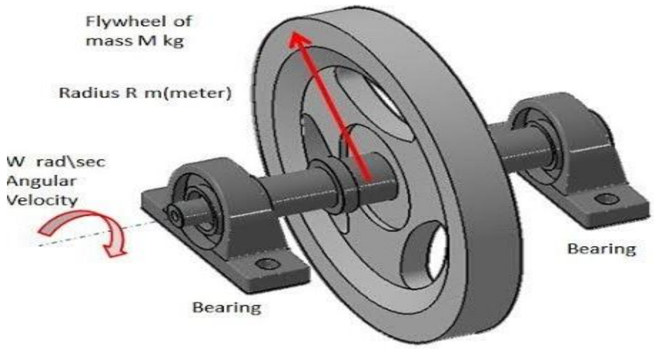


Figure 1: flywheel fitted with bearings

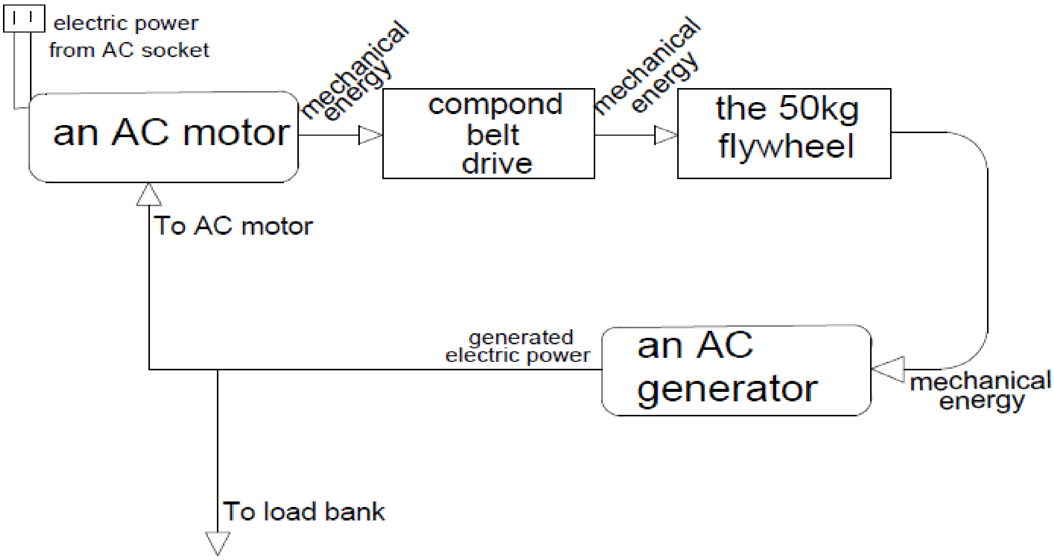


Figure 2: Block diagram for the non-fossil fuel generator

The AC motor

An AC motor, or alternating current motor, is a type of electric motor that converts alternating current (AC) electrical energy into mechanical energy. AC motors work by using electromagnetic induction to generate a rotating magnetic field that interacts with the rotor of the motor. The rotor is attached to the shaft, which then turns to perform work. The speed and torque of the AC motor can control by varying the frequency and voltage of the AC power supply as shown in Figure 3.

Figure 3: An AC motor

Figure 4: An AC generator

The AC generator

An AC generator, or alternator, is a type of electric generator that converts mechanical energy into alternating current (AC) electrical energy. AC generators work by using a rotating magnet to induce an electric current in a stationary coil of wire. The frequency of the AC current produced by the generator is determined by the speed at which the magnet rotates. AC generators are commonly used to produce electricity as shown in figure 4.

The Flywheel

A flywheel is a mechanical device that stores energy in the form of rotational kinetic energy. It consists of a heavy, rotating wheel that is connected to a rotating shaft. As the flywheel spins, it stores energy by virtue of its mass and momentum. This energy can then be released when needed, by using the stored energy to drive a load or perform work.

Hence, a flywheel of mass 50kg concentrated at the rim was used for the project.

Figure 5: The 50kg flywheel

Figure 6: The V-belt drive

Belt selection

Belt selection is an important part of designing and maintaining a system that uses belt to transmit power. There are several factors that need to be considered when selecting a belt, including the type of drive, the power to be transmitted, the operating speed, the environment, and the cost. There are several types of belts available, including V belts, flat belts, and timing belts. V-belts are the most common type and are typically used for high-speed, high-power applications.

Frame design

Choosing frame material

There are several factors to consider when choosing the material for the frame.

One of the important considerations is the strength of the material. It is especially important in the case of the fuel-less generator in which components are under threat of fatigue damage formation because of the diversified influence of many factors of deterministic and random nature. Therefore, steel was used for the frame because they can be inexpensively repaired and have the ability to reveal frame stress injuries before they become failures.

Frame dimensions

Figure 7 shows the dimensions of the various sections that make up the frame. The frame is used to support the various loads that are mounted on it. All the dimensions are however given in millimeter (mm).

Design Considerations

The functional parameters and component parts that are considered in the design of the non-fossil fuel generator are: Electric motor selection, Alternator, Balancing wheel, Machine Torque, Frame rigidity, Size of shaft, Bearing selection, Key and key way

Design Calculations

Determination of Velocity on Motor Pulley

$V = \frac{\pi D_1 N_1}{60}$ (Akerele O. V. and Ejiko, S.O. 2015)……………………(1)

Motor velocity of $17.3m/s$ was selected.

Determination of the Speed and Diameter on Driven Pulley

In other to increase the Speed of the driven pulley (blower), the speed ratio is taken to be 3:1

$N_1 D_1 = N_2 D_2$ (Khurmi, R.S. and Gunpta J.K. 2005)……………..(2)

$N_2 = \frac{N_1 D_1}{D_2}$ $N_2 = 4500\ rev/min$

NOTE: Speed ratio = 3:1

The balancing wheel is connected directly to the alternator by flange coupling; hence, same speed is transferred to the alternator.

$$D_2 = \frac{N_1 D_1}{N_2} = \frac{1500 \times 0.22}{4500} = 0.073m = 73mm$$

Centre to Centre Distance between the Pulleys

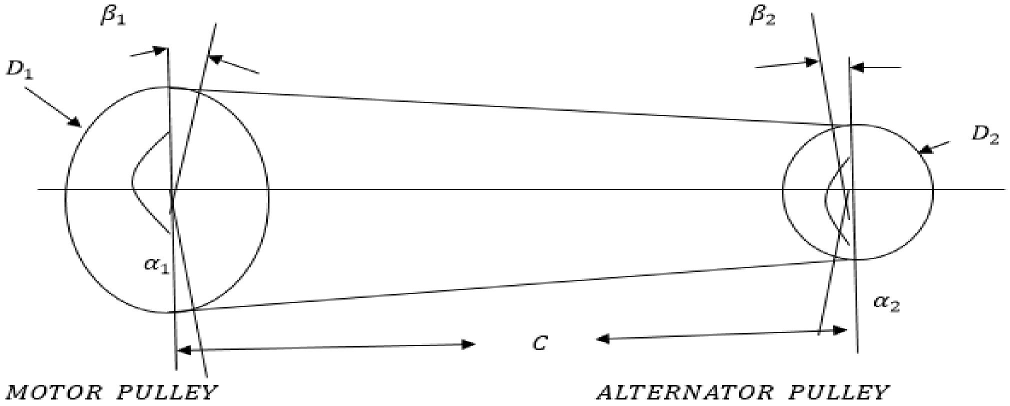


Figure 7: Centre to centre distance between the pulleys

$C = 2(D_1 + D_2)$ (Rajput, R.K. 2006)………………..(3)

$C = 2(0.22 + 0.073) = 0.586m = 586mm$

Determination of the Belt's Length

$L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{(D_1+D_2)^2}{4C}$ (Khurmi, R.S. and Gunpta J.K. 2005)……..(4)

Where

L = Length of the belt

D_1 = Diameter of the Motor pulley = 0.22m

D_2 = Diameter of the balancing wheel pulley = 0.073m

C = Center to center distance = 0.586m

$$L = \frac{\pi}{2}(0.22 + 0.073) + 2 \times 0.586 + \frac{(0.22 + 0.073)^2}{4 \times 0.586}$$

$$L = 0.46 + 1.172 + 0.037 = 1.669m = 1{,}699mm$$

$$L = 1.7m$$

Determination of Torque Transmit on the Motor

$T_m = \frac{60P}{2\pi N_1}$ (Olumide A.A. 1991)……………………………………(5)

$Where:$

T_m = Torque of the motor , $P = 15Hp$ (Recommended motor power)

$$Power\ on\ the\ motor = 15 \times 746w = 11{,}190kw \approx 11.2kw$$

$$Speed\ on\ the\ motor = 1500rev/min$$

$$T_m = \frac{60 \times 11.2 \times 1000}{2\pi \times 1500} = 71.3Nm$$

Determination of tension of the belt

$T_m = (T_1 - T_2)\frac{D_2}{2}$ (Khurmi, R.S. and Gunpta J.K. 2005)…………………..(6)

Where:

T_1 = Tension in the tight side of the belt, T_2 = Tension in the slack side of the belt
D_2 = Diameter of the balancing wheel pulley = 0.073m

$$71.3 = (T_1 - T_2)\frac{0.073}{2}$$
$$T_1 - T_2 = 1{,}953.42$$

NOTE THAT:

$$\frac{T_1}{T_2} = 2 \quad Assumed\ belt\ tension = 2$$
$$T_1 = 2T_2$$

Substitute T_1 into $2T_2$

$$2T_2 - T_2 = 1{,}953.42$$
$$T_2 = 1{,}953.42$$
$$T_1 = 2 \times 1{,}953.42 = 3{,}906.84N$$

The force required

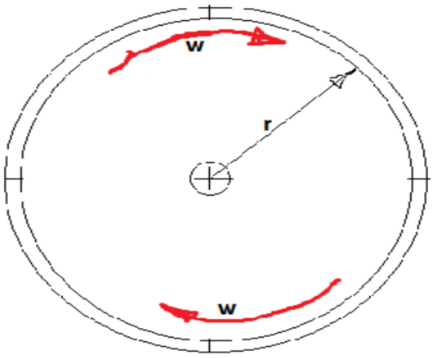


Figure 8: Centrifugal Force Analysis

The force required to rotate the balancing wheel

$F_B = Ma$ (Rajput, R.K. 2006)…………………(7)

Centrifugal force (Fc) developed in the worm beater shaft in the barrel was deduced as given by: $F_B = F_C$, $F_C = \frac{50\times(2\times4500\times3.142)^2\times0.025}{3600} = 277{,}654.6N$

$$F_C = 277.65kN$$

Torque Developed on the balancing wheel

Using the expression by Khurmi and Gupta (Khurmi *et al*, 2005) that torque (T) is equal to the product of force and radius, the value of the torque developed on shaft of the balancing wheel was calculated using

$T = F_C r_t$ (Khurmi, R.S. and Gupta J.K. 2005)……………………(8)

$$T = Torque\ developed\ (Nm)$$
$$r_t = 0.2m = radius\ of\ the\ shaft\ balancing\ wheel\ (m)$$
$$F_C = \text{centrifugal force}\ (N)$$
$$T = 277{,}654.6 \times 0.025 = 6{,}941.365 = 7kNm$$

Shaft Design

Determination of shaft diameters

The diameters, d of the Worm and beater shaft of this machine were determined using maximum stress relations given as

$d = \frac{16}{\pi\tau}\left[((M_bK_b)^2 + (M_tK_t)^2)^{\frac{1}{2}}\right]^{\frac{1}{3}}$ (Khurmi, R.S. and Gupta J.K. 2005)……….(1)

50mm diameter shaft was selected using the formula above.

Determination of alternator power output

$P = IVcos\phi$ (Khurmi, R.S. and Gupta J.K. 2005)……………………(2)

$$P = 7.5 \times 220 \times 0.85 = 1{,}402.5W = 1.4kW$$

Material Selection

In the design of any machine, material selection is a major controlling factor. The material chosen should be suitable for the conditions of operation and service of the machine. Table 1 shows the selected materials used with the justification for the selection made which were best and suitable material out of the available options considering the mechanical property of the materials, cost and availability of the materials.

Table 1: Breakdown of components and materials used

S/N	Machine component	Materials	Reason for selection
1.	Frame	Mild steel angled iron	Doesn't twist easily, withstand vibration and maintain firm stability.
2.	Shaft	Medium carbon grade steel	High torsional strength, high criteria speed and resistance to wear.
3.	Pulley	Cast iron	Increasing of speed
4.	Flywheel	Managing steel	High density and high strength to weight ratio
5.	Belt drive	Rubber	Highly flexible
6.	Bolt and nuts	Alloy steel	Hardness and high strength
7.	Pillow bearing	Alloy steel	Hardness and high strength

Methods of Construction

Non-fossil fuel generator is a device made up of different components joined, fixed or coupled together to act as a single unit for the purpose of generating electric current/electricity.

The fabrication and assembling process

I. Component from supplier: all the component parts needed for the project were purchased such as alternator, flywheel, pulley, belt, bearing etc.

II. Fabrication of frame: the different steps that were involved in the fabrication of frame include, marking out of the angle iron to provide guide for cutting of the angle iron into different size to form the frame. The marking out tools used include; T – square, Measuring tape and Marker

III. Cutting process: cutting machine was used to cut the required size that has been marked.

IV. Welding operation: the various parts that has been cut were welded together to form the frame by using suitable electrode and welding thongs.

V. Drilling operation: Holes were bored in the frame for bolting the parts to the frame

VI. Machining of the shaft: A key way was made to the shaft.

VII. The fitting of the machining shaft to the flywheel.

VIII. The mounting of the alternator.

IX. Involves fitting the two ends of the flywheel shaft to the bearing mounted on the frame and the shaft was connected to the alternator with direct coupling fitting to the pulley to the electric motor and the electric motor was mounted to the frame.

X. The belt was worn to the pulley on the electric motor and connected to the pulley on the shaft.

XI. An electric cable was connected to the alternator main as output.

Mode of Operation

The electricity is use to run/derive the AC motor with a pulley and belt fitted to drive the shaft on which pulley and flywheel is fitted, due to this the flywheel which is fitted on the shaft rotate at high speed and store energy on the other end on the shaft on which pulley is fitted, will drives the AC generator with the help of the pulley and the belt. The energy stored on the flywheel is supplied to run the AC generator to produce maximum amount of current required.

When the maximum amount of current is generated in the AC generator, this current is supplied to the AC motor by plugging the motor into the socket attached to the AC generator output to run the electric supply which we have first used to run the electric motor is disconnected and the current produce in the AC generator is used to run the motor.

Table 2Bill of engineering measurement and evaluation (BEME)

S/N	Materials	Specification	Quantity	Unit Cost (₦)	Total Cost (₦)
1.	Shaft	50mm x	1	12,000	12,000
2.	A.C generator	7.5hp	1	75,000	75,000
3.	Bearing	50mm	2	5,500	11,000
4.	Pulley	80mm	1	7,000	7,000
		220mm	1	10,000	10,000
5.	Angle iron	4m thick	1	8,500	8,500
		3m thick	1	7,500	7,500
6.	Electrode	Grade 10	1	5,500	5,500
7.	Cutting disc		1	1,200	1,200
8.	Grinding disc		1	1,200	1,200
9.	Iron pipe		1	7,500	7,500
10.	Direct coupling		1	20,000	20,000
11.	Belt	A 30	1	600	600
		A 28	1	600	600
12.	Bolt and nuts	M 17	12	80	960
13.	Washer	M 17	12	25	300
		Grand total			**168,860**

Table3. Cost of Machined Job

S/N	Parts	Types of Jobs	Machine Used	Amount (₦)
1.	Shaft	Machining	Lathe machine	2,500
2.	Frame	Welding	Welding machine	10,000
3.	Pulley	Key way	Lathe machine	4,000
			Grand total	**16,500**

Table 4 Cost of Non-machined job

S/N	Types of Job	Amount (₦)
1.	Transportation	5,000
2.	Miscellaneous	3,000
	Grand total	**8,000**

Total cost of production = cost in table 3.2 + cost in table 3.3 + cost in table 3.4

Total cost of production = N (168,860 + 16,500 + 8,000)

Total cost of production = N 193,360

RESULTS AND DISCUSSION

Results

Input Parameters

The input parameters as shown in Table 5 represent the known values from which the general design was based upon. It includes the operational speed of the flywheel and generator to produce the required voltage which was obtained from the specification of the DC motor purchased.

TABLE 5: input parameters for the analysis

S/N	PARAMETER	VALUE	UNIT
1	Generator power rating	1.4	Kw
2	Motor power rating	15	Hp
3	Rotational speed of generator	4500	Rpm
4	Rotational speed of motor	1500	Rpm
5	Diameter of small pulley of first belt drive	220	Mm
6	Diameter of large pulley of first belt drive	730	Mm
7	Distance between centres of each pulleys	586	Mm

Output Parameters

Table 6 shows the results obtained from the evaluation of the generator. It shows the summary of the output data of the parameter which include the selection of the flywheel and belt drive of the system, belt length etc.

TABLE 6: output parameters for the analysis

S/N	PARAMETER	VALUE	UNIT
1	Input force of the flywheel	277.65	KN
2	Input torque of the flywheel	71.3	KNm
3	Flywheel input rotational speed	1500	Rpm
4	Flywheel output rotational speed	4500	Rpm
5	Length of open belt drive	1700	Mm
6	Input power (power delivered by the electric motor)	11.2	Kw
7	Tight tension	3906.84	KN
8	Slack tension	1953.42	KN

Measured Values from Testing the Generator

While testing the machine, some parameters were recorded, which were basically the voltage produced and the speed of rotation of the flywheel.

TABLE 7: Measured Values from Testing the Generator

S/N	VOLTAGE (v)	SPEED (rpm)
1	0.00	55
2	101	234
3	56	103
4	58	121
5	0.00	23

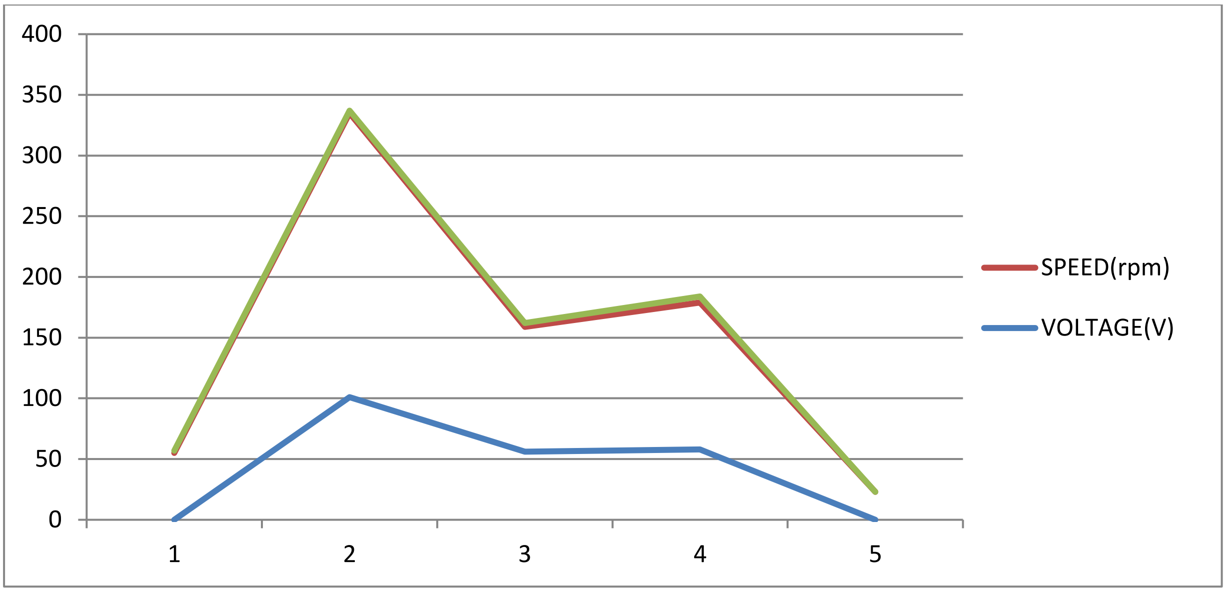


Figure 9 Graph of voltage against speed

DISCUSSION

Figure 9 demonstrates the computation and analysis done, it was found that there is a linear link between the generator pulley and flywheel speed. The quantity of voltage produced and the amount of work done on the system will change depending on the size of the flywheel or the motor wheel that is linked to the generator. Consequently, raising one of them will cause the generator to run faster, increasing the voltage it produces. The graph demonstrates that greater voltage is given at faster speeds and vice versa.

CONCLUSION AND RECOMMENDATION

CONCLUSION

The demand for new energy sources has given rise to a number of possibilities, each with a startlingly high fuel cost. But if the technology is advanced and widely used, future electrical supply costs will go down and electricity will be distributed more effectively. Flywheels are among the most promising technologies to replace traditional lead acid batteries as energy storage systems for a range of applications, such as remote power units frequently used in the telecommunications industry, automobiles, and affordable rural electrification systems.

RECOMMENDATION

It was recommended that more research work should be carryout on how to increase and sustain the power generated.

REFERENCES

1. Akerele O. V. and Ejiko, S.O. (2015), "Design and Construction of Oil Expeller", International

2. Journal of Engineering And Computer Science, India, ISSN 2319-7242 Vol. 4, Issue 6,pp. `12529 - 12538.

3. Hansan, H. J. (2018). Types of fuels for electricity generation: Electrical Energy in Agriculture.

4. Inter-governmental Panel on Climate Change (IPCC)(2018). Global warming odf 1.5°C. Intergovernmental Panel on Climate Change.

5. James, A. (2019) "Introduction to Electric Circuit (5th ed.)" New York Press, United states.

6. Khurmi, R. S.and Gunpta J. K. (2005). "A Textbook of Machine Design", Multicolourillustrativeed., Eurasia publishing house (PVT) Ltd. by S. Chand & Co. Ltd, India.

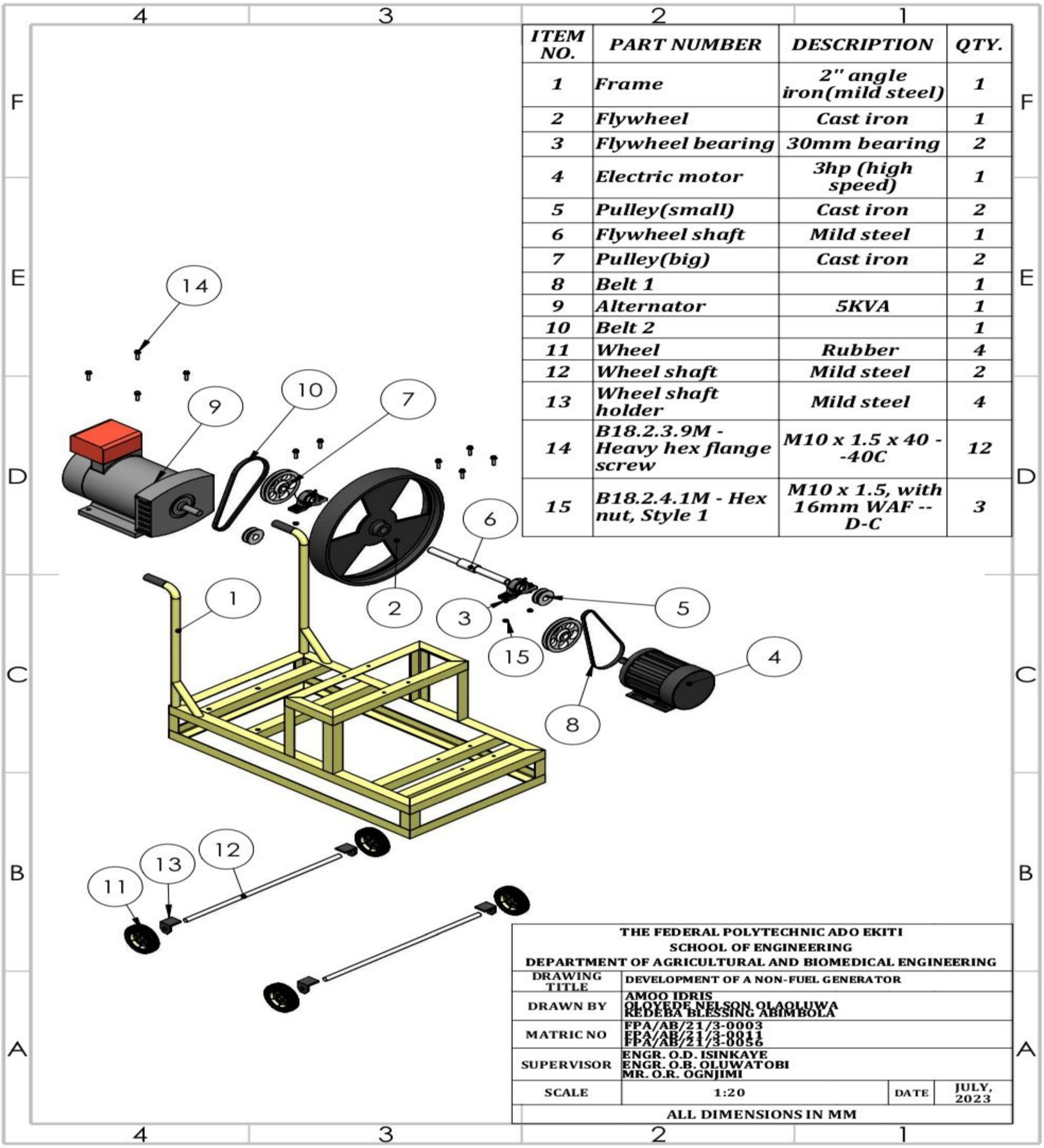
7. Knight, R.D (2018) "Physics for Scientists and Engineers: A Strategic Approach. San Francisco.

8. Ulaby, F.T (2009) "Fundamental of Applied Electro-magnetic (1999) Upper Saddle River, W. Hall, pp. 56–61. New York: Gordon & Breach.

9. Rajput, R.K. (2006). Strength of Materials, Multicolor Illustrative ed., S.chand&co.Ltd, New delhi

APPENDIX A

EXPLODED VIEW OF THE NON-FOSSIL FUEL GENERATOR



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Frame	2" angle iron(mild steel)	1
2	Flywheel	Cast iron	1
3	Flywheel bearing	30mm bearing	2
4	Electric motor	3hp (high speed)	1
5	Pulley(small)	Cast iron	2
6	Flywheel shaft	Mild steel	1
7	Pulley(big)	Cast iron	2
8	Belt 1		1
9	Alternator	5KVA	1
10	Belt 2		1
11	Wheel	Rubber	4
12	Wheel shaft	Mild steel	2
13	Wheel shaft holder	Mild steel	4
14	B18.2.3.9M - Heavy hex flange screw	M10 x 1.5 x 40 - -40C	12
15	B18.2.4.1M - Hex nut, Style 1	M10 x 1.5, with 16mm WAF -- D-C	3