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Design and Fabrication of Shredding Machine used for Plastics

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Abstract: In the present global scenario the usage of plastic is very high and this is return creating a huge environmental impact. Plastics are one of the most commonly used materials in the world today. The huge quantities of these plastic categories currently being marketed bill unlimitedly find their way to the waste dump sides. This is creating waste product problems, due to its high amount of waste generated as an upcoming solution for the existing problem a plastic shredder machine is designed and fabricated. In the present paper a low-cost waste plastic shredding machine is designed and fabricated. The design is carried out using auto-cad 2018 software and the prototype model has been developed using solid works 2017 and the analysis of the shredding machine carried out using Ansys 15.0, finally the machine fabricated considering the economic viability.

Background*: Plastic have become an essential part of our day to day life since their introduction over hundred years ago. It is one of the most commonly used materials in the world today. They come in five major categories; the Polyethylene terephthalate (PET), the High density polyethylene (HDPE), the Polyvinylchloride (PVC), the Polypropylene (PP) and the Low density polyethylene (LDPE). The huge quantities of these plastic categories currently being marketed will ultimately find their way to the waste dump sites. This is creating waste products problems due to its high amount of waste generated, non-biodegradability and the fastest depletion of natural resources regarding its short life cycle, therefore increased amount of material utilized in its production, and waste generated. Plastic bottles make up approximately 11% of the content landfills, causing serious environmental consequences. The plastic waste globally constitutes more than 60% of the total global municipal solid waste (MSW), 22% were recovered and 78% disposed.*

Materials and Methods*: In this research paper a Plastic shredder machine is designed and fabricated. After fabrication the working of the machine is tested considering few plastic bottles samples. The waste plastic shredder comprises of three major components, namely;*

- *Shredding unit*
- *Power unit and*
- *Machine frame.*

The first step of this project is to design the complete shredder unit in solid works and then followed by analyzing its week points and the threshold point of failure through Ansys. The design is then fabricated by required processes like laser cutting, welding and other machining processes.

Results*: After the successful completion of the design, fabrication and testing the output obtained was;*
The shredder shaft to a torque of 1000 Nm, the shaft experienced a small angle of twist of 0.42^o
•At the machine speed of 50 rpm, 53.3% of LDPE plastic was shredded to an average particle size of 7.51 mm2 within 2 mins.
•The specific mechanical energy of the machine at this speed and for HDPE reduced by 21% when compared to speed 60 rpm while the recovery efficiency was 95% with through out of 2 kg/hr which is 12% higher than the speed at 89 rpm.

Conclusion: *Considering the design and fabrication features of the plastic shredding machine is found to be cost effective and easily operated when compared to the conventional Shredding machine*

Key Word*: Design, Plastics, Environment impact, Fabrication.*

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I. Introduction

The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly 100 million tons nowadays. This rapid increase of plastic consumption and demand in the world today is the main factor of land and water pollution. However, as ocean covers 73% of the earth's surface, usually, pollution in land tends to end up in ocean. Because of most of plastics are non-degradable and takes decades or even hundreds of years to degrade, it is the factor why plastic pollution become worldly problem.

For more than two decades, the amount of plastic waste littering the streets has been of crucial environmental problem. The proper system of plastic waste collection is missing, and the people are not educated as to the problems of plastic waste. Every home generates waste from plastic, ranging from used nylon's, plastic bottles down to big plastic containers like buckets, jerry cans, kegs, and so on.

II. Material And Methods

2.1 Introduction to Shredder

Therefore, to overcome these challenges, it was necessary to develop a low cost waste plastic shredding machine using available local materials that can easily be operated without much skill for low and medium income earner. This will prepare the recycled plastic for the production of new products. Plastic recycling or reprocessing is usually referred to as the process by which plastic waste material that would otherwise become solid waste are collected, separated, processed and returned to use. Waste plastic shredder is a machine that reduces used plastic bottles to smaller particle sizes to enhance its portability, easiness and readiness for use into another new product. The design principle of this machine was got from the ancient tradition method of using scissors to cut materials into reduced form and scratching used by rabbits when digging or tearing. These two traditional methods were applied in the design of the machine by fabricating cutting blades to cut the waste plastic while some of the cutting blades have sharp curved edges to draw-in the plastic into the cutting blades teeth, The waste plastic shredder comprises of three major components, namely;

- Shredding unit
- Power unit and
- Machine frame.

The first step of this project is to design the complete shredder unit in solid works and then followed by analyzing its week points and the threshold point of failure through Ansys. The design is then fabricated by required processes like laser cutting, welding and other machining processes.

The major techniques employed in construction of the designed machine include machining operation on lathe machine, drilling operations on drilling machine, boring operation on lathe machine, keyway cutting on slotting machine, flame cutting using oxyacetylene gas welding machines, grinding for good finishing, electric welding using arc welding machine. Basically, these constructional techniques were broken down into four sub-heading namely; cutting operation, machining operation, welding operation and assembly; and finishing operation

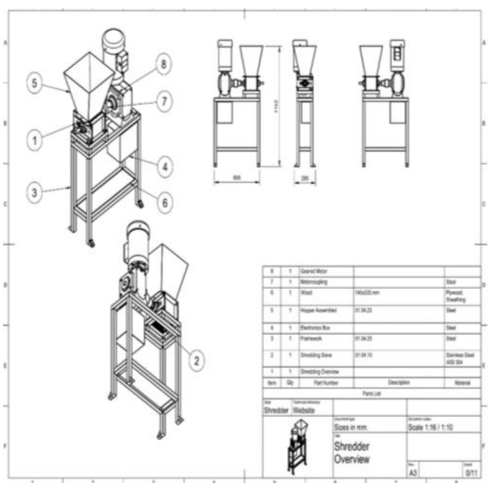

Fig 1: Shredder 2D view

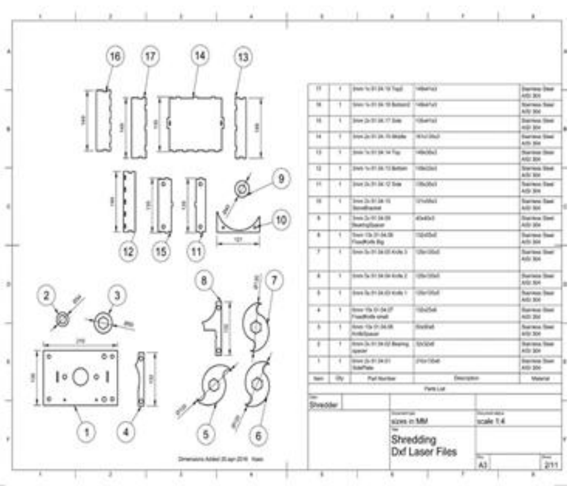

Fig 2: Shredder laser cutter parts

2.2 Construction and design of the Hopper

1.Volume of the hopper = $1/3\ [A1 + A2 + \sqrt{(1 + 2)}] \times h$

Where, A1= Area of top base
300*300 = 90000 mm
A2= Area of bottom base
150*150 = 22500 mm
h= Height of hopper=300 mm
Volume of the hopper = 0.011 m3

2.Volume of PET bottle (coca cola) in the shredding chamber:

Volume of PET bottle (Coca-Cola bottle) = Area × height

$= (\pi d4/4) \times h$

$= 7.7 \times 10\text{-}4$

No of bottle to fill the hopper = volume of hopper/ volume of PET Bottle

$= 0.011/7.7\times 10\text{-}4$

=3 bottles

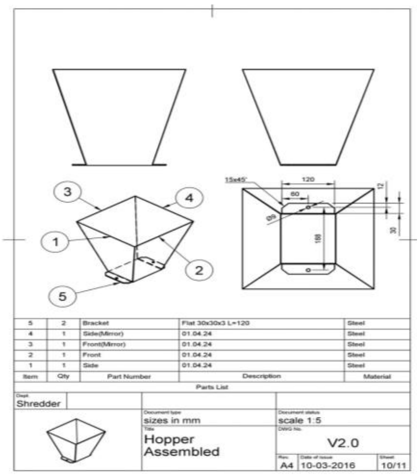

Fig 3: Hopper 2D view

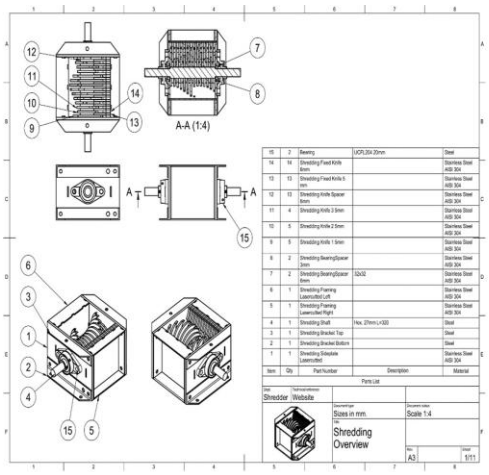

Fig 4: 2D detailing of working box

2.3. Calculations and Formulae

2.3.1 Shredder Hopper

The shredder hopper is a truncated rectangular based pyramid which is placed on the chamber that houses the shredder shafts as shown in Figure 2. The volume of the shredder hopper, Vsh, through which the plastic materials to be recycled are fed is obtained from equation (1).

$$Vsh = (1/3)(BH - bh)$$
$$= 0.011\ m3$$

where, B is the area of the rectangular base for the big pyramid, H is the height of the big pyramid, b is the area of the rectangular base for the small truncated pyramid, and h is the height of the small truncated pyramid. Taking B as 90000 mm, b 22500 mm, H 300 mm and h 300 mm, the volume of the shredder hopper is 11250173.21 mm. It is aimed that the PET plastic to be recycled will occupy 75% of the hopper volume due to space between independent plastic materials and knowing that the density of PET plastic is 5.5 kg.m-3, the mass of the PET plastic to be loaded in the shredder hopper is evaluated to be 5.12 kg (49.74 N).

2.3.2. Shredder

Shaft

The shredder shaft is a rotating part housed in the shredder chamber and it is equipped with knife-edged rings. This knife-edge rings allow shredding of the waste plastic materials to be possible as it rotates against another fixed shaft in the chamber. The shredder shaft speed, V_{ss}, is obtained from equation (2).

$$V_{ss}=\omega_{ss}.\ \Upsilon_{ss}=(2\pi N_{ss}/60)\ \Upsilon_{ss}=509\ \text{mm/min}$$

where, ω_{ss} is the angular velocity of the shredder shaft pulley, r_{ss} is the radius of the shredder shaft pulley, and N_{ss} is the speed in revolutions per minute of the shredder shaft pulley.

The shredder shaft is designed to withstand both torsional and bending loads which it is subjected to during operation, as it is being supported at its near end by two bearings. Hence, the shredder shaft diameter, dss, is obtained from equation (3)

$$d_{ss}^{3}=(16/\pi S_s)\ \sqrt{(\ (K_bM_b)^2+(K_tM_t)^2)}\ \ =27\ \text{mm}$$

Where, S_s is the allowable shear stress, K_b and K_t are the combined shock and fatigue factors as applied to bending moment and torsional moment respectively, M_b is the bending moment and M_t is the moment due to torsion. Given that the values of K_b and K_t are 1.5 and 1 respectively ,the turning moment experienced by shaft is 1000 Nm and the maximum bending moment due to the PET plastic loaded into the hopper (49.74 N) is 45.29 Nm, and the allowable shear stress is 7.6 x 10^{10} $N.m^{-2}$, the shredder shaft with diameter of 30 mm was obtained.

2.3.3 Shredding Chamber

This cuboid chamber housed the shredder shafts and shredding of the plastic material also takes place inside it before the shredded plastic material is deposited into the extrusion hopper through an orifice beneath the chamber. The volume of the shredder chamber, V_{sc}, is obtained from equation (4)

$$V_{sc}=b.H_s=0.001\ m^3$$

where, b is the area of the rectangular base for the truncated pyramid which is the same as that in Section , and H_{sc} is the height of the shredding chamber.

III. Result and Discussion

3.1 Finite Element Analysis On Shredder Shaft

It is expected that the rotating shredder shaft is subjected to torque due to the power transmitted through the belt-pulley system obtained from equation. The behaviour of therotating shredder shaft under the torque is analysed In the FE domain of the CAD application software. One end of the shaft was fixed while the other end was subjected to torque of 1000 Nm. The torque experienced by the shaft is expected to result from the plastic materials to be shredded in the shredding chamber, since the shaft is mounted on bearings at both ends and freely rotating.

The mechanical properties of the mild steel selected as material of the shaft are listed in Table 1.

The result of the FE simulation study of torsion on the stress distribution in the shredder shaft assembly is shown.
Moreover, the yield strength of the mild steel selected for the shaft is greater than the maximum stress obtained from the simulation; hence, the shaft will be able to resist permanent deformation due to torsion., shaft length of 200 mm, shaft diameter of 27 mm,.
Furthermore, the fitness of the shredder shaft for the shredding purpose was examined by running the FE simulation to determine the factor of safety distribution in the shaft. The result showed that the minimum factor of safety was 3.146, which indicate that the shaft is fit to be used for as the shredder shaft.

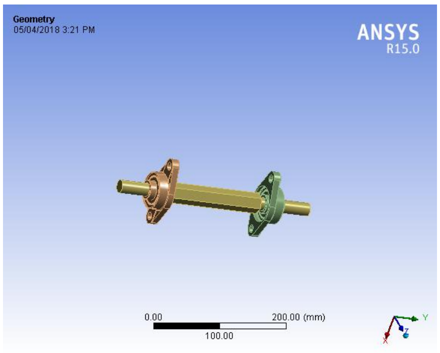

Fig 5: Geometry of the shaft

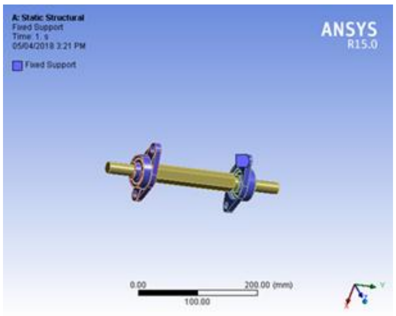

Fig 6: Fixed supports of shaft

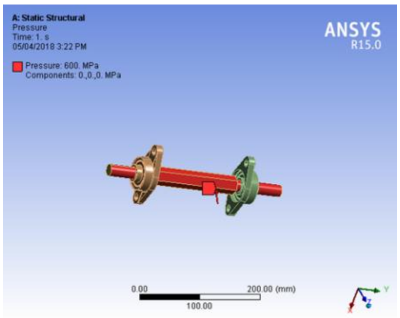

Fig 7: Pressure and components on shaft

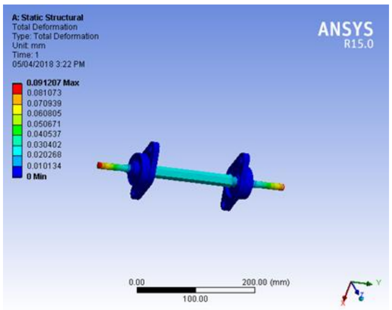

Fig 8: Total deformation of shredder shaft

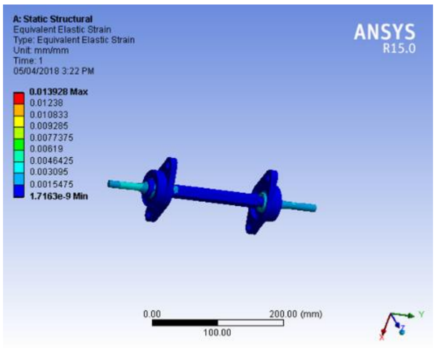

Fig 9: Equivalent elastic strain of shredder shaft

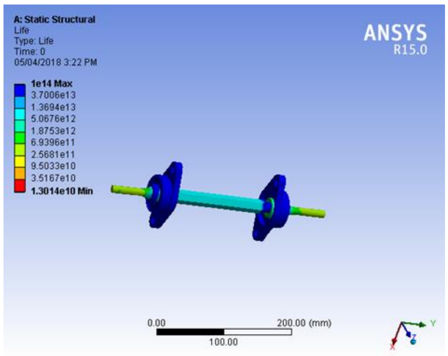

Fig 10: Fatigue life of shredder shaft

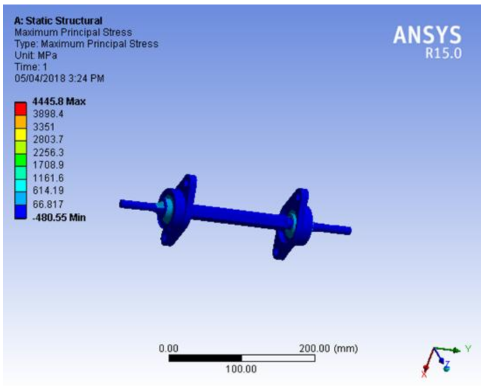

Fig 11: Maximum principal stresses on shredder shaft

IV. Conclusion

- In the present project, a part of plastic recycling machine has been successfully conceptualized, designed and fabricated. Upon the subjection of the shredder shaft to a torque of 1000 Nm, the shaft experienced a small angle of twist of 0.42o
- At the machine speed of 50 rpm, 53.3% of LDPE plastic was shredded to an average particle size of 7.51 mm2 within 2 mins.
- The specific mechanical energy of the machine at this speed and for HDPE reduced by 21% when compared to speed 60 rpm while the recovery efficiency was 95% with through out of 2 kg/hr which is 12% higher than the speed at 89 rpm.
- the machine shredded 52.3% of HDPE with an average particle size of 4.58 mm2 at this speed within 4 mins with a recovery efficiency of 83%.
- Hence, Considering the design and fabrication features of the plastic shredding machine is found to be cost effective and easily operated when compared to the conventional Shredding machine.

References

[1]. Textile and engineering institute: plastic shredding machine
[2]. Finite Element Analysis of Plastic Recycling machine designed for production of thin filament coil by P. K. Farayib
[3]. Feasibility study into recycling waste plastic oyster baskets in the south australian oyster industry by Rawtec & Econ Search
[4]. Design and Development of Plastic Shredding Machine by Mulla Irfan Faiyyaj, Mete Rushabh Pradip, Bhosale Jaydeep Dhanaji,Dange Prasad Chandrashekhar, Jadhav Suraj Shivaji
[5]. Recycling of plastics waste in Ghana; a way to reduce environmental problems/pollutions by Abota, Charles Abugri
[6]. Design and Fabrication Recycling of Plastic System by Dr. Jassim M. Abdulkarim Jaff, Darewan A. Abdulrahman, Zryan O. Ali,Khelan O. Ali,PMohammed H. Hassan.

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