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DESIGN AND DEVELOPMENT OF FILAMENT MAKER MACHINE

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ABSTRACT

3D printing is the future of mass manufacturing which assists humans in making effective designs and also in prototyping of complex parts. Now technology has reached at a point where we can print an actual working component. Polymers are generally most preferable when we talk about printing, FDM being the most common practice for 3D printing. The cost of the filaments is a challenge that is being faced now hence modifications are being continuously worked on so that we can get the best results from it. We have designed a filament making machine with Polylactic Acid (PLA), PLA+, Acrylonitrile Butadiene and Styrene (ABS) as a material (Nylon and chopped carbon-fibre composition) Onyx. These materials have good melting points. Custom filaments are also an absolute way to get innovative with the present machines. It is of greater help in saving costs and also very assistive to small industries and workshops. Different types of diameters affect the print; also, the quality of the filaments affects the print. In this paper we will design and develop a filament maker machine that will be helpful in recycling the failed 3D prints and also support structures. This will also be an innovation in the R & D department for creating newer compositions for working.

Keyword: 3D Printing, Design, Extrusion, Filament, Plastics, Shredding

1. INTRODUCTION

3D-Printing is the future of mass manufacturing. This method of additive manufacturing makes manufacturing of complex parts and products achievable. This method of manufacturing is commonly known for its way of manufacturing parts with minimum material wastage and is unified manner. Hence additive manufacturing is getting in demand, in turn also increasing production using this specific method. As we know, small water droplets when gathered can fill up the entire ocean; similarly, the minimum wastage that we consider to be minimum once entered the mass manufacturing will cause stacking up of lots of waste. This waste most likely be involving all sorts of plastics, polymers, metals etc. In 3D-Printing support structure plastics are the most likely the waste generated in the entire process. This plastic waste can be and should be recycled for not only the sustainability involvement but also the cost factor [1]. Recycling is the perfect path for a sustainable future. This can be recycled by simple extrusion process. Extrusion is a process where a material undergoes plastic deformation by the application of a force causing that material to flow through an orifice or die. The extrusion of the material is highly dependent on the type of die which is used. This shape of the extrudate is dependent on the type of material that is used sometimes some post processing must be done to maintain the shape of the extrudate. This pushing force that is necessary for the extrusion is generally achieved by a compression screw or sometimes by piston mechanism. Extrusion can also be useful for pallet making in which the extrusion process is the same except for the post process where the discrete parts are cut into predefined shapes and size. Extrusion

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process in general has the involvement of three big factors namely shredding, extrusion and spooling/rolling. For accomplishment of this development of a mini extrusion machine is in process. This machine will be able to recycle some amount of waste generated in the process with converting the plastic waste into a filament so that the spool / filament that is recycled can be again used for 3D-printing and hence saving plastic waste and costs as well.

2. LITERATURE SURVEY

3D-Printing or additive manufacturing has been in working since very early stages of manufacturing. The most common technology in 3D-printer in today's world is Fused Deposition Modelling (FDM) which is used specifically for plastics which was developed by S. Scott Crump and then was commercialized by the company he owned Stratasys, which were the first once to market its FDM machine in 1992 [2]. FDM is often used for fine prototyping, manufacturing of plastic parts that can be directly used for the application it is designed. There are many benefits of 3d printing. But when we have benefits of somethings it also often comes with some drawbacks which are ignored as of now as the 3D-printing industry is developing many more machine that will be helping in manufacturing of more and more products and help in mass manufacturing. While surveying the performance of this form of manufacturing we know it's not yet at its peak. Industrial products face issues like the loss of linkage between all the parameters that are important for manufacturing like stability, materials, etc. about 100 types of materials are available and differentiated by types like polymers, ceramics, concrete, metals etc. Of all these materials polymers are the most commonly used material. This industry has now spread across many mainstream fields like biomedical, aviation, defence, toys etc. In India 3D-printing is mainly used for sectors like automobiles, construction, oil industry, electronics etc. The 3D-printing production rate is not as much as it should be expected but is constantly increasing day by day. A report stated that in 2020 the plastic consumption reached18500 tons [3]. But with increasing demand for 3D printing plastics this will obviously increase plastic waste. This topic is ignored and might be of great danger for sustainability. And now there isn't much information on the wastage either but assumed through the data also 5000 tons of waste is generated.3D-printing being the most promising method of manufacturing it will be utmost important to reduce the waste amount for a circular economy. Reduce Recycle Reuse is the way this must be headed so as to reduce the costs and the scrap as well. The recycling research done is limited and needs much more to be performed. The plastic waste that is generated from materials like PLA, PLA+, ABS, PET, TPU etc. can be recycled through the nominal extrusion process method which will assist the printing industry by reproducing the filament from the waste.

3. 3D-PRINTING AND SUPPORT STRUCTURES

3.1 3D-Printing

3D printing or also commonly known as additive manufacturing, is the structure build in three-dimensional environment which takes reference from the CAD model. 3D printing is a term that refers to many processes that go in background like the material gets deposited, joined under the reference of the CAD model that allows us to know the size and shape of the desired object, in which the materials are being added together (like all plastics, liquids or powder grains being fused together), in a layer-by-layer manner [4]. 3D-printing involves some main processes with which the term 3d-printing is incomplete:

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3.1.1 Modelling

Modelling is a term that allows us to create an object with the help of Computer using Computer aided design. Sometimes object can also undergo reverse engineering to convert an existing object into a CAD model. In this scanning the digital data points are being generated on the object and then imported to the CAD. Models made by using the CAD tool have relatively lesser errors compared to other methods. These errors if present are identified and corrected before printing for getting error less prints. This CAD has gotten its inspiration from the manual modelling methods that were followed from a long time like sculpting, clay moulding etc. These digital models can be exported into formats that are useful for printing like the STL (stereolithography) which basically converts the model into small triangle like mesh on the surface of the model. This triangulation takes place on entire model and make the STL file heavier due to large number of it. In 2011 a new format was introduced known as AMF (Additive manufacturing format) which tries to solve the heavy file format by adding curved triangulations.

3.1.2 Printing

When you have a designed model, you can use specific slicing software to slice the model. The slicing process is followed to cut the object into small layers and calculating the amount of material it will be using to print. Just like when we make a cake, we make it layer by layer to calculate the total material that will go in each of the layers to find the total filament go into making it. This slicing software will create a G-code file which contains all the instructions that are to be followed by the printer while printing. Slicers give us control where we can create personalized configurations according to different printers, filaments, and models and also the required support structures according to the model. Once the slicing process is completed, that G-code file will be shared with the printer. The printer must be calibrated so as to get better accuracy of the print. This calibration includes calibrating all the functions of the printer like bed, nozzle etc. During the printing process, you can observe the printing process through, or you can also monitor the printing progress remotely through camera stream in real-time. Monitoring the print in real-time helps us understand the layer by-layer configurations as we fed to the slicer.

3.1.3 Finishing

Post processing is an essential part of 3D-printing and is done to almost all the objects that are printed. Support structures are the main parts that need to be taken out as they are present only and only for support. The orientation of the part is an important factor while printing which affects the print quality and also save the material wastage. If printed in wrong orientation then this can lead to having of support structures that are difficult in the finishing stage. Some of the polymers like ABS allow to smooth out the surface finish by chemical vapor process based on solvents like acetone etc. Some 3d printer machine and processes allow the user to use multiple material in one object while printing; this helps to create multiple colour object and avoid the efforts of painting them after printing. In some processes the object required internal support to be made while printing, so the overhanging parts do not fail. These supports must be removed mechanically or by dissolving the support material using chemicals or water after the print is complete.

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3.2 Support Structures

Support structure as the term suggest are the part of the object that supports the parts that are overhanging or have no base for balancing. These are identified while slicing of the object is done. These supports are later removed while post processing. The stiffness of the material that is used in printing decides the amount that the overhang will support. The overhang could stick out more if the material used is stiffer. But at some point, the weight of the overhang will cross the balancing weight of the stiff material which can lead to failing of the overhang part. There is a principle that is being used while printing call the 45-degree principle which suggest that if the angle of overhang is less than 45 then there will be no need of support structures, however if the angle exceeds the 45- degree mark then the support structure must be added for safety of the object [5].

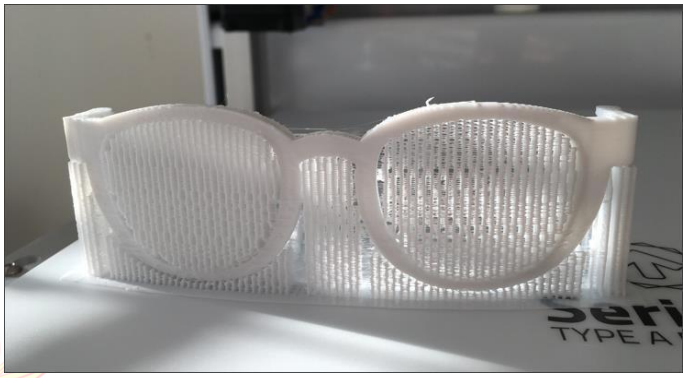

Figure 1: Support Structures

There for support structure are mainly dependent on the design of the object and also on the orientation that the object is being printed in. If all of these measures are followed, then this prevents from generating failed prints also retaining the print quality.

Figure 2: Types of Support Structures

The difference in these is just that in touch build plate option the support will remain in contact of build plate at all the time and only will be present in that area whereas if we see the place support everywhere option then the supports will be generated on the body as well. These structures are just used while printing have no later use and are generally scrapped. This leads to waste generation and affects the sustainability of the process. Therefore, for this very reason a mini extrusion machine is being developed which will perform the process of making a filament back from support structures and failed 3D-prints.

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Figure 3: Waste in 3D-printing

4. DESIGN OF FILAMENT MAKER MACHINE

4.1 Extrusion Process

Extrusion is a process where a material undergoes plastic deformation by the application of a force causing that material to flow through an orifice or die [6]. The extrusion of the material is highly dependent on the type of die which is used. This shape of the extrudate is dependent on the type of material that is used sometimes some post processing must be done in order to maintain the shape of the extrudate. In layman's language a material is pushed through a tool with a specialized shape called a die, producing continuous objects of a fixed cross-sectional profile.

4.1.1 Plastic extrusion

Plastic extrusion process is a large-scale manufacturing process that includes various types of polymers that are combined with additives which are melted together and then formed in a continuous process [7]. The process starts by taking the raw material that are polymers which are in pallets, or shredded form, these are fed through the hopper into the feed guide which guides them to the rotating screw which is rotated by help of a motor. The type of the compression screw varies from design to design and is mostly output driven. This rotating screw pushes the polymers through the heating chamber. The pushing forces compresses the polymer, plastics through the chamber. Two to three PID (Proportional Integral Derivative) temperature controller are added that create different temperature zones where the temperature gets increasing towards the end of barrel [8]. The temperature is set normally lower than the plastics melting temperature because during the pushing process extra heat is generated using the friction and force. The plastic is then pushed through a nozzle which gives us the desired output. Sometimes before the nozzle or the die a filter is added that filters out the contamination present if any. After the process when the extrudate finally exits the nozzle then it has to be cooled. The method of cooling is also dependent on the output that we have received and also size and shape of the extrudate.

4.2 Design of Filament Maker Machine

In the process of extrusion 3 basics step need to be followed for the turning the raw material to the desired material or output. These 3 processes include [9]

- Shredding: A shredder is a machine used for reducing the size of all kinds of material. Industrial shredders come in many different sizes and design variations for different applications. For this specific application a custom designed Mini Shredder is being made.

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- Extrusion: Extrusion is a process where a material undergoes plastic deformation by the application of a force causing that material to flow through an orifice or die. In this specific application the die used will be a nozzle that would convert the melted plastic into filament.
- Spooling: Spooling is the process of winding the filament that has been extruded by the extruder machine into the spool roll so that it can be used in 3D-printing directly.

4.2.1 Design of the Mini Shredder

The shredder that has be designed is 130.50 mm x 141mm and will be used for not only support structure but also for shredding failed 3d prints.

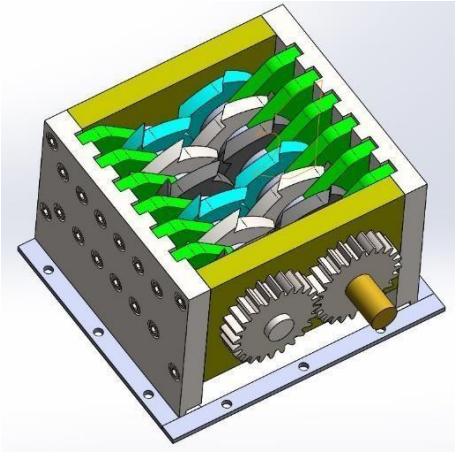

Figure 4 Isometric view of designed mini shredding machine.

The mini shredder contains a 12-blade system which are offset from each other at an angle of 22.50 for a good cut andshred. These blades have also been custom designed as this small size blades are not only rare but also the design is custom.

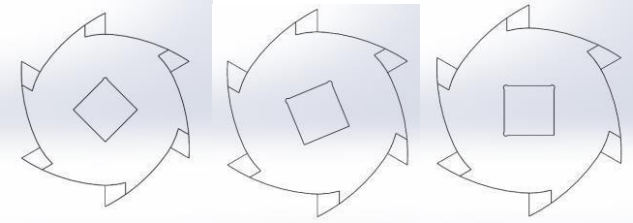

Figure 5 Shredder blade design

To hold this blades sperate from each other a spacer is also being added in between each blade. This spacer has the job to keep each blade in its region and also so that blades don't movewhile crushing.

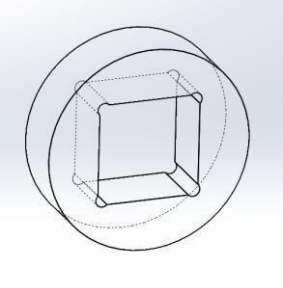

Figure 6 Shredder spacer between blade design

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This are connected with simple spur gears also with customdesigned shafts. The shredder will be attached with a mesh to get uniform shred out of it. As the shredder is directly connected to the next step which is extrusion uniform and small shreds are essential for the filament uniformity [10].This mesh is kept detachable for easy access of the piece that won't be uniformly shredded assisting in re-shredding of the scrap that will be left.

4.2.2 Design of extrusion process

The extrusion process is basically the same just in small factor. This small factor is what will be making this a challenge to build. The parts that will be involved in the process will be.

- **Heaters**: For heating band heaters will be used. These heaters will be responsible for generation of heat. Band heaters are ring-shaped heating devices that clamp around a cylindrical element [11]. Heat transfer from band heaters occurs via the conductive method. Most band heaters clamp around the outer diameter of a cylindrical element and heat the element from the outside. Some products clamp around the inner diameter of a pipe. Typically, band heaters are equipped with ceramic or mineral insulation to reduce heat loss to the environment.

Figure 7 Band heater

These heaters are accompanied with thermocouple for measuring the heat and a PID temperature controller is added to the process so as to maintain the desired temperature [8][11]. This will be the function of the heaters.

- **Extrusion**: screws an auger drill bit will be used for pushing the melted plastic further into the nozzle.

Figure 8 Extrusion Screw

This will be the guide to the plastic towards the nozzle using the spiral shape [12]. In this project a drill bit is used but generally a compression screw is used in an actual extrusion nozzle; but due to budget constrain a drill bit will be used in this.

- **Nozzle**: A nozzle is a sort of a die that will be used to take the input shape to output in this case molten plastic to Filament of 1.75mm or 2.85mm diameter depending on the requirement.

Figure 9 Extrusion Nozzle

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This will also be a custom nozzle for this project as we need it perfectly finished with good material properties. Nozzle will determine the controlled output of the system [13].

- **Connection between shredder and extruder:** Connecting any two things often needs a bridge as a guide for perfect execution. This project we will be directly connecting the shredder to the extrusion pipe by using custom designed system that will collect the shredded grains and will take them through a large to small diameter pipe so as to reduce the surface area in return increasing the pressure at the point of inlet for good.

The system will also be attached with one heater for moisture reduction in the process. This will then help to reduce the air bubbles in the filament which will help maintain the diameter of the output.

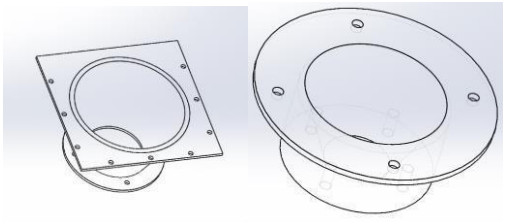

Figure 10 Connector between shredder and Extrusion pipe

4.2.3 Design of Cooling system

The cooling system is used for reducing the heat after the output this is done so that there will be no further deformation in the diameter. This is a water-cooling system for quicker results and also can clean the filament while of any dust settlement after the extrusion [14][15]. Also, this system will be using the guide holes for guiding the filament.

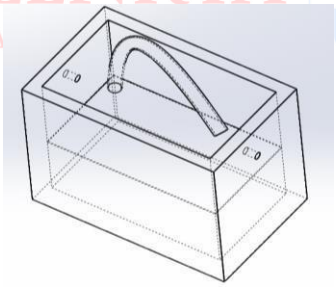

Figure 11: Cooling system

This is the cooling system that helps in maintaining the diameter of the filament.

4.2.4 Design of Spooler

Spooling is the winding process of the filament this is done simply by using a DC motor attach to roller and the spool case [16]. The spool case used will be universal as that same casing can be directly used for 3d printing.

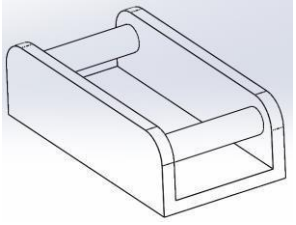

Figure12: Spooling case

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4.3 Design of Assembly

The design for the machine was completed with this and nowcan be proceeded to the manufacturing of the machine part by part.

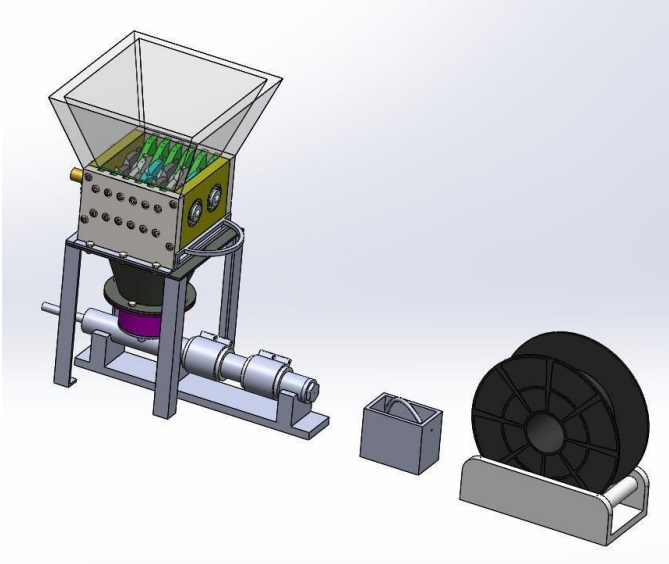

Figure 13 Assembly of the system

This machine now according to the design has the capabilityof turning the scrap of the 3D-printing into the useful filament if all works like as planned. This design can also be used in thehome of ourselves where we can shred and use the plastic PET bottles in our benefits to create a filament at home and then selling it at some cost rather than just scraping it and increasingthe plastic waste. This machine also aims at reducing the plasticwaste and keeping our earths sustainability in the hands of us.

5. MANUFACTURING PROCESS OF FILAMENT MAKER MACHINE

5.1 Process Planning

The manufacturing process of this system widely depended on the materials of use and the customized parts of the machine. This machine, as discussed consists of three main parts namely shredder; extruder; spooler. Each of these had the introduction of some standard parts as well as some customized parts. Most of the machine's main parts in extruder were kept as standard so that the maintenance of the machine will be easier and can be performed by anyone. This also help reduce the initial cost of manufacturing as standard parts be readily available. The planning at the current stage will be starting with the manufacturing of the extruder in first as that is the part that will be the main function of the project.

5.1.1 Manufacturing of the shredding system

The shedder system consists of the shredder and its supporting parts. The shredder is the part of the machine which is useful for shredding the components. This basically converts the scrap parts into small granulates. These granulates are being directly used for extrusion process. Manufacturing of the blades, spacer, cover plates, Shafts. The blades were the first parts that were manufactured as the rest of the machine depended on these. The blades were made out of D2 tool steel. This material was selected as this material shows some properties that can be very helpful for us achieving the aim. The high wear resistance is one of the main factors

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for choosing the tool steel as these blades will be in contact with each other and also have to go through a lot of wear and tear for every time the shredder blades do rotate. Also, the hardness of the tool steel is a good reason to pick theD2. The dimensional stability that it offers is very useful in this application as the size is small and accuracy needed is more. This material after hardening shows very good surface hardness and toughness of body. After buying the material the next step was to get the blade shape wire cut for which a sheet of 8mm thickness was chosen. This was the method that was used for this. For this wire-cutting the *.dwg* file was used. This file contains the shape of the blade without any of the other features of it. This method is just used to get the basic shape out of the blades. These blades are then chamfered at the edges to have a pointed blade so that it can pierce through the plastic. This was the way for manufacturing of the blades and this method was used on all of the blades. Also, the spacer being as equally important as the blade was also wire cut for better operations. This is the basic requirement of the components. These spacer and blades were then check for assembly.

Figure 14 Blades

The building of plates was done so that they could have the housing of the guide that will be placed in between the blades and also this will be moving with the spacer that is inserted. This will be placed exactly as shown in the assembly of the shredder. These guides also known as spacer between blades were also wire cut as per the design so that the precision would be maintained as desired. So now we can achieve the parts that are important to use.

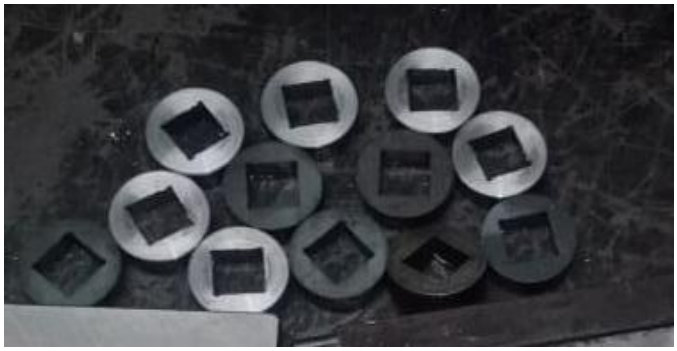

Figure 15 Spacer

Then the side plates were made using regular machining and which had to be done in the way so that all the parts have clearance and can fit through it perfectly. This method also allowed us to use the clearance for reworking and can be done for excess materials. This way we were able to achieve the production of the plates also. Then also in the plates as there is a need of bearing contacting the plate and the shredder shaft. This way we can also implement the perfect smooth motion and can ensure that all the rotary motion happens with minimum wear and tear. This bearing that are used are the standard 6202 bearing of SKF. These bearings are chosen as per the requirement of the diameter and also as they follow all the requirements in the speed as well as strength

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departments. These bearings where then fitted into the plates carefully and then a shaft is placed for checking of the area of the fit. This is how the bearing is been fitted in the position.

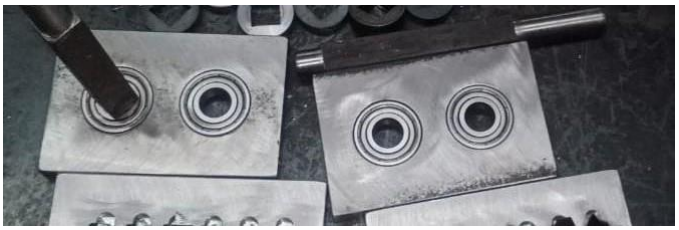

Figure 16 Plates and bearings assembly

The shafts that are manufactured fit perfectly through the bearing that are made for. The bearings here as seen in the image have been press fitted and little machining was required to get them perfectly in place. The assemble process was simple as and will as one would think of it to be. The assembly the first step that was followed was the checking of all the fitments and areas for errors were thoroughly check. While the assembly all the parts that were the main parts like the blades and spacers and the spacer between blades was the first check. Once done with the trail assembly then there is one more thing to do which is partial checking. In this check the machine is checked with its performance without an external motor. This way we understand the assembly in detail. They are just placed in their positions and seen how the tolerances have been performed. They can be seen in the image below how the function has been done and how are the assemblies holding on.

Figure 17 All parts of shredder

In this FIG we can see all the parts essentials have been manufactured and now the final assembly is left to be done. But before performing the assembly there again needs. Also, there are gears that need to be added for the assembly to be completed and in working condition. As the machine will be working off of the single motor then this will be affecting the other speeds for that a pulley combination was used to control the speed.

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Figure 18 Gears

Well in the gears in shredder the ratio of the gears is 1:1. This helps the blades to stay together without missing the sharp point contacts. This also ensures that the shredder will be performing similar on both the shafts of action. Then putting all the parts together was done. A hopper was also made from acrylic sheet which was then glues together for making the hopper. Post this the shredder machine was complete and the final assembly of shredder was made.

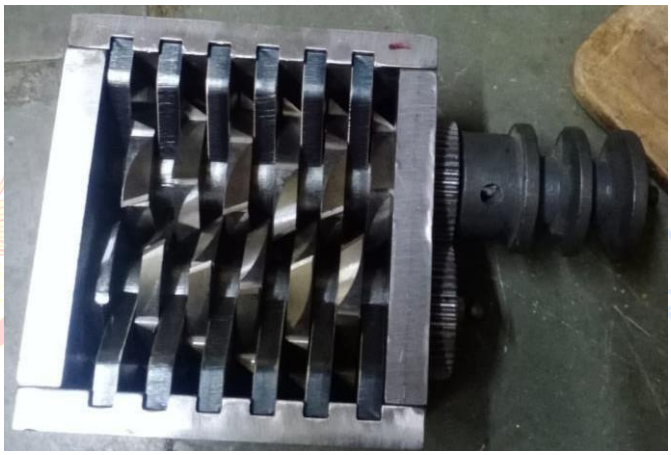

Figure 19 Full assembly of shredder

5.1.2 Manufacturing of extrusion system

The manufacturing of the extrusion system mainly uses assembling of the standard parts together for the perfect working of the machine. This included some important parts that include Band heater, barrel screw, extruder barrel, PID temperature controller, motor, gear box, hopper (which will be connecting the shredder to the extruder), Nozzle, belt, pulley, Extruder holder. These are all the parts that will be involved in the process of building the extrusion machine. Assembly of this was done by getting all the parts together and fixing them manually.

Figure 20 Compression Screw.

The drill bit that has been used needs machining done on it for removing the head of it for achieving a good flow of materials. This ensures that the amount of material flow that is being made has to carry uniform pressure and also can direct the material to nozzle easily. Nozzle was machined through a rod that was taken. This way we

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can used the nozzle as the head of the machine. The nozzle was given the out diameter of the1.75mm as that is the desired outcome that is expected from the machine.

Figure 21 Nozzle

These are standard size band heater with inner diameter 30mm. These are standard hence were easy to install with the pipe. But the main challenge in heaters was attaching a PID temperature controller. REX C-100 has been used in this which is also available as standard. The connections of this are done manually. This also is attached to the thermostat that will be responsible for sending the temperature information to the PID which will be displaying the temperature.

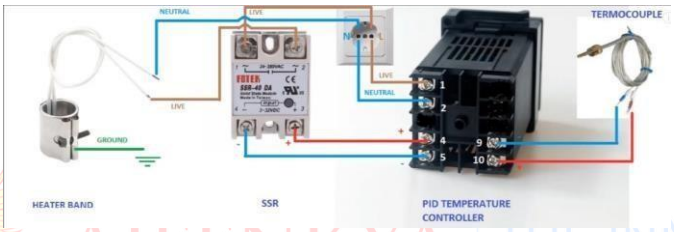

Figure 22 PID Connection

Now once this gets connected to the PID temperature controller we have the basic assembly of the extrusion system is ready and now must be attached with a motor for applying the force to push the material out of the nozzle. This motor may not be necessarily as powerful as the shredder motor this power should be enough to generate the power to push the material inside the pipe towards the nozzle. There will be a cooling system that will be attached after this which will be using a water pump that will keep the water flowing through the system at a constant speed. This cooling system will help to maintain the diameter of the filament as there will be no deformations after this. Also, the casing that will be holding the extrusion pipe is customized. This is made so that the extrusion pipe can sit a little high up and would be free from sharing the heating with the ground. For this application the motor is used. The motor used will be having 2 pulleys one will be driving the extrusion screw and then one will be for the shredder. The motor will be driving both of these and will be able to take the load that the extrusion will exhibit will functioning.

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Figure 23 Motor

Also, in the extrusion base the connector in between have been manufactured the upper connector is made from nylon. This is done in as to save costs. As this is the guide for the shredded parts. This granulates will be the ones passing through the nylon guides. This way we can while saving costs also satisfy the purpose. The main of the working will be done below the connector 2 which will be housing the extrusion pipe and the heater. For this a mica heater is being used which will take the temperatures to the point where we will be able to melt and extrude the plastics. The plastic range of temperature vary in between 120-220□C which will be the temperatures that we will be making. This will also be holding the nozzle. Post the nozzle there will be a spooler that will be taking in the filament that will be coming out.

Figure 24 Extrusion Pipe

Figure 25 Connectors between shredder and extrusion pipe.

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This will be the final stage of the manufacturing. After this is done then combining all the manufactured parts into one is the only thing remaining. The output of these will be generating the filament for usage in 3D-printing. This machine as of now has the capability to shred the metal objects which can be used as shredder. However, there is one issue that when metal parts are shred the blade tips might get chip off and hence then would be damaging the shredder. Hence it will be recommending the only plastic parts will be shred.

CONCLUSIONS

3D-prinitng is now reaching the peak of the market due to its ability of creating an object just as imagined. This tool definitely gives the designers a free hand and also the manufacturers pockets are filled. This creates a win-win situation in the market which is what always have been seemed. This also generates new possibilities of manufacturing as these removes most of the manufacturing limitation and also reduces the cost of manufacturing. This gives the people also products at cheaper costs. This 3D-printing can also be a desktop printer which are smaller in size and can perform the tasks at smaller scale but can be used at our homes and can also be used as a small office printer for small stuff. The materials that go into the 3D-printing also have variety of with printing can be done, materials like all types of plastics like PLA, ABS, PET, PETG, TPU, Nylon, ASA, PC, ULTEM etc.

these are only some of the common plastics that have been used. Also, a variety of metals has been used and even paper and food has now been started in printing. Definitely the creativity of manufacturing or printing is in our hands and till our limitations. When we talk about large scale industries then they use this technology for prototyping of machine parts that can actually be used in the application it is designed for. This emerging technology has been making promises that might change the look of manufacturing industries someday. But as every coin has two sides there is a dark side in 3D-printing too. The waste generated from 3D-printing is one of the concerns that need to be considered before this system booms and outgrows waste management. Most of the waste that is generated is from plastics and there is a heavy chance of recycling the plastics. Already as known the plastic waste is a major concern and is growing day by day. This machine will be generating the filament from the scrap that is all around us specifically the ABS, PLA scrap that we see. The development of this machine will be very helpful to all the 3D-printing technologies as this will help them make filament from the waste that is generated from their side. This recycling method allows them to recycle plastics in their offices which can be reused and hence can be developed in a way that it will also help reduce the cost of manufacturing of these filaments and will progress in making this technology more affordable for even the small-scale industries. This helps these industries to generate some ideation to grow in the direction that they have been desiring of. The machine can also be very useful when it comes to uses at our home. The PET bottle that we use are generally scraped. Using this PET bottle, we can also generate a semi-transparent filament at our houses without any help from other. This will also reduce the wastes that are generated by every common man. This will be of greater use to planet earth and will start building a sustainable future. The application of this machine is also being in to creating and then using products that are generated through the injection moulding which can be attached as a further upgrade to the machine which will help use the house scrap in the house with newer applications. The limitation of this machine is not only restricted to recycling but there is a lot of scope in the Research & development of new materials. The scope to try out and test forming of new materials will also be

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helpful as these accidentals discovers can create miracles that we never been known of. This is a new way in material discoveries as newer materials can be tried and tested in this product and can also give us new ways to look at some materials. Waste materials can also be a good companion in making newer materials. These are the benefits of this machine. This system helps in solving problems related to wastage in the developments in 3D printing. This will lead to not only a reduction in plastic waste but also in the costs of filaments. This study is just the design of the mini filament maker machine and is still in the development post which more application of the same can be developed and hence will lead to more recycling and hence increasing the sustainability of the 3D-Printing universe. This will be leading us to a better future where may be waste management will be lesser of an issue and will be able to generate more creative minds from this as this machine requires only our limitation as the barrier in discoveries as well as recycling. These machines will be able to handle the household scrapes to generate filaments.

In the early future the scope of this machine will be to reuse the plastic waste generated by the 3d printed plastics. The next step after manufacturing the first iteration of the machine will be checking the problems that will be faced in the process. The main output needed from the machine is the filament and its close to perfect diameter. More work is under-going to check and maintain the diameter of the filament. The future scope for this is unlimited application build that are possible through extrusion. Designing and changing of the nozzle can lead to different products that are just as profitable as the machine itself. In the near future the possibilities of this machine to produce the filament and experiment with its compositions can help development of newer materials that can help us build sustainability too. This usually is the method for R&D which assists. These compositions can be of great help to us in developing materials that can be useful for application that haven't yet been found of. This being an extrusion system can be changing the nozzle with the any die that is required for any application thought of. Customization can lead to solutions that are only limited by our imagination. With the proper application and design this machine can be customized to reuse the plastics that are being held in our houses. This recycling method of plastic will definitely solve the problem of sustainability. Being an application-oriented project there are many modifications that can be performed so as to make the machine perfect.

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