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Design Review and Optimization of Twin Shaft Shredder Blades for Shredding of Paddy Straw

Raut Padmakar T.[1] and Patil Jaypal K.[2]

Assistant Professor, Department of Mechanical Engineering[1]

Head of Department, Department of Mechanical Engineering[2]

Bharati Vidyapeeth Institute of Technology, Navi Mumbai, Maharashtra, India

Abstract: *Agriculture plays a vital role in the Indian economy, over 70 percent of the rural households depend on agriculture. Agriculture is an important sector of the Indian Economy as it contributes about 17% of the total GDP and provides employment to over 60% of the population. In this process, a huge amount of agricultural residue materials is produced which has no commercial utilization. Agricultural residues such as Corn Cob, Paddy Straw, Cotton Stalk, Cane Trash, Soya Husk, Juliflora, etc. are left to rot or are burnt in the fields which results in excessive Air Pollution. Agri-residues in their loose as well densified (Briquette / Pellet) form can be a wonderful source of energy that could fuel up the Nation's Economy in a much more efficient, eco-friendly, and sustainable way. Agro residues are required to be uniformly sized to make them suitable for processing and converting into Briquette / Pellet. A twin shaft shredder machine is useful equipment required to convert Paddy bales into the required size of ≤50mm so that they can be easily converted into Biomass Briquettes. This project is being carried out in a briquetting plant at "Punjab Renewable Energy Systems Pvt. Ltd" Aurangabad for utilization of Agro residues (Paddy Straw) as fuel in form of briquettes. Paddy Straw has high moisture as well as high silica content which results in high wear & tear by which Operational cost, as well as plant downtime, increases. Therefore, the design of the twin shaft shredder needs to be optimally designed such as Blade design, metallurgy, and cutting chamber design as per Paddy Bales is required to be optimized to make it suitable for processing of Paddy Straw.*

Keywords: Cutting Blade design, Blade metallurgy, shredder cutting chamber.

I. INTRODUCTION

Agricultural residues such as Corn Cob, Paddy Straw, Cotton Stalk, Cane Trash, Soya Husk, Juliflora, etc. are left to rot or are burnt in the fields which results in excessive Air Pollution. Agri-residues in their loose as well densified (Briquette / Pellet) form can be a wonderful source of energy that could fuel up the Nation's Economy in a much more efficient, ecofriendly, and a sustainable way. Agro residues are required to be uniformly sized to make them suitable for processing and converting into Briquette / Pellet. A twin shaft shredder machine is useful equipment required to convert Paddy bales into the required size of ≤50mm so that they can be easily converted into Biomass Briquettes.

This paper is being carried out in a briquetting plant at "Punjab Renewable Energy Systems Pvt. Ltd" Aurangabad for utilization of Agro residues (Paddy Straw) as fuel in form of briquettes.

Paddy Straw has high moisture as well as high silica content which results in high wear & tear by which Operational cost, as well as plant downtime, increases. Therefore, the design of the twin shaft shredder needs to be optimally designed such as Blade design, metallurgy, and cutting chamber design as per Paddy Bales is required to be optimized to make it suitable for processing of Paddy Straw.

Generally, solid wastes can be classified according to their sources such as municipal solid waste, industrial solid waste, and agricultural solid waste. Plastic waste is a constituent of the solid waste set of which Polyethylene Terephthalate (PET) is a common material of manufacture. PET is used to produce plastic bottles and several other plastic products.

The twin shaft shredder is commonly used for various kinds of shredding operations in heavy machinery & high-level products manufacturing industries. In those types of applications, their scrap and waste materials have been observed in various operations of machining, fabricatingetctc. The twin shaft shredder is accommodate these waste scraps into small blocks of steel cubes in small portable chambers. The mechanical shredding of waste is a tough job, so electrical drive systems for shredders must be especially sturdy and reliable. This also applies to the geared motors from WEG"s subsidiary Watt Drive, which the recycling machinery manufacturer uses to drive its new twin-shaft shredder. In the twin shaft shredder, the material to be shredded is pulled between two shafts rotating slowly in opposite directions, each fitted with cutter discs. The process is monitored by a PLC controller. If the machine is overloaded or foreign objects get into the cutting mechanism, the controller reverses the rotation. The gap between the cutter discs is precisely defined to reduce the shredding force. A top-mounted stripping comb holds down the shredded material and prevents it from winding around the shafts. The size of the output material is determined by the cutter width or the number of blades.

1.1 Need for Analysis

Recently, the manufacturing industry requires a higher level of design and calculation almost in every part in both fabrication and testing which can make it possible to improve and develop products. So the twin shaft shredder blades' life needs to increase for the heavy load & mass production of shredding the various kinds of parts like can be used for cost-effective shredding of all sorts of industrial waste, rubber-metal and plastic waste, special waste, metal swarf, electronic scrap, etc

This method of twin shaft shredder contains the blades in the action on the line of 16 nos. the blades have the life of a maximum of the limits based on the materials shredding in the twin shaft shredder. The method developed, especially nonlinear analysis, makes it possible to accurately design blades. Research using nonlinear analysis to solve blades problem was discussed by heavy machinery equipment, however, only single blades model was considered. The purpose of design development for the shredding blades is not only to reduce weight, quality, and reliability, improve durability when subjected to cyclic loading, or improve the quality of blades material and processing but also to reduce time and manufacturing cost in the design process to gain the highest economic benefit.

The finite element method is an effective part of CAD/CAE applied in design and analysis to solve complicated problems. Twin shaft Shredder blades simulation using commercial code such as HyperWorks, ANSYS, MSC/NASTRAN, and MDI/ADAMS by employing beam elements to model leaf spring showed accurate behavior prediction. Currently, the design of multi-leaf springs and the prediction of behaviors are more efficient using finite element methods as presented in Ref.

1.2 Materials Analysis

In the state generally, the alloy steels have used 20MnCr5 to manufacture the twin shaft shredder blades. The blade has taken in the process of laser cutting and hardening process. Then after the hardening, the blades have under the controls of tool or bench grinding operations in bench grinding. Generally, the alloy steels have under heat treatment process up to 900̊ C to 960̊ C. We are going to change the materials of EN8, EN19, EN36 & EN41instead of 20MnCr5 alloy sheets of steel to improve the production cost of this material. And to improve the durability of twin shaft shredder blades. After the analysis which one of the materials has cost-effective & process effective and easy availability. That material has going to take instead of Blades manufacturing. The blades have been designed in the view of SOLIDWORKS 18 and analyzed with the help of ANSYS 16.0

II. LITERATURE SURVEY

Dr. Fauzia Siddiqui - The different components designed along the blade are frame/stand, shaft, washers, gears, pully, etc. thus the designing phase is briefly classified as the machine construction, cutting system, and the transmission system. The total protection depends upon various parameters such as total knowledge about the system, design of a single blade and its arrangement of the main shaft, and reduction in rotation.

P.K.Farayibi. - Analysis of Plastic recycling machine design for production of thin filament coil. The conceptual design is considered fit for fabrication based on the design analysis and evaluation, using locally available and cheap materials.

Dr. Jassim M. Abdulkarim Jeff, Darewan A. Abdulrahman - I include plastic collection, manual sorting, chipping, and washing pelleting. The large particles of plastic need to be broken down into small pieces to reduce storage and transportation space requirements.

Karolina Glogowska, Jakub Rozpedowski - During the shredding process, the following parameter were analyzed: electricity consumption, the temperature inside the shredding chamber, and the temperature of the obtained recycler. The study indicates the importance of the possibility to shape the workspace of the shredder and the energy relation of the process.

A. Tegegne, et al [1] developed an electrically driven dual shafted-multi bladed shredder machine for recycling waste plastics. Angle and sharpness of the blades, space between the blades, etc. were considered. Tool steel ASIS L-2 was the steel type selected for blades with the angle of cutting equal to 56^0.

R. Ekman [2] designed and manufactured a shredder machine for plastic waste material recycling.

He used a motor of 2.2 KW and 2820 rpm for giving the required power to shred plastic bottles. He used a gearbox with a reduction ratio of 40 to reach 70 rpm for shredding speed.

M. Sakthivel, et al [3] designed a twin shaft shredder using Pro- Engineer software, the number of blades of the shredder was16 on each shaft, and the output power required was 2 Hp. Alloy steel with a composition of 20MnCr5 has been used for manufacturing the shredder blades.

S. B. Pavankumar, et al [4] designed and fabricated organic waste shredding machines, where the cutting blades are made of high carbon steel. Aplanetary gearbox with an output speed of 96 rpm was utilized.

D. A. Fadare, T. G. Fadara, and O. Y. Akanbi, Effect of Heat Treatment on Mechanical Properties and Microstructure of NST 37-2 Steel, Journal of Minerals & Materials Characterization & Engineering, 10(3), 2011, 299-308. This Study is based upon the empirical study which means it is derived from experiment and observation rather than theory. The main objective is to Study the Effect on the Hardness of three Sample Grades of Tool Steel i.e. EN-36, EN-8, EN19, and EN41after Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering.[5] Nirav M. Kamdar, Prof. Vipul K. Patel (2012), "Experimental investigation of machining parameters of EN36 steel using tungsten carbide cutting tool during hot machining", International Journal Of Engineering Research And Application, Vol.2 (3), pp.1833-1838. This survey helps to find out the place of the work to be carried out i.e. availability of setup, techniques used for such, estimated time, various cutting parameters, surface roughness & cost requires for such study carried out for such industrial survey to be carried out we designed a Survey questioner and selects various places who offer heat treatment services Ludhiana based. After a literature review and industrial survey indicate the optimal cutting parameter, minimum surface roughness (Ra), and, the maximum material removal rate was obtained and a developed model can be used to increase the machine utilization at low production cost in a manufacturing environment.[6] A.S.Dhavale, V.R.Muttagi, (2012) Study of Modeling and Fracture Analysis of Camshaft, International Journal of Engineering Research and Applications, Vol. 2, Issue 6. After selection of material & heat treatment processes further aims to perform mechanical & chemical analysis i.e. composition testing of the two tool steel EN-41, and EN-19, before treatment. After composition testing aims to do heat treatment processes i.e. Annealing, Normalizing, and Hardening & Tempering to be carried on such material & after treatment aims to perform hardness testing on the treated and untreated work samples.[7] S. Ranganathan and T. Senthivelan (2010), "Optimizing the process parameters on tool wear of WC inert when hot turning of AISI 316 Stainless steel, "Asian Research Publishing Network (ARPN), Vol. 5, No.7, pp. 24-35. In this work, the EN 36 Steel specimens heated with gas flame were machined on a lathe under different cutting conditions of Surface temperatures, Cutting speeds, and Feed rates. Cutting force, feed force, and surface roughness was studied under the influence of machining parameters at 200 °C, 300 °C, 400 °C, 500 °C, and 600 °C at a constant depth of cut 0.8 mm. The optimum result was achieved in the experimental study by employing the Design of experiments with Taguchi. . In the present study, Analysis found that varying parameters are affected in different ways for a different response. The ANOVA analysis was used to obtain optimum cutting parameters.[8] Nirav M. Kamdar, Prof. Vipul K. Patel (2012), "Experimental investigation of machining parameters of EN36 steel using tungsten carbide cutting tool during hot machining", International Journal Of Engineering Research And Application, Vol.2 (3), pp.1833- 1838. In this research work, the L18 orthogonal array-based Taguchi optimization technique is used to optimize the effect of various cutting parameters for surface roughness and Material Removal Rate (MRR) of EN 36 work material in turning operation. The orthogonal array, the signal-to-noise ratio, and analysis of variance are employed to study the performance characteristics in both dry and wet machining conditions of cylindrical workpieces using Tin coated tungsten carbide cutting tool on a CNC lathe. Five machining parameters such as spindle speed, feed rate, depth of cut, nose radius, and the cutting environment (wet & dry) are optimized with consideration of surface roughness. Results of this study indicate for the optimal cutting parameters, minimum surface roughness (Ra), and maximum material removal rate were obtained and the developed model can be used to increase the machine utilization at low production cost in a manufacturing environment.[9]

III. PROBLEM STATEMENT

In general, the shredder has been used for shredding waste plastics which are generally brittle, and the sizing of the plastic is also not a major criterion for its re-cycling. However, when comes to the question of shredding Agricultural residues such as Corn Cob, Paddy Straw, Cotton Stalk, Cane Trash, Soya Husk, Juliflora, etc. The Sizing and the service life of the blades become critical parameters to be controlled failing which results in ins infaiinnct itself. Therefore, the design review and optimization of shredder blades and cutting chamber and metallurgy of the blades need to be optimized wi concerninghe agricul concerning

3.1 Objective of System

1. Studying the Agricultural waste (Paddy Straw) via Proximate & ultimate analysis.
2. Study the Blade Material of Construction (MOC).
3. Review and study the blade design.
4. Design calculations of the Cutting blade.
5. Preparation of CAD model of Cutting Blades in SolidWorks.
6. Stress Analysis of blades.

3.2 Methodology

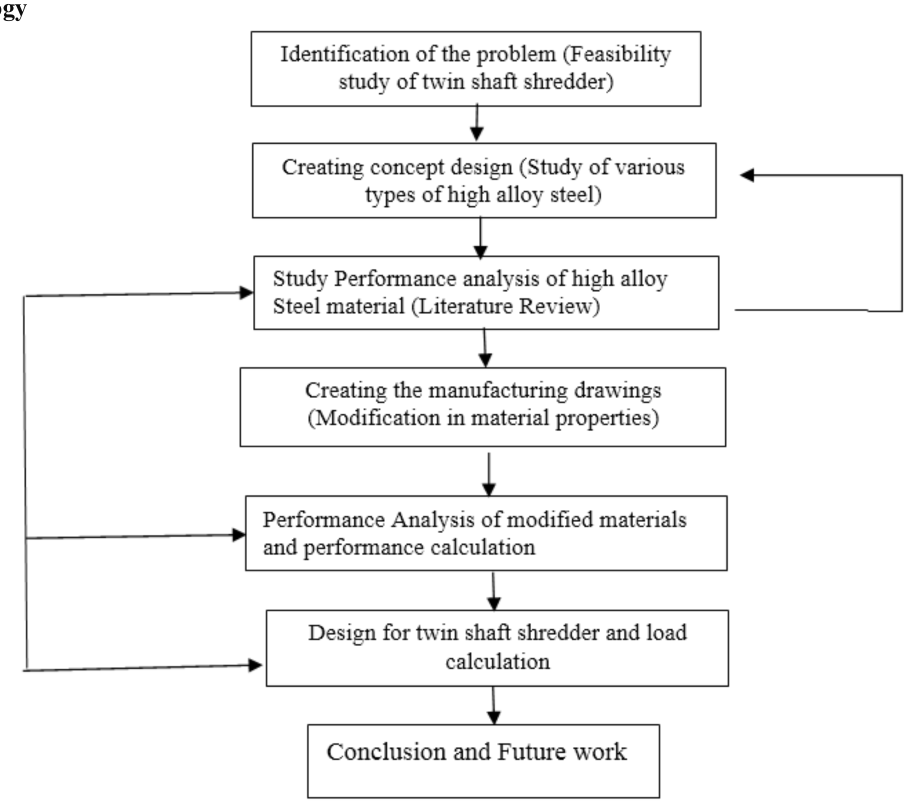


Fig. 1 Block Diagram of Methodology

1. To understand the shredder machine, the main or most important part is the blade. The blade design is a very important part of a shredder machine.
2. The design of the blade is done by using solid works 2018.
    a. The design is further classified as different components are designed separately according to load calculation.
    b. After designing, we assembled each component.
    c. This is all about CAD modeling.
    d. Once CAD modeling is done the next step is the material selection for the components

IV. EXPERIMENTAL PROCEDURES

The selection of the materials to manufacture the twin shaft shredder blades is ly identify the chemical composition of each different alloy steel material. The mechanical properties expose the values of maximum shear stress and strain, Ultimate tensile load, Elongation, yield strength and maximum temperature withstand limit.

4.1 Properties of 20MnCr5

Plasma nitriding is a thermochemical process extensively applied in metallic materials science and surface engineering due to its well–known potential for improving properties such as hardness, wear, and corrosion resistance of metallic parts. This surface treatment technique consists of the implantation of nitrogen species at low energy into the steel substrate and their subsequent diffusion into the bulk at temperatures above 300 °C. The interaction of nitrogen and steel surface leads to the formation of different types of metallic nitrides, which form the so-called “nitride layer”. Starting from the solid surface, such a modified layer usually comprises an oxide layer, a compound zone, and a diffusion zone. The resulting structure of these zones depends on several processing parameters such as the concentration of alloying elements, exposure time, substrate temperature, and gaseous mixture. The presence of a nitride layer changes the mechanisms of interaction between metallic materials and their surroundings, thus affecting their stability in aggressive environments. The incorporation of nitrogen imparts better mechanical properties (friction and wear resistance), but the dissolution kinetics (corrosion resistance) remains closely related to the composition of the corrosive medium. In this context, the 20MnCr5 steel is largely employed in industrial processes that take place in aggressive environments. Hard iron nitrides originated during the plasma treatment owing to nitrogen diffusion in the near-surface region at temperatures below the eutectic point (593 °C). Usually, two different phases corresponding to the ε-Fe2-3N and γ‘‘- Fe4N nitrides are obtained, whose high hardness improves the strength, friction, and wear resistance. However, the highest wear resistance is normally achieved when the close-packed hexagonal ε-Fe2-3N phase is primarily at the surface of the specimens. This is so because the mixed nitride layer of the ε- Fe2-3N and γ‘‘- Fe4N phases is, in fact, due to a crystal lattice mismatch. Recent work has shown that the pitting corrosion resistance of the steel can be significantly improved by nitride layers consisting of ε-Fe2-3N and γ‘‘-Fe4N phases. However, the effect of the nitride layer microstructure on the pitting corrosion behavior of the steel is still not fully understood. In this study, we address this question by analyzing the influence of plasma processing at optimal parameters (temperature 500 °C, exposure time 4h, and gaseous mixture 20 % H2, 80 % N2) on the corrosion, wear behind the visor, and microstructure of plasma-nitrided 20MnCr5 steel.

4.2 Composition of Steel Materials

EN41, EN8, EN19, AND EN36 Selection of the materials to manufacture the twin shaft shredder blades is to identify the mechanical and chemical composition of each different alloy steel meta materials mechanical properties expose the values of maximum shear stress and strain, Ultimate tensile load, Elongation, yield strength,h, and maximum temperature withstand limit.

Chemical Composition is Important Testing for making sure that the Chemical Composition of the Purchased Material Matches that of the International Standards of Materials. This Testing is done By Using the Glow Discharge Spectrometer. Surface finishing of a Single Sample of Each material is done on the Belt Grinding Machine of a 100Grit Belt. After Grinding and giving the material a good Surface finish Sample EN-8 iinseinsert in teaching. The Machine Holds the Material by Vacuum Holder of tmachinimachne No.4.1 Composition of Tool Steel as per AISI Standard

Material Composition									
*MARK	C%	Si%	Mn%	P%	S%	Cr%	Mo%	AL%	Ni%
EN-8	0.45	0.30	0.50	0.024	0.025	1.40	-----	-----	-----
EN-19	0.38	0.21	0.91	0.01	0.01	1.04	0.23	4.21	0.23
EN-36	0.70	0.25	0.42	0.012	0.01	1.05	0.14	-----	3.2
EN-41	0.40	0.30	0.60	-----	-----	1.60	0.35	1.20	-----

Then the door is closed for further Operations to be performed on the material and a command is given to the Specific Software on the Computer. This is done by using the glow discharge method, sample material is uniformly sputtered Spit up in an explosive manner] from the surface.

Industrial survey conductions were found to be a very useful approach for the selection of tool steel grade which is ill more beneficial from an industrial point of view. From the literature review, It is observed that less research work has been seen for Tool Steel i.e. EN19, EN8, EN36, and EN41 after Heat Treatment Processes Such
As Annealing, Normalizing, and Hardening & Tempering.

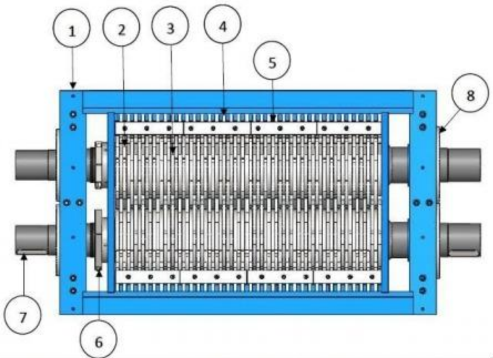
4.3 Material Comparison

After annealing specimen becomes harder than the then untreated specimen. After annealing hardness is more as compared to untreaspecimensimen. But specimen has not obtained a good microstructure. After hardening and temperispecimensis are hardest the other three specimens and have good corrosion resistance. Industrial survey conduction is found to be vaaryveryeful approach for the r selection of tool steel grade which will be more beneficial from hee or the industrial point of view. From the literature review, it is observed that less research work has been seen for Tool Steel i.e. EN19, EN8, EN36, and EN41 after Heat Treatment Processes Such As Annealing, Norming, and Hardening & Tempering.

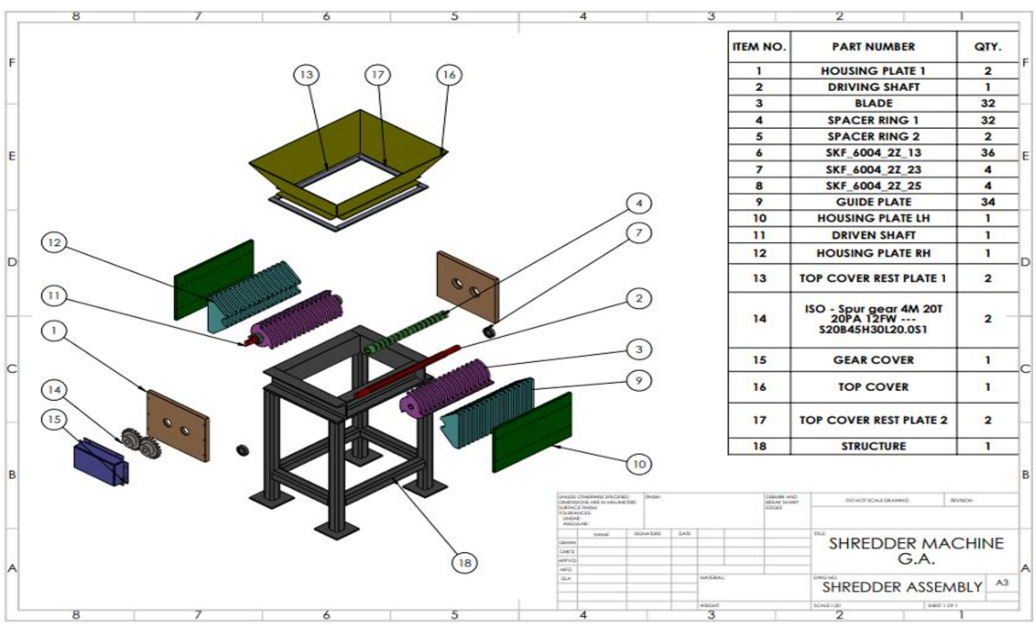
Industrial survey conduction is found to be a very useful approach for the selection of tool steel grade which is ill more beneficial from an industrial point of view. From the literature review, it is observed that less research work has been seen for Tool Steel i.e. EN19, EN8, EN36, and EN41 after Heat Treatment Processes Such As Annealing, Normalizing, Hardening & Tempering.

Also, very less work has been reported for AISI EN19 Die Steel. It is observed that the effect of hardness of workpiece material after treatment of Tool Steel i.e. EN41, EN8, and EN36 has not been explored yet, so it„s interesting to Study the Effect on the Hardness of three Sample Grades of Tool Steel i.e. EN19, EN8, and EN36 after Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering. All these aspects will be addressed in the research work. Indexing of HTPI 2012 is found to be very effective for the defined objective function. After annealing specimen of EN19 becomes softer than the untreated specimen as the hardness value shows. After normalizing hardness is more as compared to the untreated specimen. After hardening and tempering specimens are hardest than the other three specimens. After annealing specimen of EN-8 becomes softer the untreated specimen n as hardness value shown. After normalizing hardness is more as compared to untreated specimens. After hardening and tempering specimens are hardest than the other three specimens due to the formation of fine tempered martensite. After annealing specimen of EN41 becomes harder than the untreated specimen. After annealing hardness is more as compared to the untreated specimen. But specimen has not obtained a good microstructure.

After hardening and tempering specimens are the hardest than the other three specimens and also have good corrosion resistance. Future Aspects of this study to carry out further are very wide. Selecting different tool steel materials and comparing the effects on their mechanical properties. Recommended material for further work done to be carried out for similar study EN41, mild steel, HC HCR cold working tool steel grades like so many. HSS found to be very tool steel grade difficult for such study as per investigation from the industrial survey. Using Different analytical approaches is also making an effective outcome which is also recommended.



1. Housing 2. Blade 3. Spacer Ring 4. Cleaning Finger 5. Clamping Bar 6. Lock nut 7. Hexagonal Shaft 8. Bearing Cover	The Machine consists of a shredding chamber which contains two counter rotating hexagonal shafts fitted with circular blades of predetermined thickness which can have cutting hooks, depending on the material the shredder must process. The material is fed through a hopper placed above the shredding chamber. The rotating blades with the hooks placed on their circumference take the material towards the center of the shredding chamber and as the material passed though the blades it is shredded and falls by gravity underneath the shredder



ITEM NO.	PART NUMBER	QTY.
1	HOUSING PLATE 1	2
2	DRIVING SHAFT	1
3	BLADE	32
4	SPACER RING 1	32
5	SPACER RING 2	2
6	SKF_6004_2Z_13	36
7	SKF_6004_2Z_23	4
8	SKF_6004_2Z_25	4
9	GUIDE PLATE	34
10	HOUSING PLATE LH	1
11	DRIVEN SHAFT	1
12	HOUSING PLATE RH	1
13	TOP COVER REST PLATE 1	2
14	ISO - Spur gear 4M 20T 20PA 12FW --- S20B45H30L20.0S1	2
15	GEAR COVER	1
16	TOP COVER	1
17	TOP COVER REST PLATE 2	2
18	STRUCTURE	1

Fig 1: Twin blade shredder Details

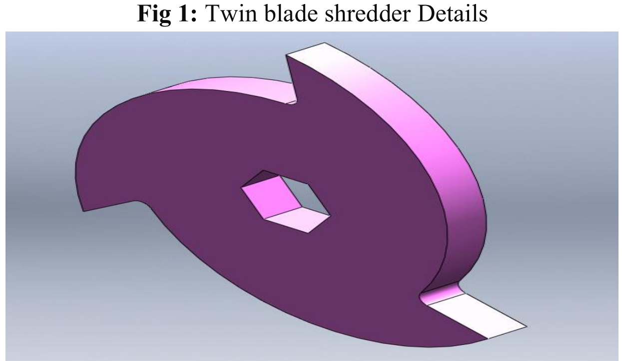


Fig. 2 BLADE TIP

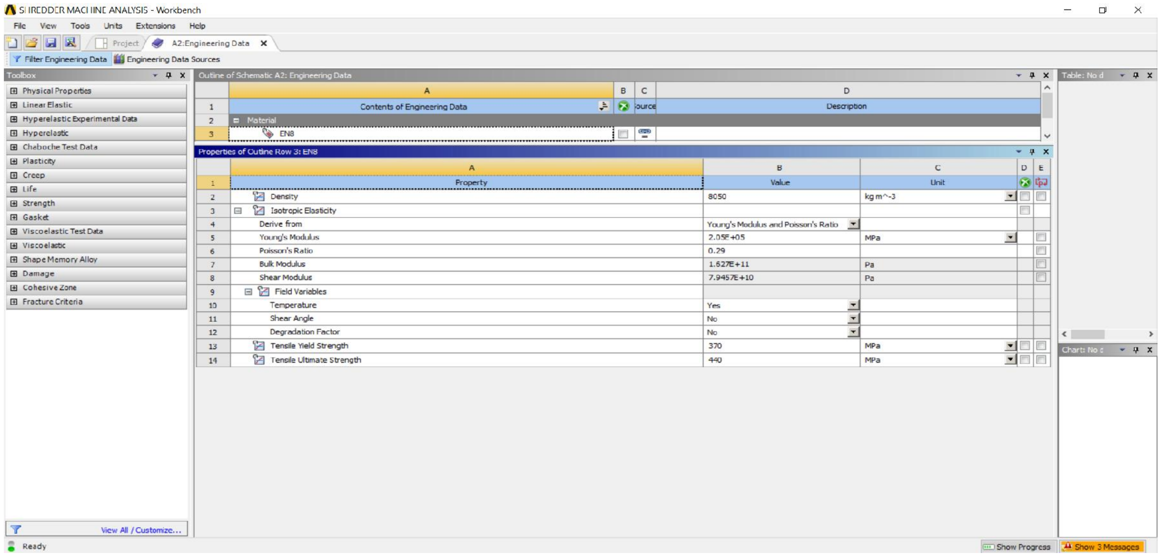


Fig. 3: Properties of EN 8 Material

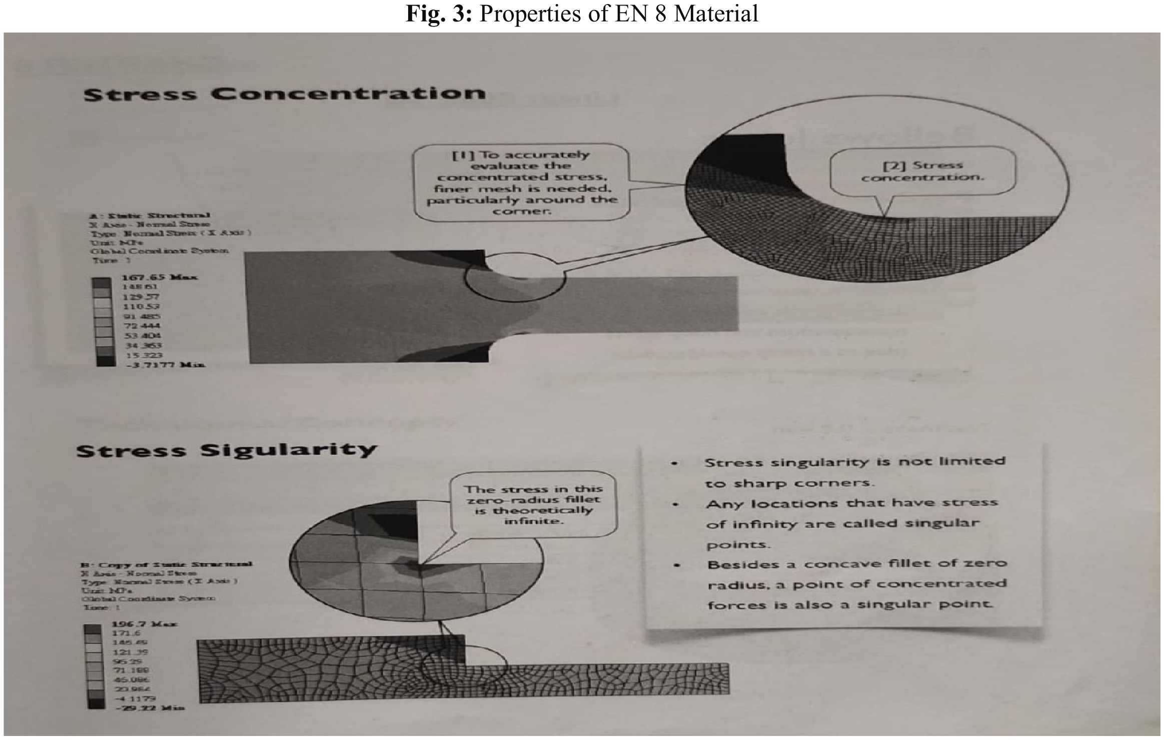


Fig. 4: Stress Concentration and Singularity

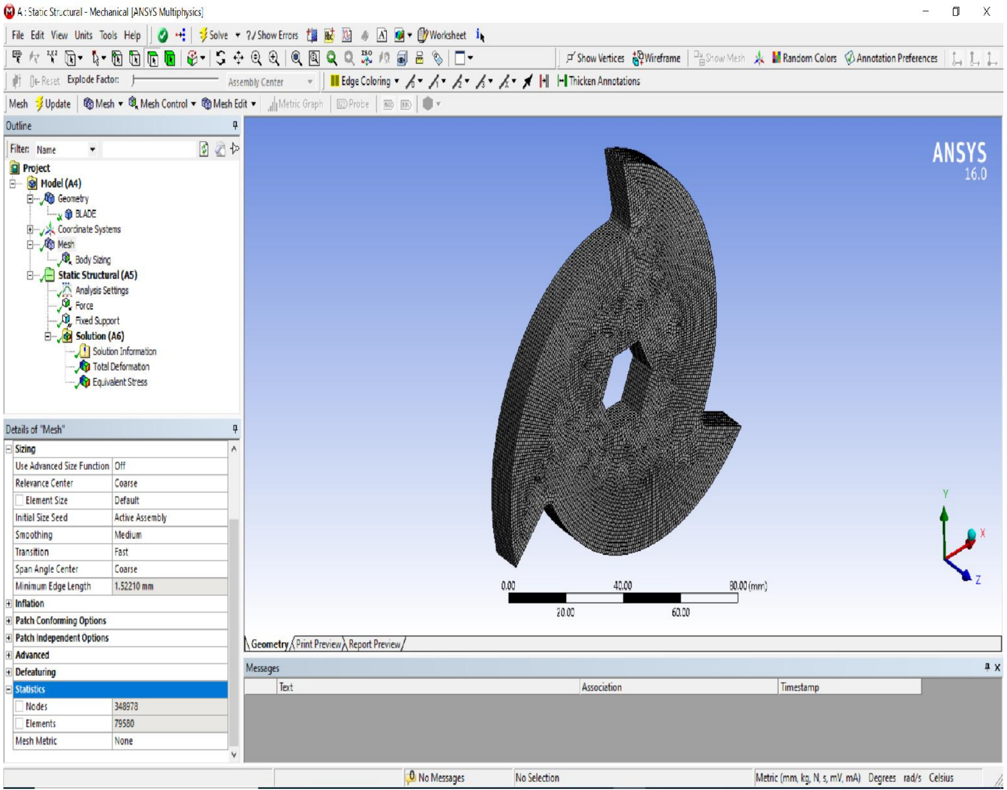


Fig. 5: Meshing

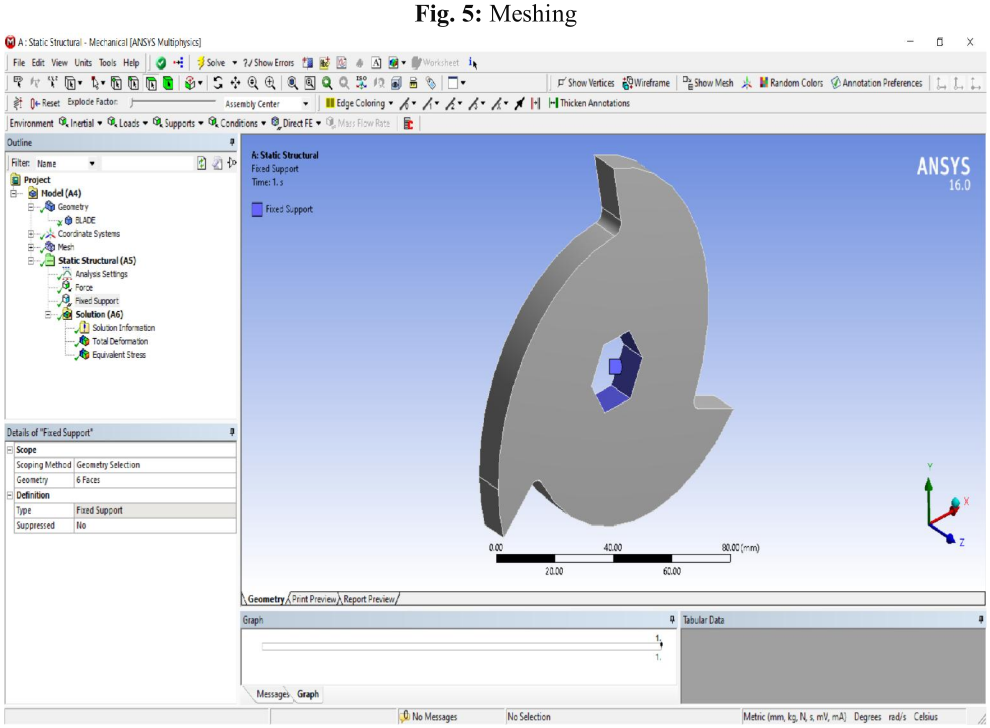


Fig. 6: Static Structural Fix- Support

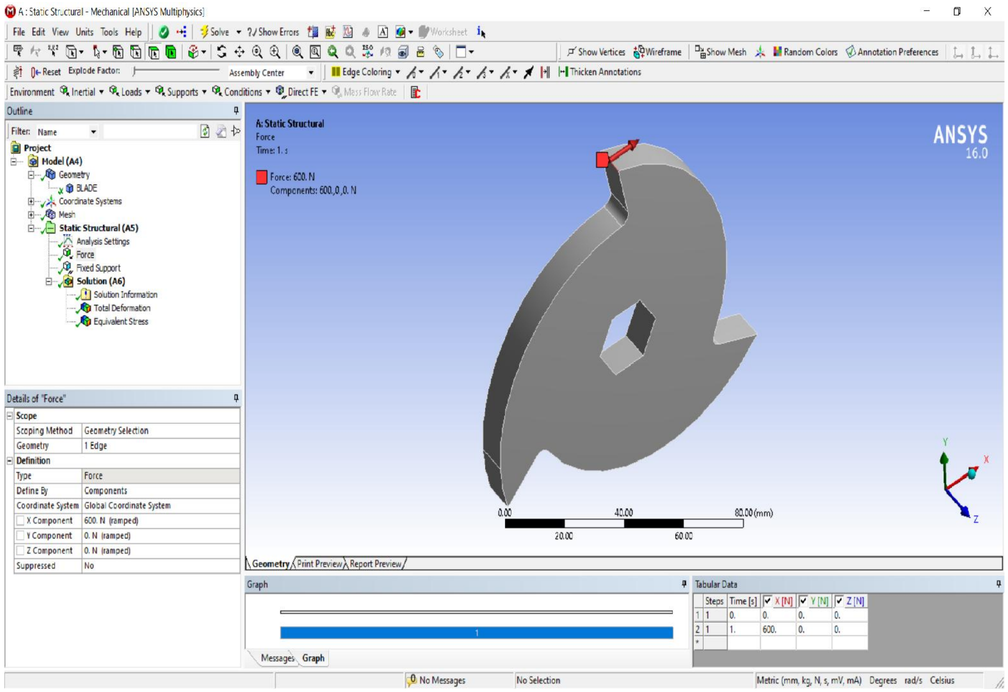


Fig. 7: Static Structural Force

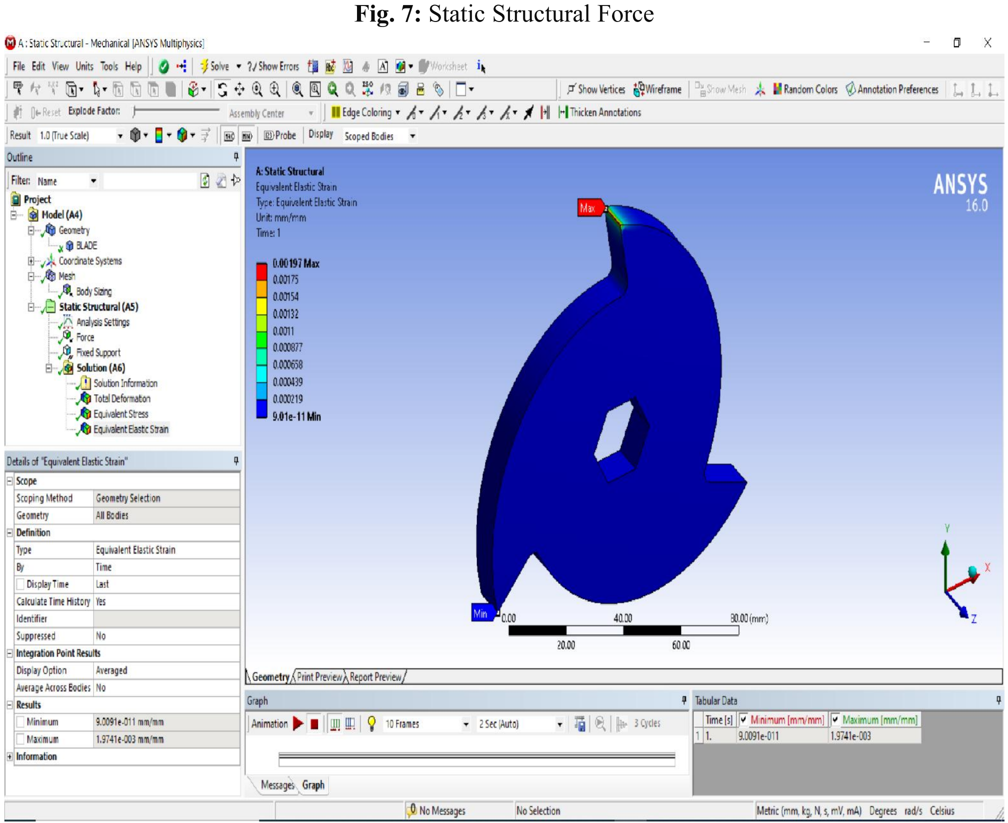


Fig. 8: Static Structural Equivalent Elastic Strain

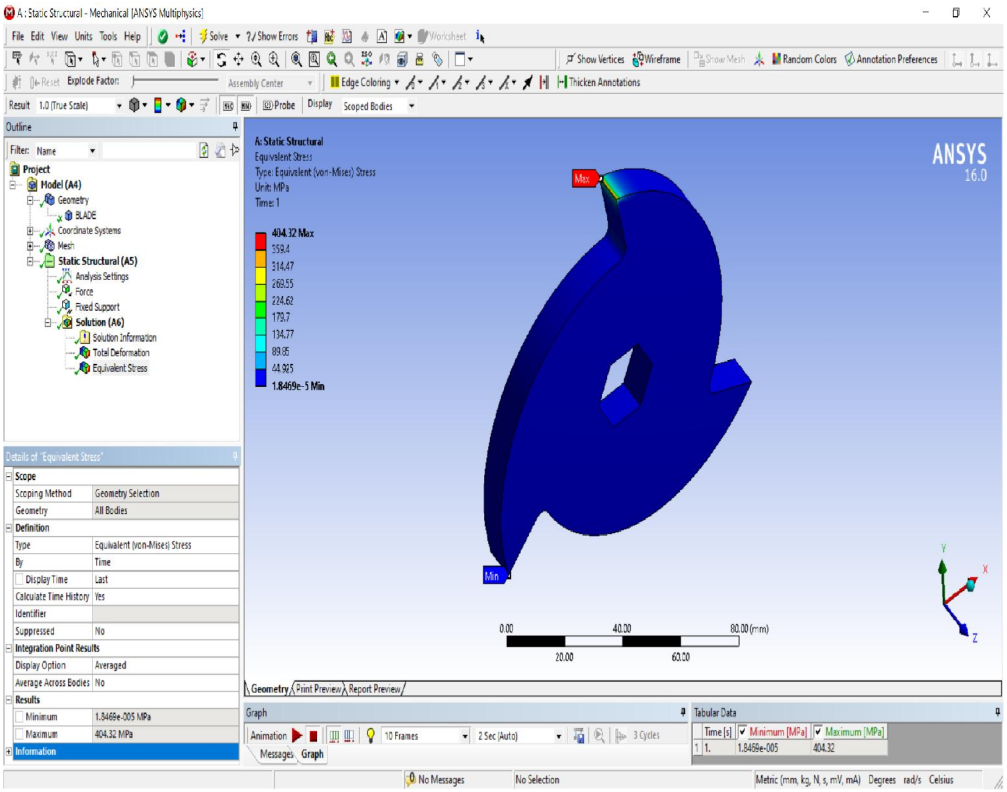


Fig. 8: Static Structural Equivalent Stress

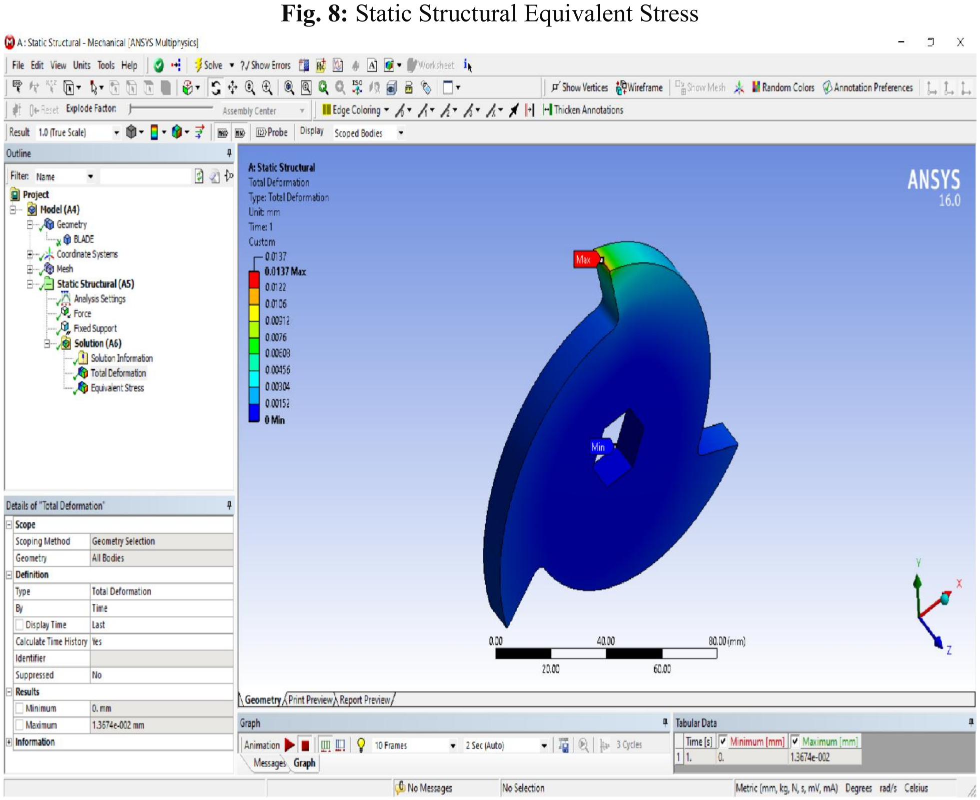


Fig. 9: Static Structural Total Deformation

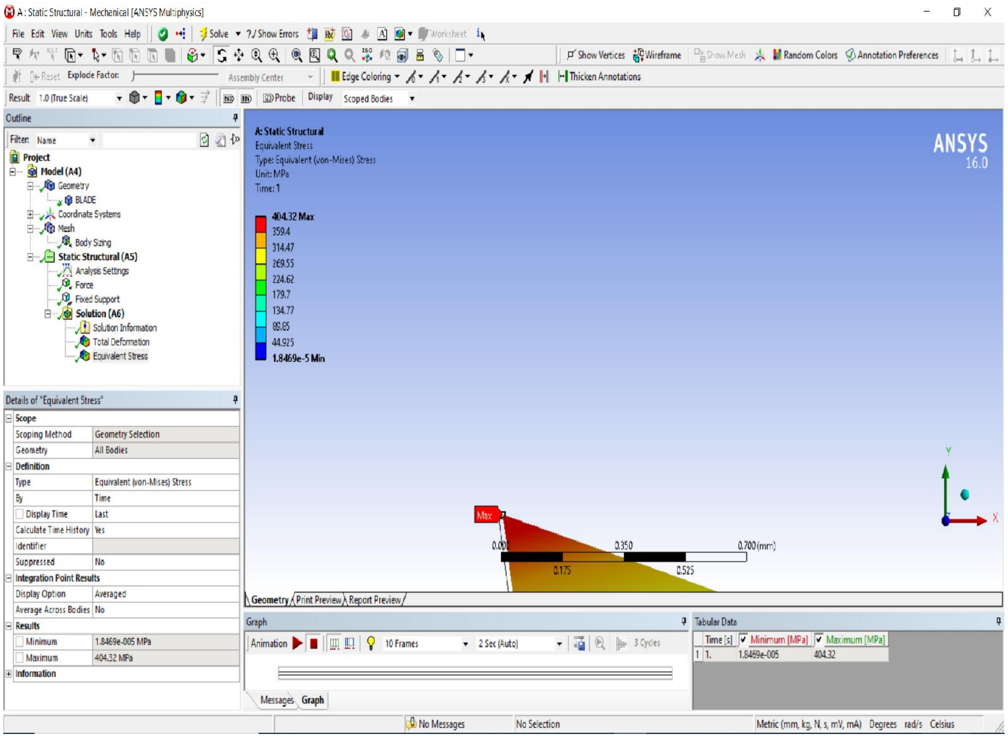


Fig.10: Static Structural Equivalent (Von-Mises) Stress

V. CONCLUSION AND FUTURE WORKS

The shredding machine for cutting waste plastics is widely used in industries for tic waste management. Paddy Straw has high moisture as well as high silica content which results in high inh wear & tear by which Operational cost, as well as plant downtime, increases. Therefore, the design of the twin shaft shredder needs to be optimally designed such as Blade design, metallurgy, and cutting chamber design as per Paddy Bales is required to be optimized to make it suitable for processing of Paddy Straw.

In this paper, a shredder blade is developed using Solid Works, and the stress analysis has been performed using ANSYS. The material of the blades and method of manufacturing was being demonstrated.

The results obtained by the Finite Element Analysis illustrated that the stresses to which they will be subjected inthe process of shredding PET plastic material are well below the yield stress of blade material.

In this study project, the twin shaft shredder blade shaves generally used 20MnCr5 material for blade manufacturing. It is capable to do the special process of heat treatment and annealing and quenching at the temperature of 910̊ C-960̊ C. But the 20 MnCr5material Quality of Life is a maximum of 30,000 cycles of rotation in the shredding of materials and rubbers. The process cost and service capability of this material are quite difficult as soon as possible.

The design of the Twin Shaft Shredder machine & Blades has been completed with the required design calculation. The Required level RPM of the Motor was also analyzed and found out as per the project of the Twin Shaft Shredding Machine.

In this paper Design of the twin Shaft Shredding Machine and Blades is completed with Solidworks software and the blades and shredding machine is analyzed with the use of ANSYS 16.0 software.

So in this project, we are using the EN8, EN19, EN36 &EN41 materials to manufacture the blades and reduce the process cost of this blade in the shredding machine. We have conducted the cutting, grinding, machining, and hardening of the major three tests hand overfeed in these materials successfully. In these tests, we conclude and select the materials of EN 8. Cause the cost and availability of these materials are simple in society. And this material is capable of our required process means the material quality of life for the required conditions is 1.5 times better than the previous one.

Vibration and dynamic stress analysis of shredder blades are under investigation for future study. And in the future calculate stack-up up the calculation of the blades assembly.

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