Design and analysis of shredder machine for e-waste recycling using CATIA

P Kumaran¹, N Lakshminarayanan², Alen V Martin³, Rahul George³, Jones JoJo³

¹Assistant Professor, Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission’s Research Foundation, Deemed to be University, Tamilnadu, India.
²Associate Professor, Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission’s Research Foundation, Deemed to be University, Tamilnadu, India.
³UG Student, Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission’s Research Foundation, Deemed to be University, Tamilnadu, India.
e-Mail: kumaranp@avit.ac.in

Abstract
In the current scenario wherein technical gadgets are ruling everywhere from personal mobile phones to official devices technological usage of the electronic and electrical gadgets is increasing day by day and the very big challenge behind it is the disposal and recycling to reduce the effect of toxic materials used in these equipment’s. Most of the countries have been disposing in huge contents of e-waste into dumping yards on abandoned islands disturbing the eco-system. This has been taken as a serious environmental issue all across the world. Even though, lots of disposal methods are in existence for safe disposal, there had been a list of limitations too. The usage of poisonous metals in micron sizes, chemicals in batteries etc. This project, is an attempt to model a crushing machine to dismantle and crush the small electronic gadgets like laptop, mobile phones and i-pads after its life time. The design of the new shredder machine with effective blade profile is to be modeled to crush the used equipment for a size that can be recycled. This project is thus to design a suitable shredder and an analysis using CATIA is expected to provide an optimum solution for the e-waste recycling problem, a need of the hour.

Keywords: Design, Shredder machine, e waste

I. Introduction
Electronics waste, commonly known as e-scrap or e-waste, is the trash we generate from surplus, broken, and obsolete electronic devices Recycling e-waste enables us to recover various valuable metals and other materials from electronics saving natural resources(energy), reducing pollution, conserving landfill space, and creating jobs. According to the Environmental Protection Agency, recycling one million laptops can save the energy equivalent of electricity that can run 3,657 U.S. households for a year. Recycling one million cell phones can also recover 75 pounds of gold, 772 pounds of silver, 35,274 pounds of
copper, and 33 pounds of palladium. On the other end, e-waste recycling helps cut down on production waste. According to the Electronics Take Back Coalition, it takes 1.5 tons of water, 530 lbs of fossil fuel, and 40 pounds of chemicals to manufacture a single computer and monitor. 81% of the energy associated with a computer is used during production and not during operation. Electronics recycling can be challenging because discarded electronics devices are sophisticated devices manufactured from varying proportions of glass, metals, and plastics. The process of recycling can vary, depending on the materials being recycled and the technologies employed.

Dr. Fauzia Siddiqui et al. has carried out a study on the design and modification of a paper shredder machine which is used in the government and private organization to destroy the confidential and important documents. The design is categorized into three main divisions as the bladed sign with different profiles and dimensions and the transmission and cutting forces as the second one and as a third part the model of the frame and blade has been done using the 3D model software Solid works which used for the motion study and analysis.

Sudhakara Reddy and Thunga Raju has done an examination on the structure and change of a paper shredder machine which is utilized in the legislature and private association to annihilate the secret and significant archives. The plan is classified into three primary divisions as the sharp edge structure with various profiles and measurements and the transmission and cutting powers as the subsequent one and as a third part the model of the casing and edge has been finished utilizing the 3D model programming solid works which utilized for the movement study and examination.

S. Vijay Ananth et al, a similar plastic shredder machine is fabricated for cutting plastic mainly the domestic waste and industrial wastes for the recycling purpose and the design and fabrication worked has been utilized by involving the mechanical parts like the shredder blade, frame involved the design calculation which produces the better efficiency cutting output. Most of the transmission mechanism of first-generation plastic shredder machine is obsessed by a low-noise belt. In Second generation shredders, Plastic gear rolls are used, since the injection and shrinking process of the shredder mechanism is difficult to perform correctly, resulting in the less accuracy of the equipment itself. In third generation shredders, the metal sprockets are used. The compelling features are achieved by quiet operation, low energy loss, efficient cutting and the perfect coordination of the system’s various components. Fourth generation machine shredder, the shredder machine’s drive mechanism is the metal gear; although the metal gear thus overcomes the above drawbacks, the impact of the metal gear and the sound of friction is difficult to prevent. Fifth shredder generation:- Diamond snug movement, use of alloy steel materials, metal tool shredding process, fully CNC machining technology, and workmanship guarantee transmission installation. Sixth generation of (modern) shredders:- The high-tech high-series multimedia grinder currently has the high-tech content that can be used to break CDROM, floppy disk, tape, video, etc. and the built-in button panel with a protective film ensures the function of the way forward, rewind, stop, and full stop. We pay priority in the western world to taking care of the standard of life.

I.M. Sanjay Kumar, et al. his design and development of Shredder machine emphasis on cutting of coconut leaves, areca leaves, and this sliced powder used to prepare the vermin compost. The waste shredder machine is designed to diminish agro waste and create it a useful nourishing fertilizer. Agriculture is one of India’s most significant economic sectors. The cultivation of coconut palms is one of the main livelihoods of Kerala and Karnataka farmers. It has been realized that large quantities of agricultural waste remain unused because they are handled, stored and managed.
This system is used to break the plastic into tiny parts in sporadically shaped drops that can be stored for further processing, which helps to produce new plastic products. Reused plastic parts are cared for in an extrusion machine where wire can be shaped like plastic called fiber and used in a 3D printer [5].

Cristian Pedraza et al., In this article, the complex force conditions of the crusher the stress characteristics and fatigue life of the blade were analyzed by the transient finite element method of analysis. The maximum stress distribution law of the shredder blade was found and revealed the mechanism of fracture of the deformations resulting from the stresses to which they are subjected. In addition, the reliability of the results of the simulation was verified by the experiment. It was found that when the blades were turned with a speed of 268 RPM, the maximum tension of the se is higher than other speeds. Comparison of two working geometries and three construction materials and criteria were established based on the results obtained from the simulations to choose the optimum blade that performs the best possible functionality [6].

M. Sakthivelet al., in his research the design and analysis of sharp edges of twin shaft shredders has taken ito account. The twin shaft shredder machine is designed using PRO-E and CREO software and the effective analysis of the intended model is performed with the twin shaft shredder model selected from disproportionate hardware designs of gear manufacturing firms. In this model 16 sharp edges are used and usually material is used for the cutting edges is 20MnCr5 steel heat treated under mined compound. Currently we are switching the material to EN36, EN19, and EN31 & EN8. In this view, the model is investigated the displacement, prompted max stress and worried about shear for both materials under the same load [7].

Sekar Ravi, the objectives of this work is to understand the value of plastic shredders for what they do, to understand that when plastics are crushed the work can be done quicker and more effectively. The use of machinery is important for industry, which is why this machine would be built to provide the organization with more effective production and make plastic garbage more effective at the time of operation [8].

In this paper the shredder blade is optimized for better grinding of the plastic waste into fine grained particles. This optimization leads to requires less labor work and there is no requirement of skilled labor in industry. In recycling, process of plastic waste required low energy due to compact form of plastic waste. It reduces the process time in industry. The machine used in this project is less of cost and thus the project is a cost effective one.

2. Methodology and problem statement

As the usage of the shredder machine for braking the various materials like paper, plastics, agriculturalwasteandsomemetalandruberparts.Duetothiscrushingoftheshredderblades due to the friction the problem of vibration and noise occurs which is high due to the material crushing hence the loosening of the assembly of the shredder blade assembly and wear of its blades are more hence here we are going to check the vibration and noise generation and suggest for the reduction of this factors.

2.1 CAD model and Analysis

Before going for the actual fabrication of the shredder machine parts assembly and the types of shredder blades it may be modeled by using the software which can be visualized as a 3D model using the CAD software CATIA V5 and can be checked for the deformation of the blades when they are crushing the materials here we are going to consider mainly the
mobile phone which mainly consist of the plastic and mother board that is made of silica that can be checked for the vibration and noise generation the natural frequency of the machine can be found and the stress can be obtained. There are shredders intended to give material decrease through a scope of reusing applications, which incorporates plastic reusing, e-waste reusing, salvaged material, tire reusing, farming waste and wood reusing. The destroying procedure produces crude material to be re-brought into assembling, just as completed items, for example, scene covering. Different terminologies are utilized to portray size decrease gear, including processors, shredders, granulators and hammer factories. so their main principle work is to lessen the size of a given material [9]

The shredder system is then used for shredding, i.e. transforming waste from macro-farming and food waste into a compact, easily decomposable type that can be used as organic manure. The waste of smaller size can decompose faster than the waste of large or macro size. Such decomposed waste can be used for crops, thereby increasing crop growth and efficiency, as well as increasing soil chemical properties such as plant nutrient supply and retention, and fostering chemical reactions [10].

We designed the shredder blade as a model and made it in one of the design software known as CATIA. The rendered image of the model shredder blade and the drafted ones are shown in figure 1 and figure 2. The model is created using the CATIA V5 software according to the dimension shown.
The thickness of the blade is assumed to be 20 mm. Additionally, the blade and the shaft are modeled as shown in Figure 3, and the assembled view of the 10 blades in the shaft is shown for the proposed fabricated view in Figure 4.

**Fig. 3** Mounting shaft of the shredder

**Fig. 4** Assembled view of the blade on shaft

### 3. Results and Discussion

As we are interested in the analysis part as a continuation of the model created, the static analysis shows the von Mises stress to the applied force here we are assumed with a force of 1500N to be acting at the edge and the stress values shown in Figure 5 and similarly the deformation also shown in Figure 6 for the corresponding forces apart from these two factors. The values obtained for stress, strain, and deformation due to the 1500N force acting on the shredder are shown in the Table 1.

**Fig. 5** Static analysis – von Mises stress

**Fig. 6** Static analysis - displacement
Table 1. Results obtained by Static structural method

| Result                              | Maximum Value | Minimum Value |
|-------------------------------------|---------------|---------------|
| Stress (Equivalent von-Mises)       | 1.64 e8 N/m²  | 1.15 e5 N/m²  |
| Strain (Equivalent Elastic Strain)  | 1.0241e-5     | 1.0838e14     |
| Total Deformation                   | 0.0378mm      | 0 mm          |

The frequency analysis is one of the major problem to be analyzed as during the process of crushing the plastic or fiber parts due to the friction the vibration of the assembly which affect the blade profile and the noise is generated which is annoying and in the long term if the same practice is to be carried out due to the vibration, the crushers may be damages and loose their life and functionality, here in the Figure 7 shows the vonmises stress due the frequency and the changes for frequency value shown in Figure 8. It is been identified that the thickness of the blade is an important criteria in the generation of the vibration and noise and the reason for identifying eh natural frequency of the blade which helps in optimizing the blade thickness and the vibration level.

![Fig.7 Vonmises stress during frequency analysis](image1)

![Fig.8 Frequency distribution](image2)

4. Conclusion

In the above task of the shredder machine blade vibration it is observed that the cutting edge are sharper which is the existing one and it is been observed that the breakage and wear of the edge occurs. Also the frequency analysis shows the vibration is more near to its periphery due to the thickness of the blade is lesser and hence an increased thickness up to 25mm with the coating at the cutting edge is suggested to decrease the vibration which gives room for the noise generation and the life of the blade may be increased. Here we are using only the cast iron blade with the nickel coating.
5. Reference

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