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Construction and Application of Solar Powered Waste Compactor

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ABSTRACT:
This study reported the construction of a solar powered waste compactor, to enhance solid waste management. The concept of this project is about the application of green energy in waste management in which the design, commercialization and the use of processes and product are feasible and economical while minimizing the risk to health and environment. The availability of the solar panel allows the trash compactor to be placed in locations where no electricity is available, this is made possible because of the presence of a 12v battery within the system. The compaction feature also allows the unit to be emptied less often than a typical trash container. The external casing was constructed using an acro board with about 2ft x 4ft in dimension and it serves as the housing to the internal component of the system. A removable bin made of wood with a dimension of 48.26cm x 30.48cm x 33.02cm or a total volume of 4.85m^3 allows easy removal of compacted waste. The compaction mechanism is carried out by a pneumatic piston joint to a scissors frame or an X-frame made of mild steel of about 294.64cm in length at full stretch. The solar powered waste management bin proposes a great improvement of a simple trash can that has the capacity to hold waste of about four to five times its original capacity. Further development on designsare suggested on the recommendation.

Keywords: Waste compactor, solar power,12v battery, green energy.

I. INTRODUCTION

The word “environment”, should not be limited to only area where humans live and carry out daily activities, but should be extended to include “physical, social, cultural, economic and aesthetic factors” which affect and sometimes determines an individual’s character (Nnamdi,2014).Managing waste generated has always been a problem in major parts of our society, especially the major cities such as Lagos, Port Harcourt and Abuja where industrialization is at its peak. “Less than one percent (1%) of Nigerian GDP is spent annually on waste management with Lagos State and Rivers State leading nationally in monthly waste collection and disposal expenditures of N300 million and N100 million respectively. This is far less than the recommended standard of three to five percent (3-5%) of national GDP. Nigeria has over thirty five percent (35%) of her population living in the cities with a growing urbanization rate of about 7% per annum and less than ten percent (10%) of the city populations enjoying marginal waste management services”(Onazi, Gaiya, Ola-Adisa, and Mangden, 2018)Wastes generated from industries, carnivals, restaurants and market places are major problem as there are not enough trash cans to store these waste, and places where these cans are provided are struggling to keep up with the generation rate of these wastes. This has resulted to severe health issues and as well contaminated the underground water (Aliyu & Amadu, 2017). Waste generation rate in Nigeria, has been a major cause for concern to the country and in the eyes of international communities (Geoffrey, 2005).
According to Kehl (1983), as cited in (Yerinmearede, Solomon and Peter, 2020). Waste compactors are not yet in high demand in Africa, when compared to other countries in the world, thus households and offices have been forced to dump their wastes on the streets due to the absence of waste compactors. This has contributed immensely to land pollution.

Besides managing the waste in our external environment, it is also important to take into consideration the waste generated in the household, because a large portion of these house hold wastes end up in the environment. According to Schanes, Dobernig and Gözet(2018), as stated in (Laurieri, Facchini,Lucchese, Marino &

Piccininno, 2020). As part of a municipal landfill diversion program. Household waste in economically developed countries will generally be left in waste containers or recycling bins prior to collection by a waste collector using a waste collection vehicle. Ordinarily, trash containers at homes and on the streets often times over flow, and solid waste management companies don't come frequently to dispose these wastes, hence the need for a more efficient and effective way of managing these wastes. To manage this problem more effectively, an automatic solar trash compactor which notifies the user when the use when the trash needs to be emptied is a better option, as it works without electricity, which is a challenge in Nigeria. The solar powered waste compactor has the capacity to hold 5 times the waste a normal refuse container of same dimension would hold (Swati, Harita, Asha, Amit, &Sneha, 2014)

This research is aimed at providing a small size, light weightandcompacting equipmentforwaste compaction, which can be useful in areas such as restaurants, homes, small apartments and cafeterias and other small business, where quantity of waste generated is usually small, in which after compression produces small sized bales that can be handled more effectively through known conventional means (Garbage pick-up trucks).

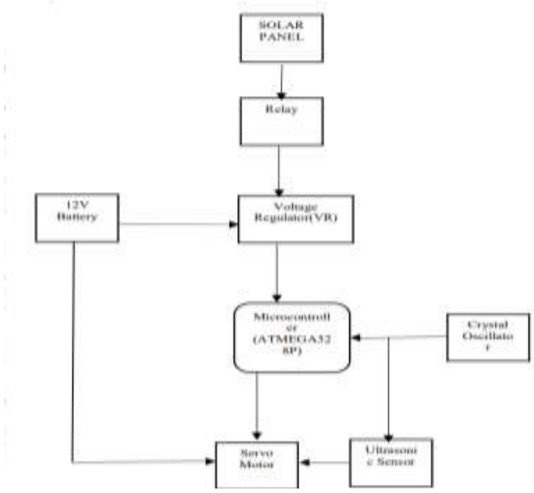
The design solar powered waste compactor consists ofa small cabinet (this serves as trash baler) and two receptacles situated at the lower portion of the cabinet. The receptacles of the trash baller is placed on a forward swinging panel,this enables the panel to swing bothforward and backward easily,as well as, facilitate the easy removal of the compressed waste from the trashbin/baler. The design also comprises of a pneumatic or hydraulic operated cylinder ram memberand this is attached to its downward movable pistonand placed above the second receptacle. Two receptables were used for this design and helps to reduce the weight of the device, facilitate easy operation and reduce design cost (Yerinmearede, Solomon, Peter, 2020)

II. RESEARCH METHODOLOGY

This section of the paper contains the processes involved to get the system working. This section mainly deals with designed aspect of the hardware and the analysis of individual unit that made up the device.

DESIGN THEORY

Different designs of a solar waste compactor have emerged over time. In spite of the wide variety of waste compactor system and the form of energy used, they all have certain feature in common which allow a systematic approach to their design. In most cases, the solar waste compactor is based on compaction of solid waste through the use of energy trapped from the sun by the solar panel.



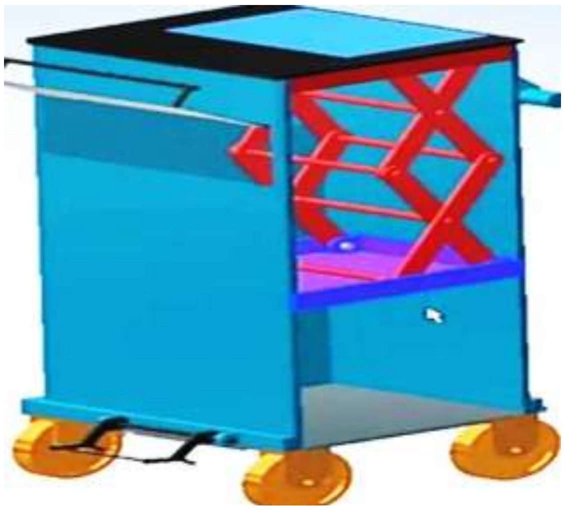


Fig. 1: block diagram of a solar powered compactorFig 2: cad view of solar compactor
Source: Isah (2020)

Material Selection Factors
The various factors which determine the choice of material are discussed below:

Properties

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability etc.The following four types of principle properties of materials decisively affect their selection.

a. Physical
b. Mechanical
c. From manufacturing point of view
d. Chemical

The various physical properties concerned are melting point, thermal conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, magnetic purpose etc. The various mechanical properties concerned are strength in tensile, compressive shear, bending, torsion and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit and modulus of elasticity, hardness, swear resistance and sliding properties.

The various properties concerned from the manufacturing point of view are,

- Cast ability
- Weld ability
- Surface properties
- Shrinkage
- Deep drawing etc.

WASTE BIN DESIGN DIMENSIONS
Specifications:
Length of the bin = 0.3597m
Breadth of the bin = 0.3597m
Height of the bin = 0.4826m
Volume of the bin =4.85m^2

Fig.3: Waste Bin

TESTING PROCEDURES

The mechanical aspect of our design (including the motor and the Acro board) can be tested by programming a signal into the PIC. That is, making sure the mechanical arm is able to travel deep enough into the trash can and pull itself back up. It is important that the mechanical aspect of the designworks perfectly before piecing all the parts together.

The optical sensors can also be tested individually. The photo detector was placed in line with a LED and current generated was measured. Current generated when the LED is off was also measured. Noise calculations were done, and data gotten is used to calibrate our microcontroller. To test the transceiver, the transmitter and receiver were placedat a determined distance apart, and transit a present bit string to see if it works. The distance covered by the trans receiver was determined by intermittently increasing the distance between the transmitter and the receiver. After putting the pieces together, testing was done again to ensure the entire equipment still works and nothing was damaged during the previous testing.

DESIGN CONSIDERATION

In designing the system, critical consideration was given to factors such as productivity, efficiency, strength, service life, reliability, weight, size, cost of assembly and dismantling, maintenance, simplicity, and safety maintenance, convenience of operation, absorptive, transitivity, cost and availability of materials, thermal energy received by the system, thermal efficiency which compresses of instantaneous efficiency and overall efficiency of the system to and heat transfer both external, internal and overall heat transfer. Also, the design focused on the indispensable qualities of the system which will enhance its acceptability by rural and urban dweller. These qualities include:

1) Affordability
2) Ease of operation and maintenance

III. DESIGN ANALYSIS

Design of the solar panel

Fig. 4: Solar Panel

A solar panel is a device that collects and converts solar energy into electricity or heat. It is known as photovoltaic panels used to generate electricity directly from sunlight. Solar thermal energy collection systems are used to generate electricity through a system of mirrors and fluid filled tubes. It is known as energy portal. A solar power technology uses solar cells or solar photovoltaic arrays to convert light from the sun directly into electricity. Photovoltaic is the process in which light energy is converted into electrical power. It is best known as a method for generating solar power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity. The photovoltaic solar panel is photons from sunlight knock electrons into a higher state of energy, creating electricity. Solar cells produce direct current electricity form light which can be used to power equipment or to recharge a battery. A less common form of the technologies is thermo-photovoltaic, in which the thermal radiation forms some hot body other than the sun is utilized. Photovoltaic devices are also used to produce electricity in opticalwireless power transmission.

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Battery Selection

Fig 5: Battery

Fig. 5: Solar Panel

In this project secondary type of battery is used and it is rechargeable. A battery is one or more electrochemical cells, which store chemical energy and make it available as electric current.

There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy. Primary batteries can only be used once because they use up their chemicals in an irreversible reaction.

Secondary batteries can be recharged because the chemical reactions they use are reversible and they are recharged by running a charging current through the battery, but in the opposite direction of the discharge current. Secondary, also called as rechargeable batteries can be charged and discharged many times before wearing out. After wearing out some batteries can be recycled.

Batteries have gained popularity as they became portable and useful for many purposes. The use of batteries has created many environmental concerns such as toxic metal pollution. A battery is a device that converts chemical energy directly to electrical energy and consists of one or more voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte.One half cell is the positive electrode and the other is the negative electrode. The electrodes do not touch each other but are electrically connected by the electrolyte which can be either solid or liquid. A battery can be simply modeled as a perfect voltage source which has its own resistance and resulting voltage across the load depends on the ratio of the battery’s internal resistance to the resistance of the load. When the battery is fresh, its internal resistance is low; hence the voltage across the load is almost equal to that of the battery’s internal voltage source. As the battery runs down and its internal resistance increases, the voltage drop across its internal resistance increases, so the voltage at its terminals decreases and the battery’s ability to deliver power to the load decreases.

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Design of the Piston

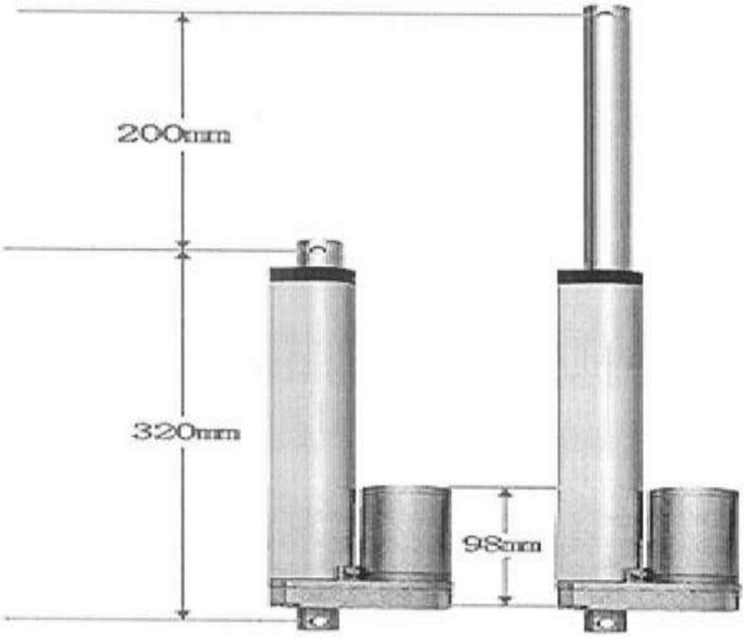

Fig. 6: Computer Aided Design model of a piston

Specification:
Length of the piston at full stretch = 520mm
Length piston at normal state = 320mm
Thickness of the piston = 18mm
Length of piston rod = 200mm
CALCULATIONS DC MOTORSPECIFICATION:
SpeedN = 30 RPM
Voltage V = 12 Volt
Current I = 0.3 A (loading condition)
Power P = V x I
= 12x0.3
P = 3.6 WATT
1 WATT = 0.00134102 HP
3.6 WATT = 3.6 X 0.00134102
P = 0.0048 HP
Motor Efficiency = 36%
Electrical power of the motor is defined by the following

Formula:Pin = I * V
Where,
Pin – Input power, measured in watts (W)
I– Current, measured in amperes (A)
V – Applied voltage, measured in volts (V)

TORQUE OF THE MOTOR
The formula for calculating torque will be
$T = (I * V * E *60) / (N * 2\pi)$
$= (0.3x12x0.36x60)/30x2\pi$

Torque = 0.412 Nm
1Kg-cm = 0.0980665 Nm
1 Nm = (1/.0980665)
=10.197 kg-cm
(10.197 x 0.412) = 4.20 kg-cm
Torque (T) = 4.20 kg-cm

Fig. 7:

Fig. 8:

Fig. 9:

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Fig. 10:

IV. RESULTS AND DISCUSSION

The design and construction of the solar powered waste compactor was successfully achieved and tested. The sizes of the compacted wastes were reduced to about a ratio of one to four of their original size. The compactor was constructed with several parts with the chief being aluminum bar, acro board, rack and pinion, solar panel, bearing and shaft.The principle of operation is based on energy stored from the solar panel been used to supply 12V to the relay driver circuit. The relay circuit controls the motor. The voltage from the panels, first passes through, a 7805 regulator which allows only 5V to pass through it. The micro controller works under 5V whereas the relay driver circuit works under 12V as mentioned above. For this purpose, a cell is provided in the system. A two-way switch is used in the circuit to control and direct the piston. An Automatic key is provided to allow the piston compress and return to its initial position automatically after a prescribed time interval. The microcontroller uses a 40 pin IC. Thus, when the voltage is passed to the relay drives.

V. CONCLUSION

Theprojectwhichisaimedatdesigningandfabricatinga solar poweredwastecompactorwassuccessfullycompleted andtestedin ordertoascertainitsperformanceandefficiency.Thefabricatedcompactorensuresthereisareductionincostthroughthe reduction of energy consumption that is associated with electrically powered waste compactors. In conclusion, if the production of solar powered wastecompactorsismassivelyencouragedandcommercialize,itwouldserveasameansofempowermentor employment to the youths of the nation and as well aid the development of our technical and technological know-how.

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