ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 7, Issue 7, July 2020

Optimized Design and Manufacturing of Waste Plastic Shredder Machine

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Abstract: Shredder machine is used to cut waste plastics thrown in land affects the environment thus to reduce the pollution due to waste plastics it is necessary to recycle for different purposes. However one of the problems is cutting/ shredding of these waste plastics. Thus the objective of this project is to design and manufacture of electrically driven waste plastic shredder machine for the purpose of recycling waste plastics to make different items or products by using locally available steel group metals. To carry out this project, tools (lathe cutters, drill bits, milling cutters, grinding cutters), equipment and machines (power hack saw, lathe machine, milling machine, drilling machine, welding machine and compressor), measuring tools (meter, steel rule vernier caliper),will be used. Experimental method was used to carry out this project for checking the variable of the machine (the angle and sharpness of the blade, gap or space between the blades, sieve size) and to select & calculate the correct parameters (cutting speed, revolution per minute) during manufacturing each component. The purposive sampling technique was used to determine types, properties, and composition of component to manufacture waste plastic shredder machine. The machine size is 1227mm height X 854mm length X 700mm width and is contained four main bodies (the hoper, shredding box, frame, and electronic box). Finally, this project is helpful in the reduction of landfill waste plastics, sewerage pollution caused by waste plastic blockage in relation to the environmental protection. It is also bringing economic benefit to society as a source of business especially to SME's which are involving in metalwork.

Key words - Waste plastic, Shredder, environmental Pollution, recycling, SME

I. INTRODUCTION

Plastics are nowadays the most important section of production and consumption by volume among the all engineering technical material. As stated in the work of [1], Ever since the emergence of plastics and more frequent application in all aspects of industry, these materials has the necessary respect and unique place on the world market for used materials. Plastics are synthetics organic materials produced by polymerization. They are typically high molecular mass and may contain other substance besides polymer to improve performance and reduce cost. These polymers can be mold or extruded in to desired shape. There are two main types of plastics, first thermoplastic and the other one is thermosetting. Thermoplastic can repeatedly soften and melt if enough heat is applied and hardened on cooling, so that they can be made in to new plastic product. Thermosetting can melt and take shape only ones. These types of plastics are not suitable for repeated heat treatment. Therefore after they have solidified they stay solid. Prior to their conversion fuel resource waste plastics are subjected to various methods of pretreatment to facilitate the smooth and efficient treatment during the subsequent conversion process.

II. MATERIAL SELECTION AND DESIGN ANALYSIS

It is estimated that there are more than 40,000 currently useful metallic alloys and probably close to that number of nonmetallic engineering materials such as plastics, ceramics and glasses, composite materials, and semiconductors. This

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large number of materials and the many manufacturing processes available to the engineer, coupled with the complex relationships between the different selection parameters, often make the selection of materials for a given component a difficult task. If the selection process is carried out haphazardly, there will be the risk of overlooking a possible attractive alternative material. This risk can be reduced by adopting a systematic material selection procedure. A variety of quantitative selection procedures have been developed to analyze the large amount of data involved in the selection process so that a systematic evaluation

The characteristics that are usually considered when selecting a material for a given application can be classified into the following categories:-

1. Mechanical behavior including shear strength, yield strength, tensile strength, elongation percent, reduction in area percent, hardness, toughness, fatigue strength and stiffness resistance to abrasion and erosion are also related to mechanical behavior;

2. Chemical properties which include corrosion and oxidation resistance

3. Physical characteristics including electrical, magnetic and thermal properties. Density is also included in this category;

4. Process ability which includes cast-ability, workability, weld-ability and machinability

The problem of selection of an engineering material for a component usually begins with setting up the target function, objective, constraints, and free variables. The Function refers to the task that the component is primarily expected to perform in service – for example, support load, sustain pressure, transmit heat, etc. The Objective refers to the target such as making the component functionally superior but cheap and light. In other words, the Objective refers to what needs to be minimized or maximized.

In selecting materials for a given application it is useful to classify them according to the major function they are expected to perform in service. One of the most difficult problems for the designer is improper materials selection for engineering purpose. The best material is one which services the desired objectives of material selection was at the minimum cost and the required purpose must be followed. So that, we considered the flowing factors while selecting material.

- Availability of the material in the form and shape desired;
- Total cost of the material including initial and future cost;
- Material properties as they relate to service performance requirements;
- Suitability of material for working condition in service;
- Substitutability of the materials; and
- The processing of the material into a finished part

Generally material selection factors are service performance (specifications), availability, economics (total cost), material properties, manufacturing processes, formability and join ability and finishing and coatings.

III..MANUFACTURING PROCESS

The drawing for a component is given along with a basic product design specification (PDS). The drawing and other available data was analysed and interpreted. This forms the basis for the material evaluation and the subsequent selection of manufacturing processes, machines, tooling, work holding devices and the setting of appropriate processing parameters. Documenting all of the decisions with regards to how the component is to be made is the next step. All of the above information's were used to produce a detailed routing sheet for the product. A detailed operation list was also being produced as well as tooling list. Finally, the cost of component will be considered based on the documented process plan. The aim of this chapter is to demonstrate the complete process planning from drawing interpretation to finished process planning documentation, that is, from design to manufacture.

1. Design for assembly

As discussed in the work of Design for assembly (DFA) has received much attention in recent years because assembly operations constitute a high labor cost for many manufacturing companies. The key to successful design for assembly can be simply stated:

(1) Design the product with as few parts as possible, and

(2) Design the remaining parts so they are easy to assemble.

The cost of assembly is determined largely during product design, because that is when the number of separate components in the product is determined, and decisions are made about how these components will be assembled. Once these decisions have been made, there is little that can be done in manufacturing to influence assembly costs (except, of course, to manage the operations well).

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2 .Assembly of the Waste Plastic Shredder Machine Component

Waste plastic shredder machine parts/components ware manufactured mainly by three processes separately. As discussed in chapter, most components were made by machining processes and the rest parts by welding and sheet metal forming. By applying the rule of assembling, sub assembling of frame, shredder head box, cutting blades with shaft and inlet hopper was made step by step with appropriate joining method. This minimizes the difficulty of assembly of all part at a time to finish the machine final image. Having those sub-assemblies, final step was to assemble all the sub-assemblies into one final real waste plastic shredder machine. In the application of assembling different tools and equipment's were used to facilitate the task of joining.

3. Blade Assemblies on the Shaft

After all components were manufactured, assembling process conducts step by step and sub-assembling of some parts was carried out to simplify the process. it was done with necessary steps to eliminate any mistake or misaligning which could cause problem in the final assembly. And the assembling and sub assembling of components was from simple to somehow difficult for the betterment of fitting. Therefore steps sub-assembling and assembling of components with the necessary is listed as follows. The figure below shows the blades, bearing and spacer assemblies on the shaft

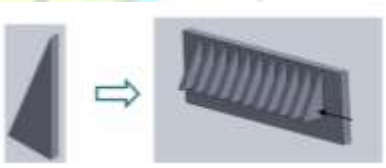
4. Sub-assembling One

Assembling blades and spacer on shaft using key. There are nine cutting blades separated by spacer to each other which are assembled in each shaft (two shafts) and the assembling mechanism is key connecting system. This assembling was done for easy handling of the blade for next step of fitting with the supporting blocks. This also helps to protect the assembler/ operator from scratching of the sharp edge of the cutting blades during handling the blades.

Nb .the second shaft assembling follows the first one procedure.

5. Sub-assembling Two

Assemble the ribs in both the front and rear plate using Ribs were joining to the two side plates according to the drawing before the box is assemble for easy control and easier process and was used shield metal arc welding process. after ribs was successfully joined, the shredding case / shredding box was constructed using temporarily fasteners (bolt and nut)

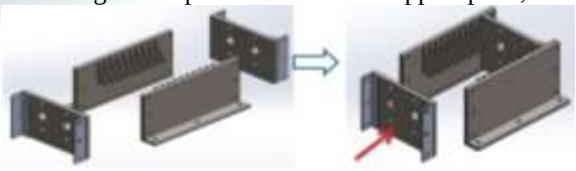


Then all side will join together to create shredder box

This assembly method helps to easy fitting of the previously sub assembled cutting blade assembly in shaft. The arrow indicated front shaft supporting plate in the above will be assembled after the two shafts are fitted to the inner box.

6.Sub-assembling Three

Fitting of cutting blades with the previously assembled shredding box exploded front shaft support plate;



in this step, it is process of assembling two sub-assemble to fining the shredder head assembly which contains the shredding box, cutting blade assembled in shafts, bearings, gears at the outside end of the two shafts. Figure below shows the step how to finalize the shredding head box.

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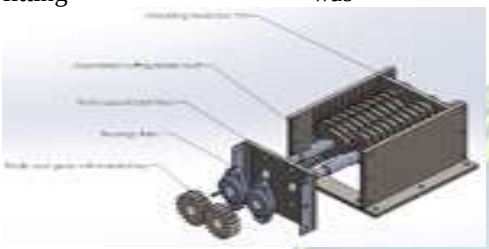
6.Assembling Four

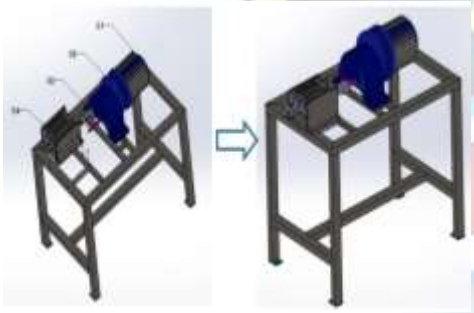
The table already prepared ergonomically friend and equipped with fitting hole for both the gear motor and the shredder head box. Then gear motor fitted first on the table or frame with bolt and nut before the shredder head box loaded to the table. Then coupling was connected to the gear motor shaft to connect with shredder shaft. Then the shredder head box loaded to the frame and then by sliding to the coupling hole and aligning to the holes on the frame, fitting was done.



The table/frame is prepared, gear motor was then fitted on the frame and the shredder box was fitted to the table by aligning its shaft with the couple connected gear motor.

7.Assembling Five

The hoper is simply brought and placed on



the top of the shredding head box the joined with small size screw type bolt/small size bolt and nut.

8. Assembling Six

It is similar to hoper and placed to opposite direction of hopper to receive a shredder plastic material. And its position is slightly tilted for easy receiving.

9. Finally Assemble the Electric Box on the Frame

Final assembly

IV. Result And Discussion

Most parts of the machine were produced/manufactured and assembled in Federal Technical and Vocational Education and Training Institute and some few parts in one of the satellite college which is Addis-Ababa Tegbareid-id Poly Technic College because of some difficulty of machine to produce in FTVETI. It is designed to shred any plastic in to small piece to ready it for further processing of recycling that aimed to minimize the problem of land filled waste plastics. The result of discussion conducted at each chapter is summarized as follow;

Appropriate Material Selection tor Each Component

With the guidance of different literatures, related documents and experiences, the right material selection for each component of this project was discussed and clearly analyses in material selection and design analysis chapter. Even though some materials are difficult to found or not available due to issue of procurement for the practical production according to the design and material selection, the necessary steps are clearly stated and conducted.

Appropriate Manufacturing Process to Manufacture/Fabricate Components of the Machine

Manufacturing of components of the machine laid majorly in machining process and the rest is by welding process. Machine tools such as Lathe machine, milling machine, band saw and drilling machine were used to produce the machinable component with an appropriate selection of parameters and variables. And the deserved quality and size of components were produced according the design and working drawing.

And based on the functional requirement and guide line of design for manufacturing, the weldable part of the machine was decided to use shield metal arc welding process because of its cost effectiveness, availability.

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Assembling and Testing

After manufacturing all the components of the machine, it is discussed that the assembling of parts should be as easy as possible for maintenance and repairing incase if there is a tendency of disassembling. So, as a result the critical part of the machine is discussed to be assembled in temporary joining method using bolt and nut for easer dismantling and the parts needed to be ridged were joined by welding. Electrical connection was done after the assembling of every physical components and it is discussed that to have three phase breaker, over load and start & stop push button for better electrical safety. And after successfully assembled each parts, operational testing was conducted. During testing of this machine, some activities have been made such as;

Coupling Connection Motor Driven Mechanism

We have test the coupling connection mechanism of the geared shafts and checked the cutting blade free load rotation, stability of the machine, revolution per minute of the cutting blades and free clearance rotation of the cutting blades.

Result of Cutting Testing

We test the cutting performance of the machine and as it rotates at its desirable rpm which is the rpm of the gear motor at 65 revolution per minute and waste plastic materials was added or feed to the shredder box through the inlet hopper and shreds into small size pieces (approximately 8-10mm). There are nine blades with three cutting edges for each assembled in two shafts and rotates at 65 rpm and each cutting edge touches the plastic to be shred three times in one minute totally 27 times shredding action is applied in one minute and the shredded plastics was dropped down to the outlet then delivered into the receiving part.

V. CONCLUSION

The importance of this machine is high in minimizing the problem of environmental pollution on land fill and sewerage line and it is the time to response for the environmental pollution by changing the throw away plastic to recyclable raw material by shredding into small pieces for further processing. It can shred any kinds of plastic.

This machine has the following advantages:

- Manufactured from local materials
- Easy to assemble and disassemble
- It does not need highly skilled man
- Convenient for transportation
- Affordable and cost effective
- easy to maintain
- environmentally friend and
- Creates job opportunity

It can be easily manufactured and distributed to various areas of our country especially in the main city of the country and easily adapted as technology transfer to SMEs. In summary this machine/project has the following advantages;

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