International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

Design and Fabrication of Plastic Bottle Shredder

Jaypalsinh Rana[1] Sahil Shah*[2], Mit Shah[3], Mikul Prajapati[4], Harshil Mehta[5]

[1]*Assistant Professor, Department of Mechanical Engineering, Indus University, Ahmedabad, India*

[2,3,4,5] *Final year student, Department of Mechanical Engineering, Indus University, Ahmedabad, India*

Abstract – *One of the most vital assets for humanity at present is plastic. Both the water and food packaging industries extensively use plastic in their products. Plastic waste management needs to be of utmost importance as plastic waste is not congruent at all places. Plastic continues to threaten the quality of our land, water, and air. More than 40% of this quantity is disposed of unsafely. Plastic disposal in rural areas needs to improve as people in the rural area lack correct guidance and a sense of plastic waste disposal. Plastic does not decompose at all. At present, the available shredder machine is too heavy and costly. Hence in our project, we choose to design and development of the plastic Shredder Machine which is light in weight and less costly. So our intension behind this project is to process plastic waste as cheap as possible by cutting where it is made for reducing labor work which results in cost reduction. In this project there describes the experimentation of plastic bottle cutting machines and analysis of mechanism used in the machine. A plastic bottle cutter is a machine used for cutting the plastic in small pieces to make waste management easier. We are making this project model for recycling of plastic wastage in the domestic area; industries as well as it can be useful to the scrap collectors. This machine is a solution to the problem of space.*

1. INTRODUCTION

Plastic is one of the widely used materials all over the world and it is also used as a substitute for paper in many other places. The high proportion of plastic used at present is because it is light in weight, durable and inexpensive material. Plastics are used for the wide range starting from packaging, toys, food wrapping and electronics industry. [1] Plastic is difficult to recycle and it also involves a high amount of money in recycling plastics and designing a machine for the same is also difficult. By this project, we aim to reduce the cost of transportation of plastic by shredding it into finer grains which can then be transported to recycling plants in bulk quantities and also at a cheaper rate. A plastic shredder is a machine that is designed and fabricated to cut larger parts into smaller particles which can then be transported easily to the recycling plant, we can consider a shredder as an intrinsic part of the plastic recycling system. [2,3] We got the idea of designing this machine from the scissors working principle of cutting parts into their smaller form. Shredding machine consist of a cutter whose main task is to cut the plastic into smaller form. In this Shredding machine we are not using a belt instead of that we have directly made an assembly of shaft and motors through gears and bearings.

The shredding machine will run on electric power through a motor whose specification is mentioned in Table 1.

1.1 Plastic hazard and problems

Plastic waste disposal is a cumbersome process, also one of the major problems involved in plastic recycling is that repeated recycling of PET bottles can lead to the formation of carcinogenic material and this drawback is the main reason that only a small portion of PET bottles is recycled. [4] Some of the major hazards of using plastic in large quantity are:

1) Plastic tends to remain in our environment for several years it cannot be biodegraded and it just gets piled up.

2) Plastic can cause human health problems such as birth defects, low immunity, and cancer.

3) Groundwater gets spoiled due to plastic.

4) Wildlife existence is greatly affected by the usage of plastic.

5) Plastic spoils our food-chain

6) Different sorts of pollutants are attracted by the use of plastic

7) Plastic costs billions to abate

1.2 Current plastic waste scenario

After China, the largest population in the world is in India around 1.324 billion people which become notable for rapid urbanization and industrialization. Since India is a developing country, the large amount of solid waste is generated daily as people of the village started migrating to cities, resulting in an environment-related problem for cities. Among all solid waste, 1-4% of waste is generated from plastic waste, among which most plastics are coming from household use, food packaging, water bottles, and industrial product. Along with this many of the states in India have a coastal region that hosts many recreational activities sue to which many plastic wastes are generated. Outside villages

and cities, inappropriate dumping of wastes is taking place. Due to this inappropriate action, unhealthy and chaotic condition is created which not only affects the health of people living around it but also creates landfill problems. Finally, it results in major implications regarding the environment conferring the pollution of groundwater.

To reduce plastic consumption, efforts have to be taken considering the use of renewable raw material to innovative products through recent development in technology. Also daily, plastic should be avoided and alternative products should be used which will help to improve the healthy environmental conditions. As the population in India is forecasted to experience unprecedented growth from currently 1.31 billion to 1.65 billion by 2030, the management of plastic waste in rural areas needs innovative solutions to address the challenge. [5]

Commercial production of plastics that started around the 1950s has enjoyed exceptional growth, to reach the present global annual production of 330 million metric tonnes (Mt) for 2016(Plastics Europe, 2017). At the present rate of growth, plastics production is estimated to double human biomass. In packaging or construction two major application areas, impressive success has been achieved by plastics unparalleled by any competing materials. Plastics production is energy-intensive with resins having an embodied energy of 62-108 MJ/kg much higher than for paper, wood, glass or metals(except Aluminium). About 4% of fossil-fuel extracted annually is presently used as raw materials for plastics. By the year 2050 plastics manufacturing and processing may account for as much as 20%of the petroleum consumed globally and 15% of annual carbon emission budget (World Economic Forum, 2016). The most-used synthetic plastic, polyethylene (a type of bio-plastics) can be made by switching to biomass feedstock. Presently a comprehensive data set of municipality-level waste generation data for various countries is not available. We believe the exercise is important as it yields likely global 'hot spots' for plastic waste at present and will progress shortly keeping the limitation of evolving country-level waste generation data into higher-resolution maps of finer granularity in mind. In general, increasing migration into urban areas would exacerbate the developing hot-spots.

1.3 Objectives of the study

1) Studying the machine with different elements such as gear, motor, shaft

2) Designing of shredder and running it with help of gears instead of belt drive.

3) Fabricating a compact and efficient shredder

4) Developing a cost efficient shredder

5) To design different components of machine

6) To carry out analysis of shaft and cutter in terms of stress, strain and displacement

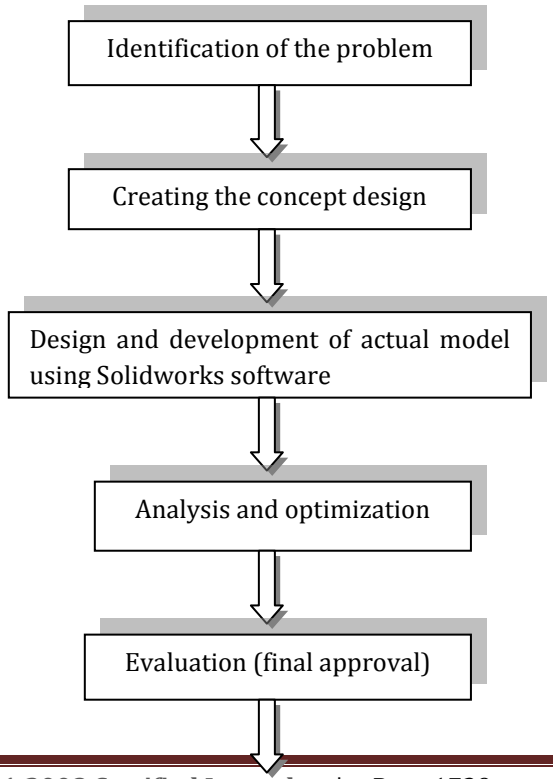
7) To obtain desired result and conclusion

2. COMPONENTS OF THE MACHINE

Table – 1: Parts of the machine

Component	Material used	Quantity
Hooper cover	Mild Steel Grade- IS2062	1
Hooper	Mild Steel Grade- IS2062	1
Cutter	Carbide tip- Mild Steel 2062	14
Bearing	Carbon Steel Ball Bearing	4
Shaft	Mild Steel Grade- IS2062	2
Gear	Mild Steel Grade- IS2062	2
Coupling	Flange Coupling	1
Key	High speed Steel	8
Electric Motor	1.5 HP and 1440rpm	1
Frame	Mild Steel Grade- IS2062	1
Spacers	Mild Steel Grade- IS2062	16

3. METHODOLOGY TO DESIGN MACHINE



Presentation

4. CALCULATIONS

Design of various parts of machine is described below:

4.1) Motor Calculations

A=W*T

A= cutting area made by the edge of the blade

W= width of cutting edge

T= thickness of cutting edge

Motor requirements: 1.5HP, 1440RPM max speed and 1.5 HZ

4.2) Hooper Specifications

450mm * 450mm Upper side at cutter

450mm * 280mm

4.3) Torque exerting on the blade as well as shaft

Torque (T) = Force * Perpendicular distance

4.4) Frame Dimension

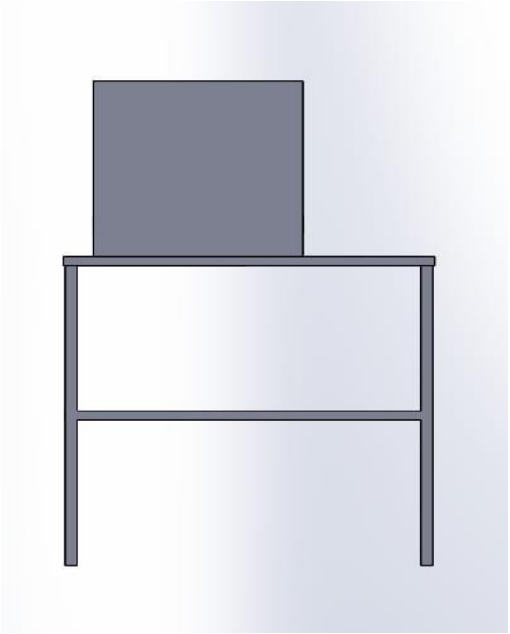


Fig -1 : Frame of machine

Made with Mild Steel(MS) L-type angle

Height: 1m

Length: 400mm * 400mm

4.5) Power required

P = 2*3.14*N*T/60

CHECKING FOR DESIGN SAFETY

Blade material: mild steel (ultimate shear strength= 580Mpa)

Shaft diameter calculations:

Solid shaft diameter:

Shear strength = (16*T)/ (3.14*d)

4.6) Production Rate

R= circumference of cutter*rpm/ length of bottle

Bottle size = 150mm

Cutter circumference = 376mm

RPM= 20

Production rate =50 bottles/minute

Weight of one bottle= 6.4gms (average)

Total plastic chips= 19.2kg/hour of chips

4.7) Cutter design

This is a 4 point cutting tool which we are going to use in our project for shredding plastic waste. The material used for cutter is Carbide tip –Mild Steel 2062. The cutting speed Vc = pi*D*n/1000. The inner diameter of the cutter is 40mm and outer diameter is 120mm. The design of cutter is shown in figure 2.

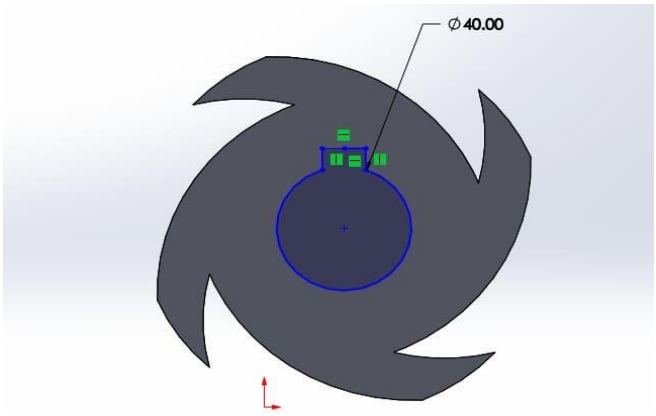


Fig -2: Cutter design

5. ANALYSIS

The shaft and the blade have been analyzed for strength and deformation in ANSYS software. Firstly the shaft and the blade have been meshed by solid mesh type and then various parameters such as cutting force and load are applied. Properties of the material of both shaft and blade are preselected and upon analysis, we can obtain results regarding total deformation, stress, and strain. The result of both studies is presented in Table- 2 and 3.

Table – 2: Result obtained through analysis of shaft

Type	Total Deformation	Maximum Shear Stress	Maximum Shear Elastic Strain
Minimum	0.00mm	2.188e+02N/m^2	4.230e-09
Maximum	4.226e-02mm	3.285e+06N/m^2	1.244e-05

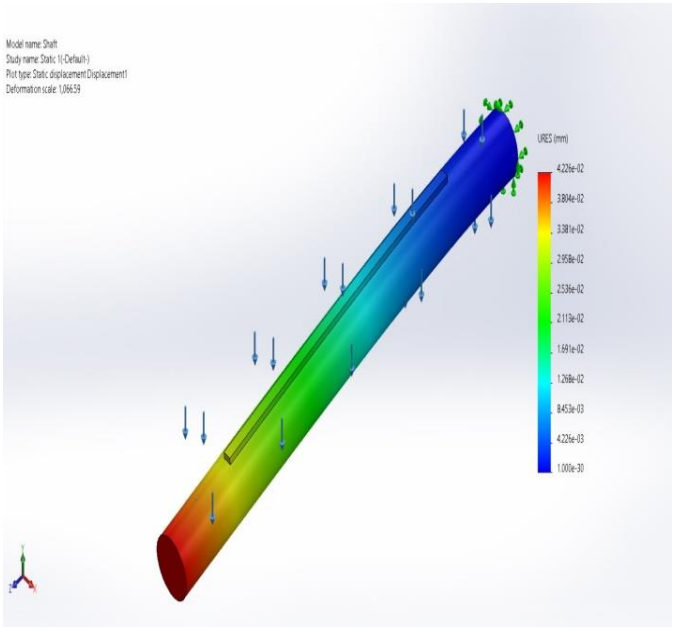


Fig -3: Maximum Shear stress

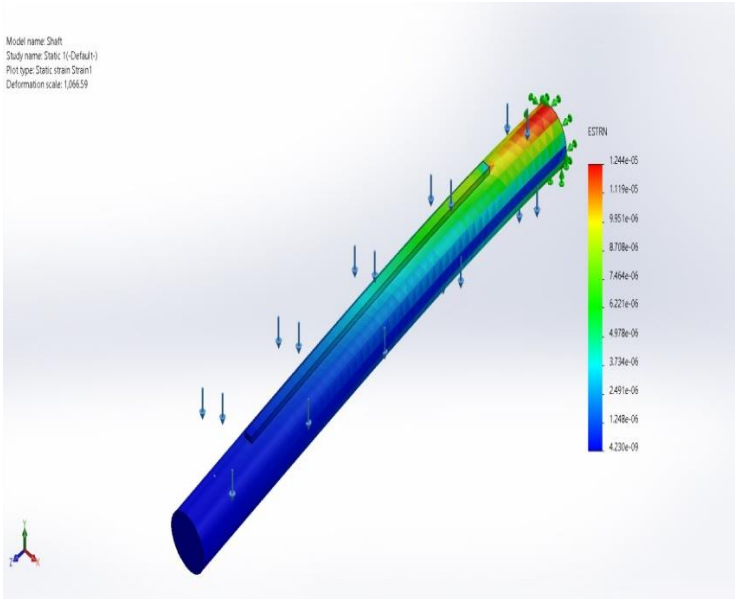


Fig – 4: Total deformation

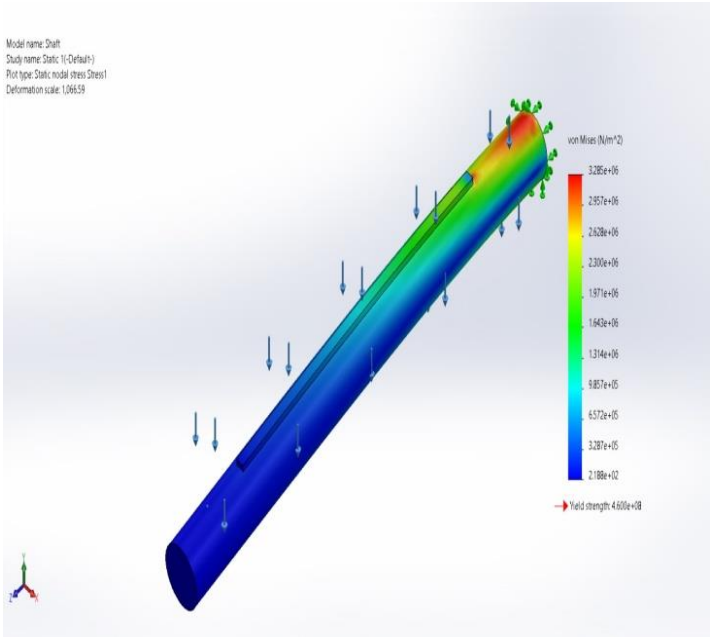


Fig – 5: Maximum Shear Strain

Table – 3: Result obtained through analysis of cutter

Type	Total Deformation	Maximum Shear Stress	Maximum Shear Elastic Strain
Minimum	0.00mm	3.065e+03N/m^2	1.414e-08
Maximum	6.951e-0mm	1.026e+04N/m^2	3.301e-08

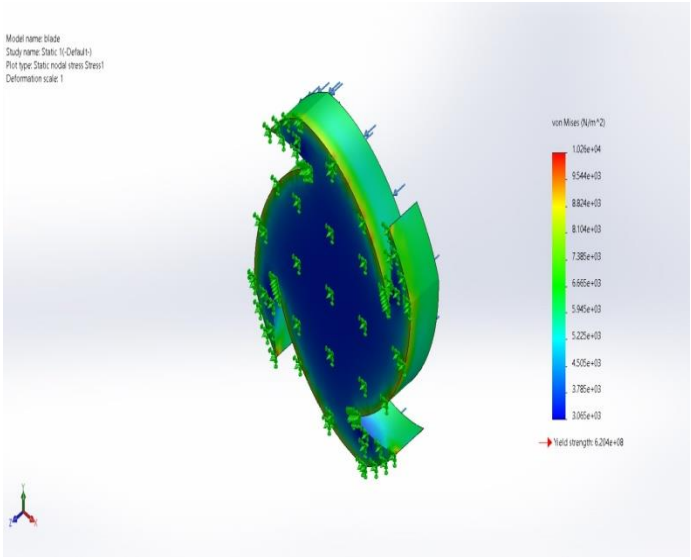


Fig – 6: Maximum Shear Stress

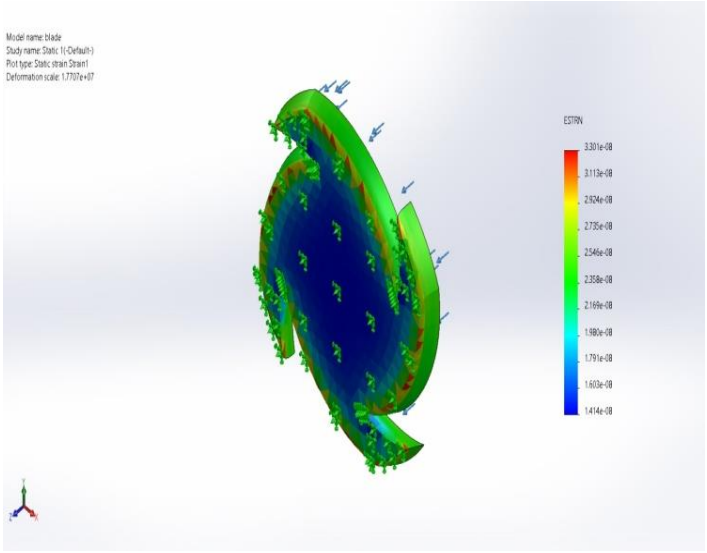


Fig – 7: Total Deformation

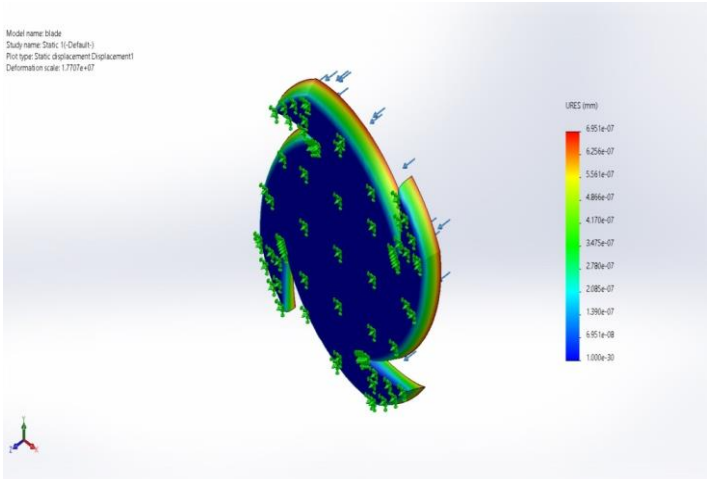


Fig – 8: Maximum Shear Strain

6. DIFFERENT VIEWS OF MACHINE

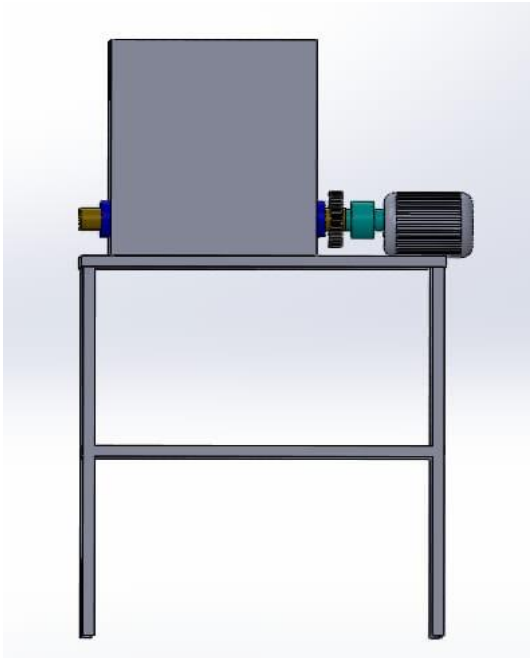


Fig – 9: Side view of machine

This is a side view of our machine in which a motor, a part of shaft, frame, bearings and a box in which cutter is mounted is visible.

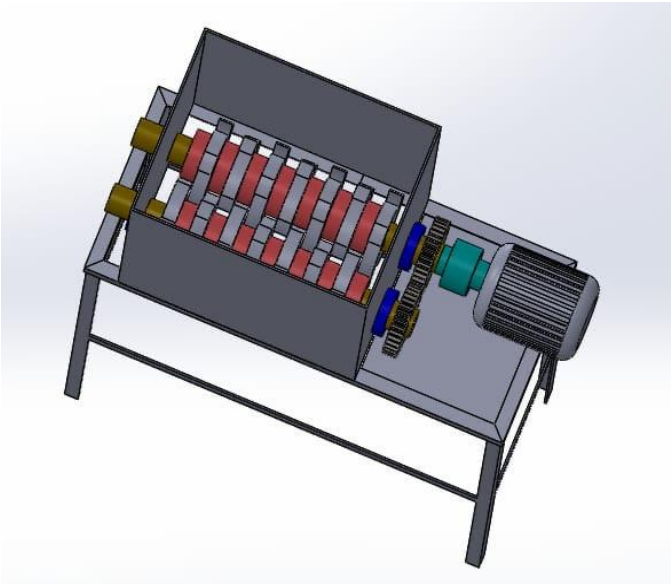


Fig – 10: Isometric view of the machine

This is the isometric view of our machine in which every part of the machine is visible along with frame.

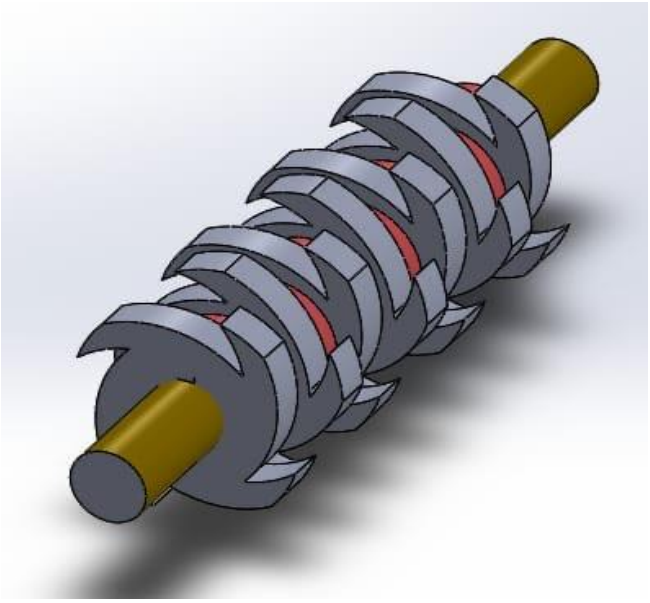


Fig – 11: Assembly of Shaft and Cutter

This is a view of shaft on which 14 cutters are mounted at a standard angle for better cutting efficiency.

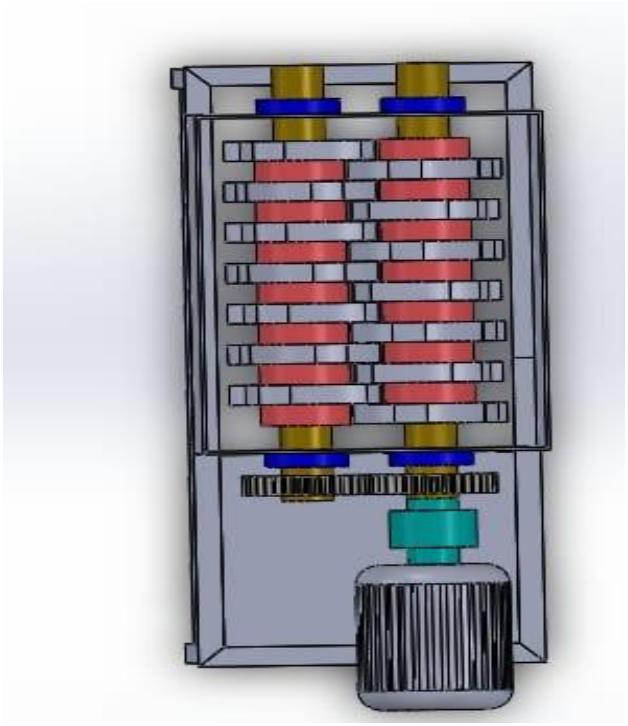


Fig – 12: Top view of the machine

This is the top view of the machine were two shafts used is visible over them are mounted 14 cutters with bearings, couplings, and gears.

7. RESULT

We experimented with three different types of bottle and thus we were able to obtain the result mentioned in Table - 4. The speed of the machine is 20 RPM. From the above result, we can say that enough quantity of chips can then be transported to the recycling plant and recycling cost can be reduced significantly.

Table – 4: Result table comprising of different sized bottles

Type of bottle used	Production rate per min	Weight of the bottle	Total plastic chip per hour(kg)
250Ml	50 bottles	6.41 g	19.2 kg
330Ml	45 bottles	14g	37.8 kg
600Ml	33 bottles	19.71g	39 kg
3 L	21 bottles	45g	56.7 kg

8. CONCLUSION

To conclude we can say that this plastic shredding machine is a great source for plastic waste management. In today's world with increase plastic consumption this machine will prove quite effective in plastic waste management. Also, the cost of this machine is affordable. The main advantage of this machine is that we have not used a belt so there are no chances of a slip of belt and thus the safety of the workers is also considered. Further, the cost of maintenance is reduced as there is no requirement of changing belt over a period of time. Overall this machine will help industries for efficient plastic recycling.

REFERENCES

[1] Krisha Therese T. Pajarillo, Cost efficient Dual Shredder for Paper and Plastic: A Prototype

[2] Akash.B. P, Christina, Darshan.K. S, Manoj, Plastic Waste Management by Mechanical Shredder Machine, IJARIIE-ISSN (O)-2395-4396 Vol-5 Issue-2 2019

[3] Prashanth.P, Mohammed Ali, Kaushik S Patel, Design and Fabrication of Water Bottle Crusher, International Research Journal of Engineering and Technology Volume: 04 Issue: 06 | June-2017

[4] ND Jadhav, Akshay Patil, Harad Lokhande and Deepak Turambe, Development of Plastic Bottle Shredding Machine, International Journal of Waste Resources, Jadhav et al. Int J Waste Resour 2018, 8:2 DOI: 10.4172/2252-5211.1000336

[5] Akash.B. P, Christina, Darshan.K. S, Manoj, Plastic Waste Management by Mechanical Shredder Machine, IJARIIE-ISSN (O)-2395-4396 Vol-5 Issue-2 2019