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Modelling and Fabrication of a Water Hyacinth and Agro Wastes Shredder for Clean Maritime Waterways and Environments

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A B S T R A C T

The problems associated with agro wastes littering the environment and that of water hyacinths hindering smooth sail of boats and other marine vehicles in the waterways necessitated this study. Accordingly, in order to clear the maritime waterways and environment of wastes, the modeling and fabrication of a water hyacinth and agro wastes shredder has been done. The materials used in the construction of the shredder were locally sourced. The modeling of the shredder was carried out using the SOLIDWORKS and AUTOCAD Software respectively. It was done after proper taking of dimensions of each of the components: either the one that is to be fabricated or the one that it will require purchase and to fix it. Thus, an affordable and homemade shredder was fabricated. It is recommended that the water hyacinths and the agro wastes should be dried before crushing it in the shredder together with oiling and greasing of the rollers and cutter's bearings, and the well crushed wastes should be packaged for the utilization as biogas/biomass for power generation.

Keywords: *Modeling, Fabrication, Water Hyacinths, Agro Wastes, Maritime Waterways, Environments*

1. INTRODUCTION

The agriculture's wastes are referred to as remnants from planting together with harvesting of agriculture's produces like crops, vegetables, fruits, meat, and poultry. While the water hyacinth which is also known as pontederia crassipe grows on top of the seawater covering the waterways causing severe detriments together with damaging influence on the water, fisheries and sailing. These water hyacinths and agro wastes can be gathered manually dried, shredded and utilized as biogas/biomass (Adrian, 2017; Hussein, 1992, Obeid, 1984; Batanouny and EL- Fiky, 1984; Sculthrope, 1967). Accordingly, these wastes produced depend on the kind of agriculture's activities that need to be conducted. Globally, agriculture has been regarded as the biggest profession, generating a range of waste constituents that required a different technological treatment together with managerial practicable practices. The cardinal calling of Nigeria's population is pendent on agriculture at abidance status, with Nigerians holdings low and dispersed and these wastes are also referred to as byproducts. Precisely, these byproducts, otherwise known as remnants, are the not output produced through cultivations together with the harvesting of agriculture's produces but they also encompass materials that can be beneficial to man's consumptions and other energy-related usages (Obi *et al.,* 2016). While a very huge number of the population is facing the issues of the management of waste constituents before and after harvesting (Adewumi and Omoresho, 2002); the water hyacinth has been proven successfully for biogases/biomasses generation in the fermentation of distinct abilities (Ikhtyar and Shamsuzzaman, 1984; Dhahiyat *et al.,* 1984; Hharipada - Sarker *et al.,* 1984). Studied showed that twenty-five of cow dungs doubled with seventy-five percent of dried water hyacinth generates the best methane, and it eludes the very large potentiality of the water hyacinth as an unconventional energy source, and it is approximated that a ton of the dried water hyacinth gives three hundred and seventy thousand liters of biogas (Abdel-sabour,2010).

2. LITERATURE REVIEW

While a very huge number of the population is facing the issues of the management of waste constituents before and after harvesting (Adewumi and Omoresho, 2002); the water hyacinth has been proven successfully for biogases/biomasses generation in the fermentation of distinct abilities (Ikhtyar and Shamsuzzaman, 1984; Dhahiyat *et al.,* 1984; Hharipada - Sarker *et al.,* 1984). Studied showed that twenty-five of cow dungs doubled with seventy-five percent of dried water hyacinth generates the best methane, and it eludes the very large potentiality of the water hyacinth as an unconventional energy source, and it is approximated that a ton of the dried water hyacinth gives three hundred and seventy thousand liters of biogas (Abdel-sabour,2010).

However, the agro wastes are made up of the following wastes: animal wastes like manure: cow dungs and animal cadavers; food processing wastes such as only twenty percent of maize preserved in a sealed can and eighty percent waste; crop waste, which includes corn stalks, sugarcane residue, drops together with preferred fruits coupled with vegetables – water hyacinths, pruning, and dangerous doubled with poisonous agro wastes like pesticides, insecticides together with herbicides respectively (Vitali *et al.,* 2013). The expansion of agro produce has unpretentiously brought a rise in the abundance of livestock wastes; agro crop bagasse coupled with agricultural industry based byproducts like dried water hyacinth for biomass. The consequential increase of agro wastes is presumably if the world, emerging countries like Nigeria perdure to accentuate farming systems. The annual estimation of agro waste is approximately nine hundred and ninety-eight million tons and organic solid related wastes amounted to eighty percent of the all the solid wastes produced in any farm (Agamuthu, 2009; Brown and Root, 1997).

Recently, almost all wastes are used for power generation. Meanwhile, a very large number of agriculture's wastes are not used, the reason being that there is a difficulty in the handling, management together with the storage of them. Precisely, the reasons are their small bulk density, large area volume for depository. And that is the reason why the farmers on the field burn the waste emanating from the crop's harvest. Hence, this burning of agriculture's wastes is done repeatedly annually without looking at its economic benefits; therefore, the need for this waste shredder emanated, thereby helping in shredding the agriculture's waste for economic gain (Sanjay and Kumar, 2015).

However, there are different crops that are being planted in Nigeria, but after the crop's harvest, the wastes are either set ablaze or discarded without looking at the nutritious content. Also, with the rise in Nigeria's and the world's population at large, the command is to stabilize agriculture's produce in a supportable way. Furthermore, a natural equilibrium requires to be sustained for life's existence together with property (Screenivas *et al.*, 2017).

Oladejo *et al. (2020*) designed and fabricated a shredding machine, and an appropriate appraisal was conducted, and it was found that it surpasses the common manual type and the fabricated shredder is better than chopping twigs.

Pavankumar *et al. (2018*) conducted development together with construction of an organic waste shredder. Experimentally, the model framework was prepared, and it was concluded that the constructed shredder surpasses the manual shredder machine that shreds organic waste, and it can be utilized for medium-scale businesses, thereby generating income.

Pawar *et al.* (2018) reviewed the construction and development of a paper shredder. Their work looks at how to reduce the challenges faced with conventional paper shredders. In order to reduce the challenges of the conventional shredder, some changes were proffered in the reviewable paper that it will assist in modifying the machine for better usage.

VijayAnanth *et al. (2018*) constructed a designed plastic shredder for industrial utilization and plastic waste management in a clean environment. The operation of the machine needs no skilled labourer because it only needs less labour, and it minimizes industrial processing timing. It was recommended that the shredder should be well maintained since it requires less maintenance cost for durability.

Ben *et al*. (2007) performed mechanical shredding of water hyacinth and how it affects the quality of the water in the Sacramento-San Joaquin River Delta, California. The work was done in dual sections: shredding machine boats in the fall of 2003 and the other in the spring of 2004. It was discovered that the shredding influences the quality of the water, but the specificity of it depends on the site and period of the shredding.

Abdulkadir *et al. (2020*) designed and fabricated an agro-waste shredder with locally sourced materials. The shredder was tested, and it runs very well, and the results showed that the size of the shredding aperture of the shredder meaningfully influenced the shredding efficacy of the shredder.

Furthermore, this study will look at the modeling and fabrication of a water hyacinth and agro-waste shredder for clean maritime waterways and environments. Also, measures to utilize the shredded wastes as biogas/biomass will be implored and suggested for further investigation.

3. MATERIALS AND METHOD

3.1 Materials Used

The materials utilized for the construction of this shredder were gotten locally and they are: stainless sheet plate, contact roller (AISI 316 stainless steel), shredder blades (carburizing steel), DC motor, chain, sprocket, supporting frame rods, blade frame, shaft, bearings, mounts, jaw coupling, screws, bolts, AUTOCAD and SOLIDWORKS software respectively.

3.2 Methods

3.2.1 Modelling and Fabrication Consideration

The materials utilized in the fabrication of the shredder were selected on the basis of availability, durability, and affordability, and easy to fabricate and all the materials were locally sourced. Practically, the modelling and design was done for the hopper; in the shaft certain pertinent considerations of the properties of it was looked at and considered; the transmission velocity, length, angle of contact, and power transmitted on the belt which helps in rolling the cutter of the shredder was also considered (Khurmi and Gupta, 2013; Oladejo *et al*, 2020).

3.2.1.1 Hopper's Modeling

$V_H = \frac{1}{3}(A_i + A_{ii}\sqrt{A_i + A_{ii}})h$ `(1)

Where,

V_H = Volume of the hopper; A_i is Area of top base (cm^2); A_{ii} is Area of bottom base (cm^2) and (h) is Height of hopper

3.2.1.2 Volume of Twig in the Shredding Chamber's Modeling

$$V_T = \pi r^2 h \tag{2}$$

Where,

V_T is the volume of Twig; r is the radius of the twig (cm) and h is the height of the twig (cm)

3.2.1.3 Shaft Diameter's modelling

$$d^3 = \frac{16}{\pi s_s}\sqrt{(2(Kbmb) + 2(Ktmt)} \tag{3}$$

Where,

d = diameter of the shaft (mm); S_s = Allowable shear stress of metal with key way = 40 × 106 N/m2 ;(mb) is maximum bending moment (Nmm) ;(mt) is torsion moment (Nmm) ;(kb) = combined shock and fatigue factor applied to bending moment and (kt) = combined shock and fatigue factor applied to torsional moment respectively.

3.2.1.4 Modelling of the Belt

The modelling of the belt encompasses the following:

i. Speed Transmission Ratio which is given as:

$$\frac{N_f}{N_d} = \frac{D_d}{D_f} \tag{4}$$

Where,

N_d is Speed of the Driver (Electric motor);N_f is Speed of the follower (r.p.m.)

D_d is Diameter of the driver and D_f is Diameter of the follower .

ii. Velocity of Belt

$$v = \frac{\pi D_f N_f}{60} \tag{5}$$

iii. Velocity ratio of a belt drive

$$V_R = \frac{D}{d} - \frac{N_{ii}}{N_i} \tag{6}$$

Where,

D is diameter of the driven pulley in (m);d is diameter of the driving pulley in (m) ;N_i is speed of the driven pulley in r.p.m. ;N_{ii} is speed of the driving pulley in r.p.m. (electric motor) and V_R is velocity ratio.

iv. Centre distance from the pulley

$$x = \frac{d+D}{2}\, d \tag{7}$$

v. Length of the belt

$$L = \frac{\pi}{2}(D + d) + 2x + \frac{(D-d)^2}{4x} \tag{8}$$

Where,

x is Centre distance from the two pulleys in mm; D is diameter of the driven pulley in mm and d is diameter of the driving pulley in mm

vi. Contact Angle

$$\alpha = Sin^{-1} \left(\frac{R-r}{2x}\right) \tag{9}$$

Where, θ is Angle of contact; R is radius of the driven pulley in (m); x is Centre distance from the pulley in m and α is wrap angle of the smaller pulley Power transmitted by the belt.

vii. Power transmitted by the belt

$$2.3 \log\frac{T_i}{T_{ii}} = \mu\theta \tag{10}$$

Where,

T_i is tension at the tight side of the belt and T_{ii} is tension at the slack side of the belt ; $\mu =$ coefficient of friction between the belt and pulley and P_T is power transmitted.

Therefore, $P_t = T_i - T_{ii}$ (11)

Also, the modelling of the shredder was carried out using the SOLIDWORKS and AUTOCAD Software respectively. It was done after proper taking of dimensions of each of the components: either the one that is to be fabricated or the one that it will require purchase and to fix it. Also, the Equations 1 – 11 are the model equations utilized for the design. **Figures 1 – 3** show the pictorial representation of the 3D modelling of the shredder and its components. These components of the shredder are instructed on how to assemble it.

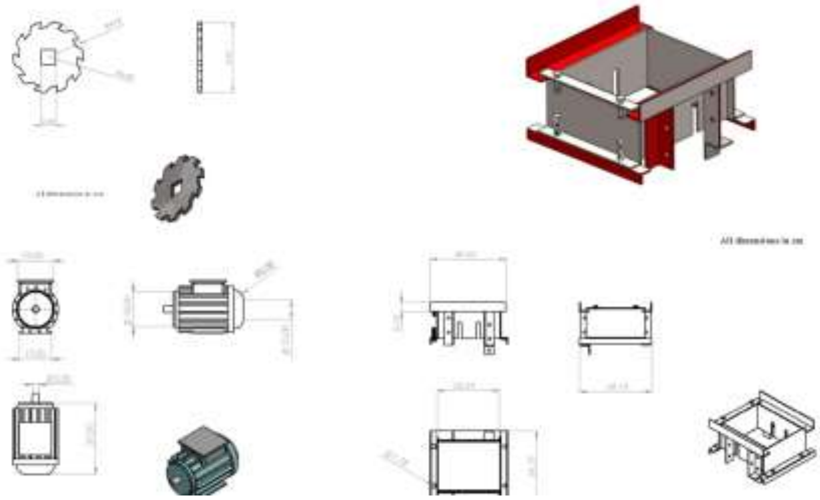

Figure 1 3D Components Modelling of the Shredder with Sectional Dimensions

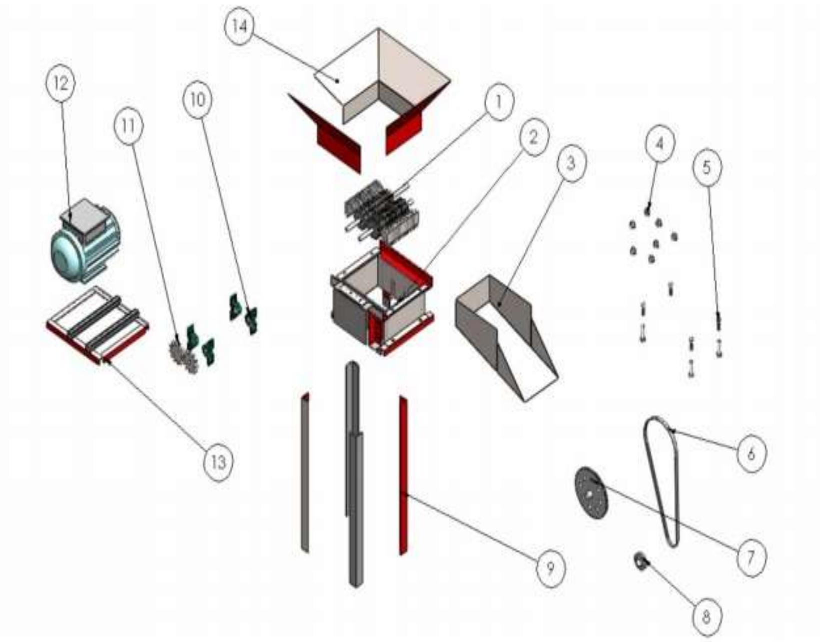

Figure 2 3D Components Assembly of the Shredder

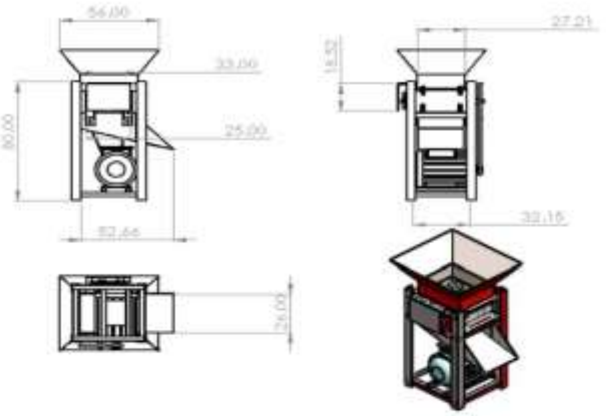

Figure 3 3D Full Assembled and Sectional Modelling the Shredder with Dimensions

3.3 Fabrication Process

The shredder is drawn to precision using the SOLIDWORKS Software and after that; cutting and milling of the various sections were done with the aid of the cutting and milling machines. The housing of the shredder was fabricated using the welding machine and it was done according to the assembly drawing which entails all the dimensions and also shredder's blade was fabricated using carburize steel respectively. Furthermore, after fabricating the housing frame and the shredder's blade, the other shredder's components that were not fabricated but were locally sourced were assembled to make up the shredder.

4. RESULTS AND DISCUSSION

4.1 Result

The Shredder was fabricated after painstakingly fabrication processes of cutting, milling, grinding and assembling of all the components of the shredder together. The fabricated shredder is depicted in **Figure 4**.

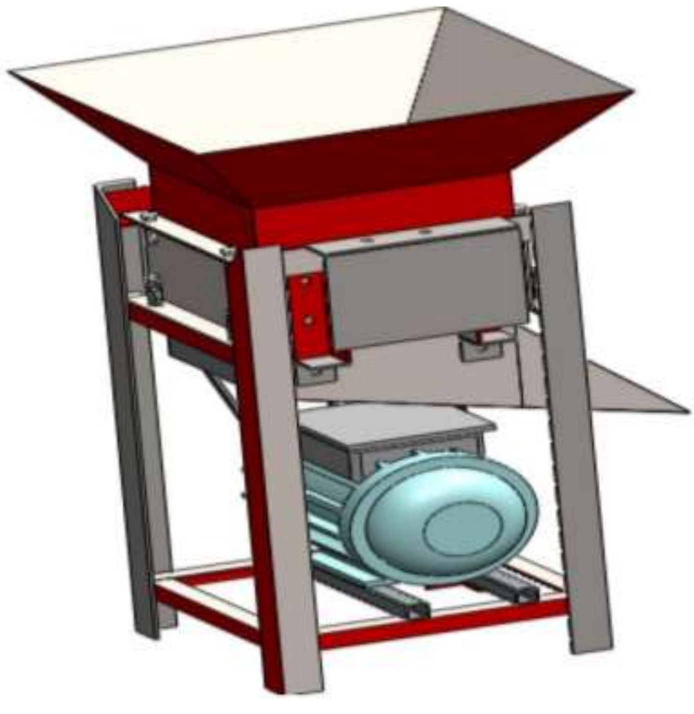

Figure 4 3D Depiction of the Fabricated Shredder

4.2 Discussion

The shredder will be utilized to crush agro- wastes and water hyacinths in order for clean environments and maritime waterways. The water hyacinths and agro – wastes will be crushed by the shredder when they are dried. The dried shredded wastes of both the water hyacinths and agricultural produces will be utilized as biomass or biogas to generate energy.

5. CONCLUSION

The modelling and fabrication of a water hyacinth and agro wastes shredder for clean maritime waterways and environments has been done. The study focuses on the modelling and fabrication of a shredder that will be used to crush agro wastes and water hyacinths. The materials used in the construction of the shredder were locally sourced. The modelling of the shredder was carried out using the SOLIDWORKS and AUTOCAD Software respectively. It was done after proper taking of dimensions of each of the components: either the one that is to be fabricated or the one that it will require purchase and to fix it. Thus, an affordable and homemade shredder was fabricated. It was recommended that the water hyacinths and the agro wastes should be dried before crushing it in the shredder together with oiling and greasing of the rollers and cutter bearings.

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