DESIGN AND FABRICATION OF PLASTIC BOTTLE SHREDDER FOR PERINAD GRAMAPANCHAYAT

PROJECT REPORT

DEPARTMENT OF MECHANICAL ENGINEERING
T.K.M. COLLEGE OF ENGINEERING
KOLLAM-691005, KERALA

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

2019

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CERTIFICATE

Certified that this is a bonafide record of project work entitled **DESIGN AND FABRICATION OF PLASTIC BOTTLE SHREDDER FOR PERINAD GRAMAPANCHAYAT** *submitted by* **AFSAL MOHAMMED. B (TKM15MP005) HARIKRISHNAN. M R (TKM15MP027) SHIBILA. S (TKM15MP050) SREEHARI. S (TKM15MP052)** *during the year* ***2018-19*** *in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Production Engineering of the APJ Abdul Kalam Technological University (KTU).*

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DECLARATION

We, Afsal Mohammed B, Harikrishnan M R, Shibila S, Sreehari S, hereby declare that,

this project report entitled 'Design and fabrication of plastic bottle shredder for Perinad

Gramapanchayat' is the bonafide work of us carried out under the supervision of Prof.

Faraz P Junaid, Assistant Professor, Department of Mechanical Engineering, T.K.M.

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declare that, to the best of our knowledge, the work reported herein does not form part of

any other project report or dissertation on the basis of which a degree or award was

conferred on an earlier occasion to any other candidate. The content of this report is not

being presented by any other student to this or any other University for the award of a

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ACKNOWLEDGEMENT

We take this opportunity to express our deep sense of gratitude and sincere thanks to all who

helped us to complete the project successfully.

We are deeply indebted to our guide **Prof. Faraz P Junaid**., Assistant Professor, Department

of Mechanical Engineering and co-guide **Dr. Nizar Hussain M**, Associate

Professor,

Department of Mechanical Engineering for their excellent guidance, positive criticism and

valuable comments. We are greatly thankful to **Dr. Mohammed Sajid N. K**, Head of

Mechanical Engineering Department for his support and cooperation. We are thankful

Dr. K K Abdul Rasheed , Former Head of Mechanical Engineering Department for his

support and cooperation. We are thankful to our Senior Advisor, **Dr. Nizar Hussain M**,

Associate Professor, Department of Mechanical Engineering for his great support and

guidance throughout our project. We are thankful to the staff of Mechanical Engineering

Workshop for their strong support throughout our project. We are also thankful to the

teaching and non-teaching staff of T.K.M. College of Engineering who have supported us for

the successful completion of our project.

Finally we thank our parents, friends, near and dear ones who directly and indirectly

contributed to the successful completion of our project.

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Shibila S

Sreehari
S

ABSTRAC
T

Plastic is one of the most commonly used material in the world today. Most of the plastic

materials used nowadays are non-biodegradable or it takes decades to degrade. This leads to

an increase in the amount of plastic waste in the environment. Recycling is an important

approach currently followed to reduce the impact and represents one of the most dynamic

areas in the plastic industry today. Machinery available to shred plastic waste are very costly

and bulky. This project is in collaboration with Perinad Grama Panchayat, as a part of the

government initiative to reuse the plastic in road construction.. This project aims to design

and fabricate a plastic shredding machine, which is cheaper and user friendly than the existing ones as per the customer requirements. This project also focus to minimise the pollution due

to plastics in Perinad Grama Panachayat, to improve the transportation of waste plastic (PET)

bottle by reducing its volume, and to ensure that bottles are not used beyond its shelf life.

Keywords : Plastic, Machine,
Shredder

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CHAPTER 1

INTRODUCTION

1.1. OVERVIEW

One of the prevalent environmental problem encountered in most developing

countries is Solid Waste Management .Municipal Solid Waste is mainly characterized by

paper, vegetable matter, plastics, textiles, metals, rubber and glasses. MSW management is

gradually becoming a plague that requires immediate attention for optimum protection of

public health and environment. In recent times, studies have shown that apart from the

environmental pollution and contamination of ground water by organic waste, plastic waste

such as polyethylene terephthalate (PET) bottles is one of the waste management problems

hampering the developmental and aesthetical state of our environment as a result of its

indiscriminate disposal. Polyethylene terephthalate is a polyester made from terephthalic acid

(a di-carboxylic acid) and ethylene glycol (a di-alcohol) through the process of

polymerization. Since the Introduction of PET bottles over 60 years ago, it has been a means

of packaging water, juices, carbonated soft drinks, edible oil, liquor, chemicals etc. However

manufacturers as well as consumers have grown increasing interest in the use of PET bottles

due to a number of reasons .In attempt to prevent sharing of drinking cups and maintain

hygiene, PET bottles became widely acceptable because they are disposable, cheap,

lightweight and made of durable materials which can readily be mouldedinto different shapes

and sizes relevant to a wide range of applications.

As a result of the world's increasing population which is about 7 billion people, there

has been a high tendency for empty PET bottles to increase. The global PET packaging

market was worth $48.1 billion in 2014, amounting to almost 16 million tons according to a

new market report.Demand for PET packaging is expected to increase by an average of 4.6%

annually over the next five years, and will amount to 19.9 million tons, worth $60 billion by

2019. With overall PET packaging consumption of 15.4 million tons in 2013, PET bottles

for beverages accounted for over 80% of overall sales at 12.5 million tons(up to 3.7% on

2012). In 2013, bottle water became the largest category for PET packaging; sales of PET

water bottles grew by 7.3% reaching 5.45 million tons. This statistic poses a great

environmental risk as a result of the fact that bottles made of polyethylene terephthalate (PET)

material is non-biodegradable and can spend millions of years in the ground with little or no

decomposition . The huge quantities of PET bottles currently being marketed and consumed

possibly find their way into waste dumpsites, and this creates serious environmental problems.

One of the solutions proposed was in utilizing waste environmental plastic in road construction. The experimentation at several institutes, private organizations indicate that the

waste plastic, when added to hot aggregate bituminous mix will form a fine coat of plastic

over the aggregate and such aggregate, when mixed with the binder is found to give higher

strength to the road, higher resistance to the water and better performance of the road over a

period of time. Waste plastic such as carry bags, disposable cups and laminated pouches like

chips, pan masala, aluminium foil and packaging material used for biscuits, chocolates, and

milk and grocery items can be used for surfacing road. PET bottles crushing machine is that

which performs the function of crushing PET bottles or plastic materials into granules or

shreds for recycling and production of new products rather than using virgin raw materials

for production. From the a fore mentioned points of view, crushing of PET bottles for

recycling is cheaper than manufacturing the bottles from virgin raw material, and can also

help in controlling the waste disposal problems ravaging the environment particularly in

developing countries. For this reasons, there is a need for expansion of plastic recycling

programs as well as cheaper machines to handle the problems associated with plastic waste

management particularly PET bottles which has a wide range of application worldwide.

The available PET bottle crushing machines are very costly and mostly does not

satisfy customer requirements. This study is focused on the modification of design of a

crushing machine for handling of used PET bottles. We are planning to design a plastic

shredding machine for PerinadGrama Panchayat which is cheap and user friendly.To design

a plastic shredding machine we need to compare various plastic shredding machines

availiable and the different components present in it.

1.2. Background and Motivation

For the last three years we were actively working in Perinad Grama panchayat in the

field of health, education and environmental conservation. As part of World Environment

Day 2018 Campaign by United Nations Volunteers India on the theme "Beat Plastic

Pollution" we had organized several campaigns on the Panchayath. During discussions with

the authorities we came to know about the plastic shredding unit in the panchayath. We visted

the unit and helped them in their work. We came to know about the problems faced by them.

During the discussion about the final year project we decided to solve their problem. We

visited another plastic shredding unit at Mayyanad. They also had similar problems. Thus we

decided to fabricate a customized plastic shredding machine.

1.3. Objectives

From the reports and field studies it was understood that the plastic shredding machines

currently available are very costly and not user friendly. Also there was a requirement of a

PET bottle shredding machine at Perinad Grama Panchayat for crushing of PET bottles.

To summarize, the main objectives of the project were to:

- Effective plastic disposal and recycling.
- To design a plastic bottle shredder to improve performance, output quality,

  assembly and/or user-friendliness.
- To fabricate a working model of the machine.
- To Shred Plastic bottles into various sizes.
- Optimize building cost.

1.4.Scopes

The project ranged from the complete study and testing of plastic shredder at different places to the development of a new design of the shredder. Ultimately, the goal was to build a physical and functioning version of the new design of the shredder.

- Improves transportation of plastic wastes.
- The shredded plastic can be used in the construction of roads, pavements etc.
- The shredded plastic residue can be used in the manufacture of new products.
- Ensure plastic bottles are not used beyond its shelf life.
- Fabricate plastic shredding machine to panchayats as per requirement.
- Install plastic shredding machine in all public places, hospitals etc.

CHAPTER-2
LITERATURE SURVEY

2.1.
Overview

In the field of designing the plastic bottle shredder machine, various works had

already been done. Some of the works related to the designing and fabrication of such

machines had been mentioned
below.

2.2. Works done in the field of designing plastic shredder machines

Designed and manufactured a Plastic Bottle Crusher which is portable compact and

manually operating. He determined the crushing force that is required to crush a plastic bottle

as experimentally, and found that it is well within the range of the force that can

ergonomically be applied by an average human. The machine was then designed on the basis

of the load required to crush the bottle. The tentative design and dimensions of machine

components was then taken for fabrications. The Manufacturing difficulties brought further

changes in the design. In the next stage of process testing was carried out on the Machine.

The Machine thus designed has the agility to crush Bottles of different dimensions as

observed in the Testing and Experimentation phase. Experiments were also conducted on

crushing of Cans. On an average the Machine reduces the volume of bottle to 49% of the

initial volume. It was found that the machine is capable of crushing cans as well with some

appropriate positioning of can (Yeshwant et al.,2014).

Proposed a design for Plastic bottle shredding machine, in which cutting blades are

made up of mild steel and used two teeth spiral type blade. Both side of the shaft are mounted

in ball bearing, with a total length of (shaft) 595 mm with diameter of 45 mm. Here the proposed design uses a single shaft for rotating cutter and achieved a volume reduction of

50% (N.D Jadhav 2018).

Designed a Plastic recycling system, which combines both shredder as well as

extruder. Shredder is designed with a three teeth blade rotor cutter and two stationary cutter

blades. Here used .5 hp motor as the power source and power is transmitted with Belt-Pulley

arrangement. Crushed plastics to a size of .5 – 1 cm, experimentally he concluded that product

flow rate of HDPE increases with motor speed (Dr. Jassim et al.,2016).

Developed a polythene recycling machine from locally available materials. He adopted a

mechanism of fixed and rotary blades for slitting the loaded wastes. The rotary blades are

rotated by a single phase high speed electric motor and the friction generated provides the

heat required to soften the plastic waste charges. Belt and Pulley arrangement is used for

power transmission. And concluded that the recycling machine produces an average of 35 kg

of small flakes of recycled waste per hour at a machine speed of 2880 rpm. (MI Fayyaji 2017)

designed and developed a plastic shredding machine and he used N8 steel for making blade.

This machine is not designed for plastic bottles and he says in report that with the same

machine of plastic shredding, bottles cannot be shredded. Here also .5 hp Electric motor with

1440 rpm is used as the power source (Andrew et al., 2012).

2.3. Works done in the field of Plastic recycling

Centre for innovations in public systems proposed the "Use of plastics in Road

construction". In that they concluded that Thermoplastics like Polyethylene Terephthalate

(PET), Low Density Poly Ethylene (LDPE), Poly Vinyl Chloride (PVC), High Density Poly

Ethylene (HDPE), Polypropylene (PP), Polystyrene (PS) are recyclable.Plastic-tar roads have

benefits over conventional roads such as the overall reduction in bitumen consumption by

8%, enhanced load carrying strength, reduced wear and tear, prevents release of 3 tonnes of

CO_2 (through disposal by burning) into the atmosphere, increased road strength, excellent

resistance to water and water stagnation, no stripping and potholes formation, enhanced

binding, reduced rutting and ravelling, improved soundness property, negligible maintenance

cost of the road, no leaching of plastics and no effect of UV radiation. So we are planning to

design a shredding machine for PET bottles. In the recycling and recovery routes of plastic solid wastes, the four routes of PSW treatment are detailed and discussed are primary (Extrusion), Secondary(Mechanical), tertiary(Chemical), and quaternary(Energy recovery) schemes and technologies. The secondary method of mechanical is our interest, where scraps are the feedstock and thereby generally reduces its size to a more suitable shape like pellets, Flakes or Powders (Baeyens 2009).

This study presents a detailed characterization of Shredder residues (SR) generated and deposited in Denmark from 1990 to 2010. It represents approximately 85% of total Danish

SR. A comprehensive sampling, size fractionation and chemical analysis was carried out on entire samples as well as on each individual size fraction. All significant elemental contents except oxygen were analyzed. The unexplained “balance” was subsequently explained by oxygen content in metal oxides, carbonates, sulphates and in organics, mainly cellulose. Using mass and calorific balance approaches, it was possible to balance the composition and, thereby, estimate the degree of oxidation of elements including metals. This revealed that larger fractions (>10 mm, 10–4 mm, 4–1 mm) contain significant amount of valuable free metals for recovery. The fractionation revealed that the >10 mm coarse fraction was the largest amount of SR being 35–40% (w/w) with a metal content constituting about 4–9% of the total SR by weight and the <1 mm fine fraction constituted 27–37% (w/w) of the total weight. The lower heat value (LHV) of SR samples over different time periods (1990–2010) was between 7 and 17 MJ/kg, declining with decreasing particle size. The SR composition is greatly dependent on the applied shredding and post shredding processes at the shredding plants causing some variations. There are uncertainties related to sampling and preparation of samples for analyses due to its heterogeneous nature and uncertainties in the chemical analyses results (≈15–25%). This exhaustive characterization is believed to constitute hitherto the best data platform for assessing potential value and feasibility of further resource recovery from SR (Nassera Ahmed, Henrik Wenzel, Jette B.Hansen, 2014).

CHAPTER 3
METHODOLOGY

3.1.
Introduction

Firstly, by conducting a field visit, the problems of the existing plastic shredding

machine and the feedback from operating workers were collected. Fig 3.1. Shows the details

of field visits conducted at various plastic shredding unit. Then through literature survey the

technical side and various innovations made in this field were identified. Brainstorming

sessions were conducted and generated various design concepts. All the generated designs

were critically evaluated and found the best feasible solution. After finalizing the concept, general layout of the proposed design was made.

Second stage involves the engineering calculations of the individual parts in plastic shredder machine. Utilizing the machine design theories, calculations, individual part dimensions, and required material was determined. Modelling and assembly of parts need to be completed using softwares like solid works, Auto Cad, Ansys. Along with that, the raw materials required is to be purchased. Using the production drawings parts will be fabricated using college workshop facilities. In the manufacturing of cutter EDM facility will be made useful. Similarly CNC Milling machine, Lathe, Drilling Machine..etc are planned to use in the manufacturing phase. Finally parts will be assembled to form the machine.

Fig 3.1 Field study results

3.2. PROJECT PLAN

The purpose of this chapter is to give insight into the methodology used during the course of

the project. The actual building of the machine involved several manufacturing steps that we

lacked practical experience with and so had to be done in part by the workshop supervisors.

The project plan in the form of gantt chart is attached in here.

Fig 3.2 Project
Schedule

3.3. PRE-STUDY

3.3.1. Industrial Shredders

By investigating a multitude of different industrial shredders I realized that they all build on the same principle, with different configurations of two key aspects based on the application of the machine.

3.3.1.1. Shafts

The most basic disparity between the different designs is the number of knife shafts. Most of the shredders studied were either single or double shafted but some heavy duty ones were even made with four. The obvious advantage of having several knife shafts is of course that the number of cutting actions at any given time increases with the number of shafts which increases the speed of the process. The major advantage with several shafts, however, seemed to be a noticeable increase in instability to pull material through the machine.

Fig 3.3 Four shaft
Shredder

**3.3.1.2.
Knives**

The second attribute that usually differs is the design of the knives themselves. This is highly

dependent on the application they are to be used for. Heavy-duty shredding such as cars,

engine blocks, transmissions and other large metal pieces require the knives to be thicker and

smaller, coupled with a slower speed to increase torque. The number of teeth also affects the

performance of the machine. More teeth mean faster cutting; but it also increases the risk of

the object to be shredded skipping on top of the knives, as well as the risk of clogging the

machine and thus forcing a reverse of the spin direction. If the knives have too many teeth

the machine may not be able to shred tougher objects as more teeth will be engaged at any

time. Most machines use one of the two tooth designs with minor variations. The first is in

the general shape of a hook where the cutting edges are square. Typically, the hook is made

with a straight cutting edge and a straight or rounded supporting back, as seen in Figure

3.4.used a curved cutting edge instead. The other type uses triangularly shaped teeth and

similarly shaped counter knives, see
Figure 3.4.

Fig 3.4 Industrial shredder
knives.

Fig 3.5 Triangular teeth and counter knives.

1
3

As seen in Figure 3.4.many high end shredding machines use easily replaceable cutting edges

to improve maintenance and longevity. There are a few other variations typically adapted to

the specific task they perform. One such is a paper shredder. As the main purpose is not only

to reduce it to smaller pieces but also to destroy the information contained on it, the paper

needs to be reduced to small enough pieces that the text and images become unintelligible.

As the paper does not cause much resistance, these machines can be designed with a larger

amount of blades that are much thinner. If shredding the papers into strips is enough, a simple

dual-shaft design with completely round knives would suffice.

Fig 3.6. Paper shredder with hook knives.

CHAPTER 4 DESIGN OF PLASTIC BOTTLE SHREDDER

4.1. POWER SUPPLY

UNIT

4.1.1. Electric Motor Selection

Ultimate Tensile strength of PET plastics = 65 Mpa [5]

Fig 4.1. Cutter

Here the Shredder blade uses shear, to cut the plastic material. So here the stress generated

due to cutting blade action should be equal or more than the strength of the material.

Let $\mathbf{F_b}$ be the force exerted by the blade on the plastic material and **A** is the cross sectional

area where the blade makes contact with the plastic material. Assume the area as a rectangle

shape.

Max. Shear Stress of the Material = 80 % Tensile strength

=.80×65 =52 Mpa

$\frac{F_b}{A} = \tau$ (4.1) Area=**A**= $1.5 \times .30 \times 10^{-4}$

$\mathbf{F_b} =$

$\tau \times A = 52 \times 10^6 \times 1.5 \times .30 \times 10^{-4} = 2340$ N

Radius of the cutter =R= 5
cm=.05 m

Torque(T) = $F_b \times R = 2340 \times .05 = 117$
Nm Speed of cutter blade N = 30 rpm

1
5

$$P = \frac{2\pi NT}{60} \quad (4.2)$$

$$= \frac{2\times\pi\times30\times117}{60} = 370 \text{ w}$$

1 hp = 746 w

So here, P= .5 hp
Considering the safety factor as 2,
Then ; P = 1 hp
So our required motor is of min. 1 hp power

4.1.2. Power Transmission

Shredder blades shreds the material by shearing, here it needs more torque than its speed.
Hence we need to reduce the speed of the shredder thereby increase the torque. Various
reduction methods are available, so we made a study and finally selected REDUCTION GEAR mechanism for power transmission.
The comparison made between these methods can be summarized as follows.

4.1.2.1. Belt Drive

A belt is a looped strip of flexible material used to mechanically link two or more rotating shafts. A belt drive offers smooth transmission of power between shafts at a considerable
distance.

Fig 4.2 Belt drive

Advantages of Belt Drives:

- Belt drives are simple are economical.
- They don't need parallel shafts.
- Belts drives are provided with overload and jam protection.
- Noise and vibration are damped out. Machinery life is increased because load fluctuations are shock-absorbed.
- They are lubrication-free. They require less maintenance cost.
- Belt drives are highly efficient in use (up to 98%, usually 95%).
- They are very economical when the distance between shafts is very large.

Disadvantages of Belt

Drives:

▪ In Belt drives, angular velocity ratio is not necessarily constant or equal to the ratio of pulley diameters, because of slipping and stretching.

▪ Heat buildup occurs. Speed is limited to usually 35 meters per second. Power transmission is limited to 370 kilowatts.

▪ Operating temperatures are usually restricted to –35 to 85°C.

▪ Some adjustment of center distance or use of an idler pulley is necessary for wearing and stretching of belt drive compensation.

4.1.2.2. Chain Drive

Chain drives are positive drives there is no slip, hence the velocity ratio remains constant. Chain drives are suitable for small centre distances and can be used generally up to 3metre but in special cases even up to 8 meter.

Fig 4.3 Chain
Drive

Advantages of Chain
Drive**:**

- Positive non-slip drives
- Efficiency is high
- Employed for small as well as large centre distances up to 8m.
- Permit high velocity ratio up to 8:1
- Transmit more power than belt drives
- They produce less load on shafts compared to belt drives
- Maintenance is low

Disadvantages of Chain
Drive:

- Driving and driven shafts should be in perfect alignment.
- Requires good lubrication

• High initial cost

4.1.2.3. Gear Drive

Gear drives find a very prominent place in mechanical power transmission. Gear drives are preferred when considerable power has to be transmitted over a short distance positively with a constant velocity ratio.

Fig 4.4 Gear Drive

Advantages of Gear Drive:

- They are positive non-slip drives.
- Most convenient for very small centre distances.

- By using different types of gears, it will be possible to transmit the power when the axes of the shafts are not only parallel, but even when nonparallel, intersecting, non -intersecting and co- planar or non-coplanar.
- The velocity ratio will remain constant throughout.
- Any velocity ratio as high as, even up to 60:1 can be obtained.
- They have very high transmission efficiency..

Disadvantages of Gear Drive:

- They are not suitable for shafts of very large centre distances.
- They always require some kind of lubrication.
- At very high speeds noise and vibrations will be more.
- They are not economical because of the increased cost of production of precision gears.
- Use of large number of gear wheels in gear trains increases the weight of the machine.

Using the above data and survey conducted, a decision matrix is prepared, as per the result; gear box with a ratio of 50:1, selected for power transmission.

Table 4.1. Decision Matrix (Power transmission)

4.2. SHREDDER SUB-PART

Shredder sub part (SSP) includes Knives, Counter Knives and its assembly with

power transmission module. In this part the shredding of plastics taking place, so the design

of which carry an importance.

Shredder Box inner dimensions = 30 cm x 20 cm

4.2.1. Knives and Counter Knives

Combination of Knives and counter knives will increase the cutting action. As per the

requirement it is here custom designed. Fig 4.2.1 Shows arrangement of knives and counter

knives

.

Fig 4.5. Knives (Grey) and Counter knives (Red) (Precious plastic.com)

In knives selection we considered mainly three different types of cutter, and made a selection using decision matrix.

Fig 4.6. a) Two teeth blade b) Three teeth blade c) Multi teeth blade

Factors Cost Reliability Cutting
Efficiency
Design simplicity
Cutting cycle time
Safety Weighted
score Customer weightage 20 % 25% 20% 15 % 10% 10 % 100% Two teeth blade 4 3 2 4 2 3 3 Three teeth blade 3 4 3 3.5 3 3 3.35 Multi teeth blade 1 3.5 3.5 2 3.5 1.5 2.6

Table 4.2 Decision Matrix (Blade)

With the available information a comparison study is made between the different types of
cutter, then a decision matrix is prepared. From the matrix results it is decided to use a Shredder blade with following specifications;

Number of teeth in the blade = 4
Number of cutting blades per shaft = 6
Thickness of cutting blade = 1.6 cm
Material Selected : **202 STAINLESS STEEL PLATE**

4.2.2. Design of Shaft

Fig 4.7.Sketch of Shaft with blades

Shaft is the member which carries the blades and transmits power from the source with the

help of couplings and pair of spur gear, and they are supported on bearings.
Number of shafts in SSP = 2
Material Selected for Shaft: **EN8/080M40(AISI1040)**, σ = 465 Mpa
According to knives configuration at a time three cutter will exert force on the plastic material for shredding, and the applied force be $\mathbf{F_b}$ F_b= 2340 N (from previous calculations) Length of shaft = 30 cm

Power (P)= $\frac{2\pi NT}{60}$ (4.3) Power = 1 hp, N=30 rpm

Using the equation; Torque on shaft (T) = $\frac{p \times 60}{2\pi N}$ = 240Nm (4.4) Weight of the cutter (W_c) = .8 kg x 9.81 =8 N Weight of the rod = 1.8 kg x 9.81= 18 N
Weight of the gear = .75 kg x 9.81=7 N
22

First consider the spur gear for synchronizing two shafts,

Fig 4.8. Spur gear

Pressure angle of the gear (α) = 20°

Pitch circle diameter of the gear (d_p)= 70 mm =.07 m

$$\tan\alpha = \frac{F_r}{F_t} \quad (4.5)$$

$$T = F_t \times \frac{d_p}{2}$$

$$F_t = 6850 \text{ N}$$

$$F_r = F_t \times \tan\alpha$$

= 2500
N

To find critical section, where the Max. Bending moment acts, bending moment diagram of

Shaft
prepared.

1. Vertical Load Diagram: Here all the loads that acts on the vertical plane of the shaft

   were considered. And from BMD, vertical component of moment (M_v) at each point can be taken out.

2. Horizontal Load Diagram: Here all the loads that acts on the horizontal plane of the

   shaft were considered. From BMD, Horizontal component (M_h) of moment can be determined.

$$\text{Net Moment } (M_R) = \sqrt{Mvx^2 + Mhx^2} \quad (4.6)$$

Fig 4.9A. Vertical Load diagram

From the diagram the BM at each points can be determined as,

$M_{AV} = 0$, $M_{v1}=20.58$, $M_{v2} =47.06$, $M_{v3} = 73.8$, $M_{v4} = 83.4$, $M_{v5} = 129$, $M_{v6} =157$, $M_{vc}= 101$, $M_{vB}=171.6$. M_{AV} = Vertical moment component at bearing A M_{Vi}= Vertical moment component at each blade

2
4
Fig 4.9B. Horizontal Load diagram
M_{hA}= 0, M_{hB}= 62.5, M_{h1} =99.68, M_{h2} = 125, M_{h3} =189, M_{h4} =150, M_{h5} =115,
M_{h6} =90, M_{hc}=130
After calculating the resultant moment at each point,the max. Bending moment acts on the shaft,
M_{max} = 203 Nm Factor of safety = 2
$\sigma\ max = \frac{\sigma yt}{fos}$ (4.7) = 232 Mpa
25
ASME Code for design of transmission shafting:
According to Max. Normal stress theory
$d = [\frac{16}{\pi.\sigma\ max}(CmM + \sqrt{(CmM)^2 + (CtT)^2}) \times (\frac{1}{1-K^4})]^{1/3}$ (4.8)
For a solid shaft $K=\frac{di}{do} = 0$ C_m = Combined shock and fatigue factor applied to bending moment = 2 C_t = Combined shock and fatigue factor applied to torsional moment =2
Solving the equation, d=30mm
So the shaft design can be summarized as;
Material selected : EN8/080M40(AISI1040)
Dimensions : 30 cm, 3 cm (Dia.)
Number of Shafts : 2
4.2.3. Design Of Ball Bearing
Inner diameter = Shaft Diameter =30 mm
Axial load acting on the shaft = 0
Net Radial Load acting on the shaft = Weight of parts + Cutting Force
= 80 + 7020 = 7100 N
Equivalent load acting on one bearing =P = 3550 N
Bearing operating hours =Lh= 18 hours per week for 5 years

=18 x 5x 52 = 4680 hours.
RPM of the shaft = **N**= 24 rpm
Rating life in millions of revolutions = Ln = = 6.8 (4.9)
Ln = (4.10)
Specific capacity = C = 6800 N
Using design data book, Deep grove ball bearing selected : **30BC02 (SKF 6206)**
26

Fig.4.10 Key, Fig 4.11 Ball Bearing

4.2.4. DESIGN OF KEY

Shaft diameter = 30mm

Torque = 240Nm

Using design databook,

Width of the key = d_4 = 8 mm Thickness of the key = d_6 = 5 mm it can be standardised as, (Design data book)

w = 8 mm, t = 8 mm

Considering for one cutter blade;

Tangential force applied = F =

2340 N

Shear strength required = = = 39 Mpa

(4.9
)

Selected material same as shaft Material EN8D

4.2.5 Specification of spur gear

Material : Cast Iron

Outside diameter : 85 mm

Module : 2.5

Tooth depth : 6 mm

Pressure angle : 20

Addendum : 2.5 mm

Dedendum : 3.5 mm

Number of Teeth : 32

Fig 4.12 Spur Gear

CHAPTER 5 MODELLING & ANALYSIS

5.1. CAD/CAE

Computer aided design or CAD has very broad meaning and can be defined as the

useof computers in creation, modification, analysis and optimization of a design. CAE

(ComputerAided Engineering) is referred to computers in engineering analysis like stress/strain, heat transfer and flow analysis. CAD/CAE is said to have more potential to

radically increase productivity than any development since electricity. CAD/CAE builds

quality form concept to final product Instead of bringing in quality control during the final

inspection it helps to develop a process in which quality is there through the life cycle of the

product. CAD/CAE eliminate the need for prototypes. But it required prototypes can be used

to confirm rather product performance and other characteristics. CAD/CAE is employed in

numerous industries manufacturing, automotive, aerospace, casting, mould making plan

general-purpose industries. CAD/CAE systems can be broadly divided into low end, mid end

and high-end systems.

Low-end systems are those systems which do only 2D modelling and with only little 3D

modelling capabilities. According to industry static's 70-80% of all mechanical designers still

uses 2D CAD applications. This may be mainly due to the high cost of high-end systems and

a lack of expertise. Mid-end systems are actually similar high-end systems with all their

design capabilities with the difference that they are offered at much lower prices. 3D solid

modelling on the PC is burgeoning because of many reasons like affordable and powerful hardware, strong sound software that offers windows case of use shortened design and

production cycles and smooth integration with downstream application. More and more

designers and engineers are shifting to mid end
system.

High-end CAD/CAE software are for the complete modelling, analysis and manufacturing

of products. High-end systems can be visualized as the brain of concurrent engineering. The

design and development of products, which took years in the past to complete, If now made

in days with the help of high-end CAD/CAE systems and concurrent engineering.

5.2 MODELING

Model is a representation of an object, a system, or an idea in some form other than that of

the entity itself. Modeling is the process of producing a model; a model is a representation of

the construction and working of some system of interest. A model is similar to but simpler

than the system it represents. One purpose of a model is to enable the analyst to predict the

effect of changes to the system. On the one hand, a model should be close e real system and

incorporate most of its salient features. On the other hand it should not be so complex that it

is impossible to understand and experiment with it. A good model is a judicious tradeoff

between realism and simplicity. Simulation practitioners recommend increasing the

complexity of a model iteratively. An important issue in modeling is model validity, Model

validation techniques include simulating the model under known input conditions and

comparing model output with system output. Generally, a model intended for simulation

study is a mathematical model developed with the help of simulation software. Software used

for modeling was Solid Works.

5.2.1 Solid Works

SolidWorks is a solid modeler, and utilizes a parametric feature-based approach which was

initially developed by PTC (Creo/Pro-Engineer) to create models and assemblies. Parameters

refer to constraints whose values determine the shape or geometry of the model or assembly.

Parameters can be either numeric parameters, such as line lengths or circle diameters, or

geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc.

A model in SolidWorks usually starts with a 2D sketch. The sketch consists of geometry

such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added

to the sketch to define the size and location of the geometry. Relations are used to define

attributes such as tangency, parallelism, perpendicularity, and concentricity. The dimensions

in the sketch can be controlled independently, or by relationships to other parameters inside

or outside of the sketch.In an assembly, the analog to sketch relations are mates.

5.3 ENGINEERING DESIGN

Solid Works offers a range of tools to enable the generation of a complete digital

representation of the product being designed. In addition to the general geometry tools there

is also the ability to generate geometry of other integrated design disciplines. We created 3D

Model of this project by using SOLIDWORKS Software.

The models are shown below.

Fig 5.1 Model of Machine

1. Hopper
2. Shredder Box
3. Depositer
4. Motor
5. Gear Box

Fig 5.2 Model of Shredder Box Fig 5.3 Model of Cutter

Fig 5.4 Model of Depositer Fig 5.5 Model of Hopper

5.4 ANALYSIS The alternate arrangement of cutter is shown in Fig 5.6

Fig 5.6 Cutter Assembly

We have done the analysis in Solid works by the following steps;

1. Solid works Simulations

2. Study advisor New study Static study

3. Apply material Mild Steel Close Ok

4. Fixture advisor Fixed Geometry Select the faces

5. External load Force/Pressure/Torque Apply the Force/Pressure/Torque on the required faces

6. Connection advisor Contact set Automatic condition Pick the each part of the model Ok

7. Result advisor Create mesh Result

3
3

5.4.1 Stress Analysis

Force = 2340 N, Torque = 240Nm, Weight of the cutter =8N (Per cutter)

Fig 5.7 Stress analysis of Cutter

5.4.2 Displacement Analysis

Fig 5.8 Displacement analysis of Cutter

5.4.3 Strain Analysis

Fig 5.9 Strain Analysis of
Cutter

5.4.4 Stress Analysis of Shaft

Torque = 240 Nm, Weight = Weight of cutter + Weight of shaft = 78 N

Fig 5.10 Stress Analysis of

shaft

CHAPTER 6 FABRICATION

6.1 PROCEDURE

The manufacturing process in the fabrication of plastic shredding machine includes drilling, milling, welding, grinding, cutting, CNC milling, EDM etc.

Stage 1: The shredder box is constructed using mild steel plate having a dimension of 20mm×25mm×16mm thickness. Pilot holes were drilled on the plate and fixtures were made in order to hold the work piece in CNC milling machine. NX software was used to prepare the code for CNC milling(Annexure I).The plate was machined using CNC milling to a dimension of 15mm×21mm×15mm. A curve of radius 28.56 mm was provided at the bottom to accommodate mesh and bearing holes of diameter 62 mm were machined. A plate was fillet welded on an inside corner to fasten the shredder plate (Fig 6.1, Fig 6.2),30BC02 Ball bearing was installed on the holes.

Fig 6.1 Blank with Dimensions Fig 6.2 Final Product with Dimensions

Fig 6.3 Punching Fig 6.4 Drilling

Fig 6.5 CNC
Milling

3
7

Working Parameters of CNC Milling;

$$V = \frac{\pi \times D \times N}{1000} \quad (6.1)$$

Cutting Speed of M.S. (MILD STEEL) = V = 25m/min (π= 3.1416)
Dia. Of End Mill = D= 15 mm
Revolutions per minute = N= .....rpm

$$N = \frac{V \times 1000}{\pi X D}$$

N= (Vx320)/D
N= (25x320)/15
N = 533.33333rpm
Feed Per Tooth = Fz= 0.065mm
Number of Teeth = Z= 4
Feed = f= .....mm/min
f= Fz x Z x N (6.2)
f=0.05 x 4 x 533.33333
f=138.66667mm/min

Fig 6.6 welding Operation Fig 6.7 Bearing Side

Stage 2: The frame of the main body was made using rectangular tube (2.5"×1.5"). It was

joined together using electric arc welding to a height of 750mm. Foundations for mounting

electric motor, Gear box, Shredder Box...etc were also made on the frame.

Fig 6.8
Frame

Stage 3: EN8D rod of dimension 40mm diameter and 500mm length was purchased for shaft.

Then the rod was turned and machined to a dimension of 30mm diameter and 350mm length.

Polishing is done using emery paper of standard size. Key slots were made on the shaft to

accommodate keys of size 8mm×8mm in gears and cutters. Slotting was performed in CNC

milling.

Fig 6.9 Turning Operation in Lathe

Fig 6.10 Key way making in CNC milling

Stage 4: Blank material (Stainless Steel Grade 202) dimension 150mm×150mm×60mm was purchased to manufacture cutter. Cutter of required profile was machined using EDM.

Electrical discharge machining (EDM), also known as spark machining, spark eroding,

burning, die sinking, wire burning or wire erosion, is a manufacturing process whereby a

desired shape is obtained by using electrical discharges (sparks). Material is removed from

the work piece by a series of rapidly recurring current discharges between two electrodes,

separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is

called the tool-electrode, or simply the "tool" or "electrode," while the other is called the

workpiece-electrode, or "work piece." The process depends upon the tool and work piece not

making actual contact.

Fig 6.11 EDM
Operation

4
1

Fig 6.12 EDM Machine Fig 6.13 Cutter

Stage 5:.Depositer and hopper are the major parts that made using GI sheet(26 Gauge). It is

designed in such a way that it suits with the main frame of the machine and considering the

aesthetics ,ergonomic of the parts.

Fig 6.14 Depositer Fig 6.15 Hopper

4
2

Stage 6: In this stage the shredder box was assembled completely. The two shafts with key

way were inserted into the bearing sides, and the cutter, spacer are inserted alternatively. Key

of size 8 x 8 mm were inserted to hold and transmit power to the cutter and spur gear from

the motor via gear box. Gear Box and Motor are coupled using Love joint couplings.

Fig 6.16 Shredder
Box

Fig 6.17 Drive
Assembly

6.2. FINISHING

To finish off the build ,the framework, depositer, hopper were assembled in the frame of the machine. The complete machine is shown in Figure 6.18.

Fig 6.18 Finished machine

4

CHAPTER 7

RESULT

The proposed machine was successfully fabricated and tested. The final machine is an

outcome of a series of processes. It was expected that the fabrication cost would go beyond

that projected in the estimate. Fortunately, due to the purchase of raw materials from

Coimbatore at cheap price the total cost was not much more than the projected. The

machining of cutter using CNC took about 12 hours of work per cutter. Since it was time

consuming and not economical we further carried out machining using Wire cut EDM. It was

found that the use of reduction gear box instead of belt drive or chain drive was efficient

considering safety and space saving aspect. Firstly we machined the shaft without providing

a step cutting at the end to couple the gear box without slipping. But later on we realized that

it was necessary to provide step cutting. And we used nylon material as spacer for cutters.

But we found that it was not efficient for long term usage because of wear. During assembling

there was some problems with balancing and we solved it by using washers to adjust height differences. 1hp motor of speed 1440 rpm coupled to a reduction gearbox with speed ratio

60:1 produced an output of 24 rpm in the shaft. The cutting force that was determined

theoretically was sufficient to cut the plastic bottle. Plastic bottles was shred to a size of 1-2

cm and the size varied for different variety of plastic bottles.

CHAPTER 8

CONCLUSION

The goals of building a machine that can shred plastic waste into fine enough shreds to be

usable in future machines for producing new products were met. This points to the effective

disposal and reuse of plastic waste. The plastic shredding unit was also made into a module by attaching it to a frame that fastened to the mainframe by bolts. The machine can shred 3

kg of plastics in 1hours. The design of cutter, number and arrangement of cutters and speed

of rotation produced effective cutting of plastic bottles. The changing between different

sieves to produce other quality of output should also see a substantial improvement for user

friendliness.The material costs of building the machine was managed to be kept to minimum,

though at a cost of greatly increased building time.

This project work has provided us with an excellent opportunity and experience to use our

limited knowledge. We have gained a lot of practical knowledge regarding planning,

purchasing, assembling and machining while doing this project work. We also felt that the

project work is an insight into the fact that real engineering involves identification and

solution of problems of common people. We also understood about the difficulties in

maintaining the tolerances without compromising quality. We have done everything possible

to make this project a reality with better utilization of available facilities. Also we are proud

that the work was completed within the limited time.

4
6

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APPENDIX A
BILL OF MATERIALS

Description Material Details Quantity Unit Price Amount (In
Rupees)
Electric Motor
Single Phase 1HP
1 5000 5000
Reduction Gear Box
60:1 1 4000 4000
Metal Plate Stainless
Steel
Grade 202 33(kg) 215 7000

Shaft Rod EN8D 50 mm dia 10(kg) 80 800 Spur Gear Cast Iron 2 400 800 Ball Bearing 30BC02 4 100 400 Metal Plate Mild Steel 21(kg) 65 1400 Other Accessories
5000
Labour Charge 10000
Total : Rs.37400

ANNEXURE 1

CNC milling program