SPUR GEAR DEVELOPMENT USING ADDITIVE MANUFACTURING TECHNIQUES

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Abstract - Convention manufacturing processes are based on cutting the material to obtain a final product. The additive manufacturing process, as the name implies suggests a different approach path applying adding material layer by layer to obtain shape/product. This paper proposes suitable aims techniques and materials that can be used to manufacture mechanical gears. The project then prepares a gear model to perform structural stress analysis. Later, the analysis was performed on a custom-made gear and on a gear manufactured for additional production.

Key Words: Gear, Additive, Analysis, Stress, strain, 3D Printer …

1. INTRODUCTION

Additive manufacturing is the method of manufacturing 3D objects by depositing materials layer by layer with the 3D printer. Initially, it was used only for the production of functional or aesthetic prototypes, but thanks to the consistency in this field and the increase in precision, material range of materials, and repeatability of this technology, it has become an industrial production technology.

Additive manufacturing offers tremendous benefits and is used in a variety of various tasks. It is used in the aerospace industry, it is used because duet's ability to produce complex geometric parts and its weight-saving properties used process method aerospace industry is FDM.

In the Automobile industry, additive manufacturing is used with various materials d for rapid prototyping with cost and weight reduction reductions making parts that are ready-to-use parts for as not yet been realized only available for the design of elements in a few vehicles. In the medical field are more increasing.

1.1 Problem Definition

His project will focus on the possibility of using fused deposition modeling as a method to produce functional tooling for manufacturing spur gear manufacturing gears will also consider the use of printing as a direct manufacturing process for spur gears because the cost of 3D printing materials for high-volume production can be very high, for large-scale manufacturing we will also compare the manufacturing cost and feasible batch size with the existing injection molding process.

1.2 Objective

For applications where only a small number of units are required injection molding may not be a viable option.

Due to the fact that the initial cost of designing tooling molding is very high, this hashed is only cost-effective when very large quantities need numbers manufactured. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

The goal of the objective project is to make use of one of the rapid prototyping methods process). Fused deposition modeling as a manufacturing method instead of Injection Molding whenever a small quantity volume of suction is required to achieve a reduction in cost and time.

2. METHODOLOGY

Every production technique involves distinctive stages of manufacturing like cloth series, education, layout, modeling, fabrication, and inspection. Identical to plastic spur gear production specific stages are involved as shown in the parent. Like the selection of materials, modeling of spur tools, conversion of modeling record to STL record, slicing of the modeled spur gear, and three-D printing of spur equipment.

In the first level, fabric is selected on the premise of its properties after that spur tools model is created via CAD software, and conversion of this version is into STL (standard Tessellation Language) after that reduction is accomplished to create the 3D printed thing.

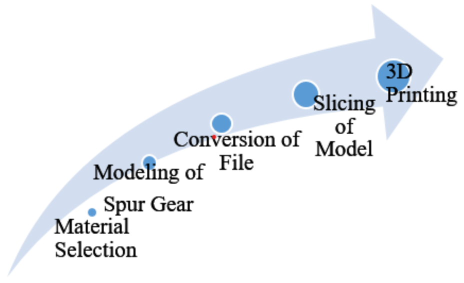

Fig -1: Stages of Plastic Spur Gear Production

FDM elements are used to provide direct tooling through the use of the burnout method; however, no widespread efforts to apply those FDM parts as a right-away tool in the form of mildew for generating wax patterns were made. The FDM molds have a longer lifestyle compared to the rubber molds produced by way of the present process of silicone rubber molding.

However, the surface roughness related to the FDM elements makes it less appropriate for the usage of it as an immediate tool. Also, the wax gets trapped inside the layer-to-layer gap, and as a result, the elimination of the wax sample without detrimental to the pattern isn't viable. Right here the authors have made an attempt to provide FDM molds in order that they can be used as direct tooling in place of steel molds which are made by conventional production.

3. CAD MODELLING AND ANSYS SIMULATION

After calculating all of the forces that we are acting on the gear and required for equipment production. We evolved our CAD version of equipment with the use of SolidWorks software and did a simulation using Ansys. The CAD model is observed with the aid of the Ansys simulation cited in this phase.

3.1 Steps for 3D Model Production

- Select the plane on which the design wishes to be drawn.
- Pick sketcher is used to create a 2D representation of the element and create a spur gear profile.
- After growing a profile exit from Sketcher and enter component layout.
- By using the use of the padding alternative upload fabric to the profile of the spur gear.
- In the end, by the usage of the slot option make a slot inside the hole created with the aid of the pocket at the spur tools face. The final modelled spur gear as shown in Fig.

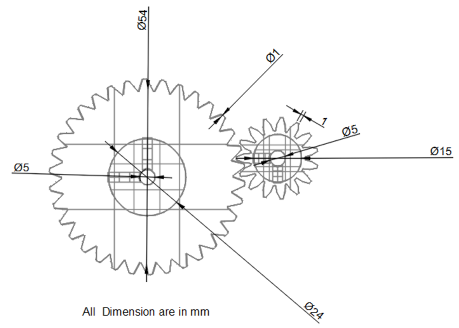

Fig -2: Gear of 2d view

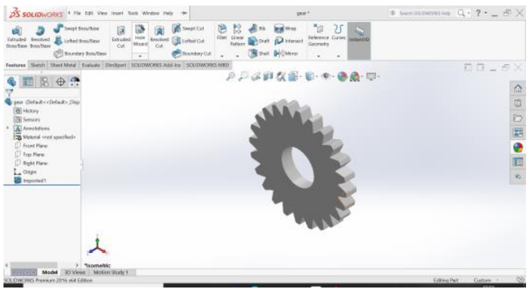

Fig -3: Spur gear 3D modal

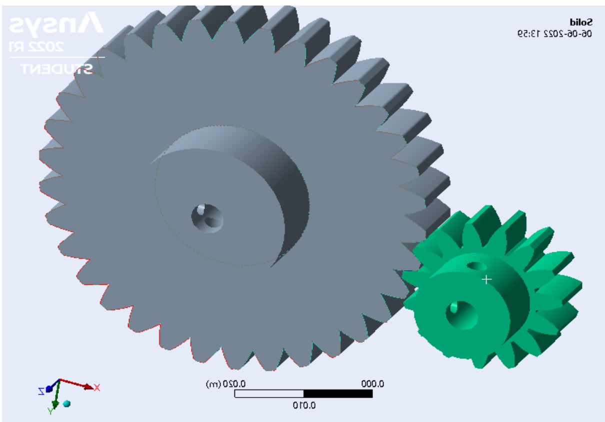

Fig -4: Material apply

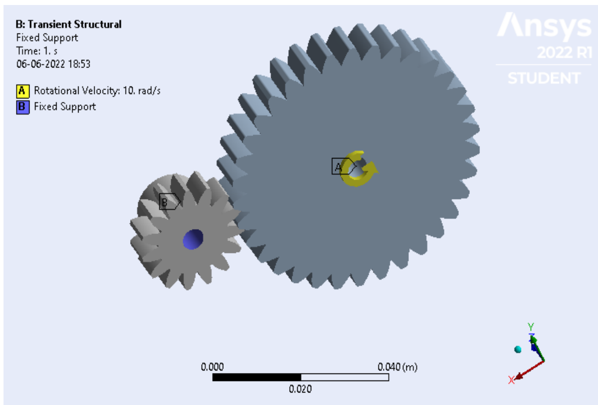

Fig -5: Boundary condition

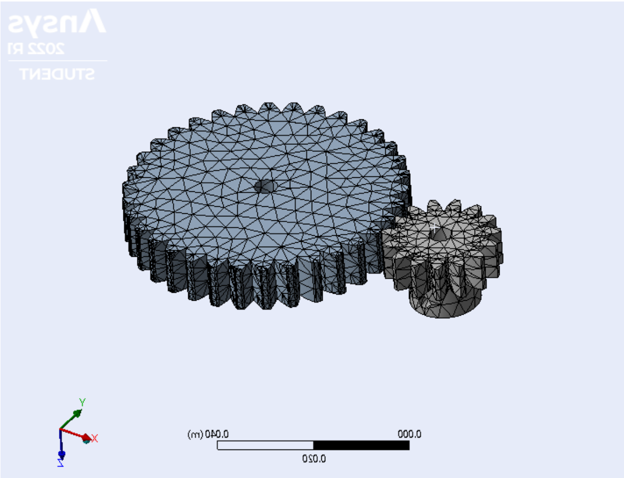

Fig -6: Mesh modal

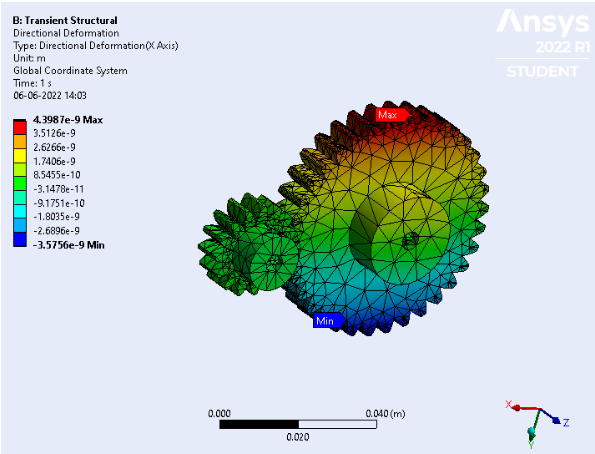

Fig -7: Directional deformation

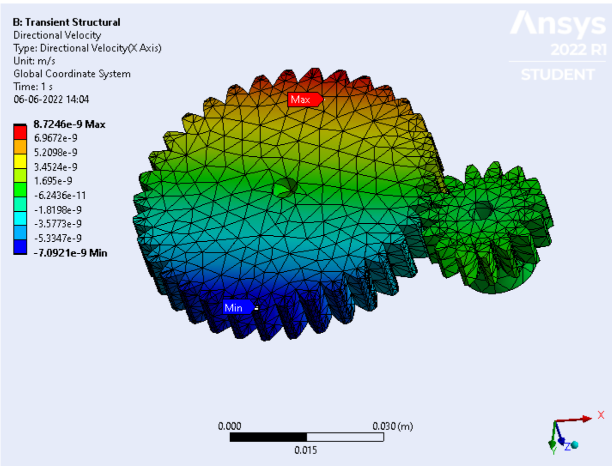

Fig -8: Directional velocity

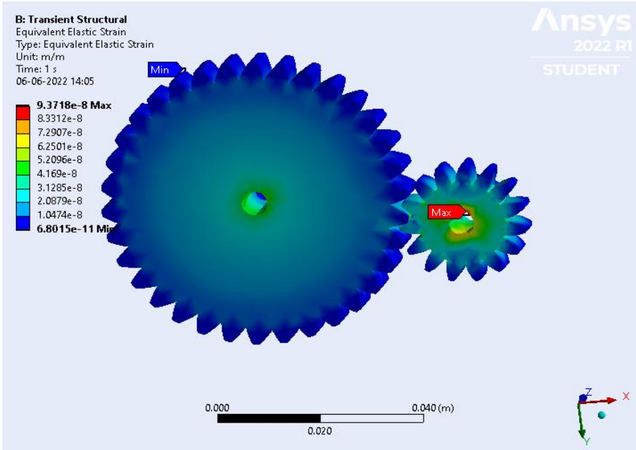

Fig -9: Elastic strain 1

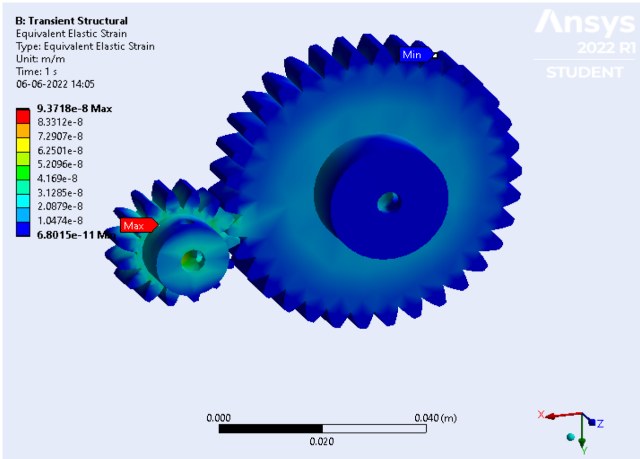

Fig -10: Elastic strain 2

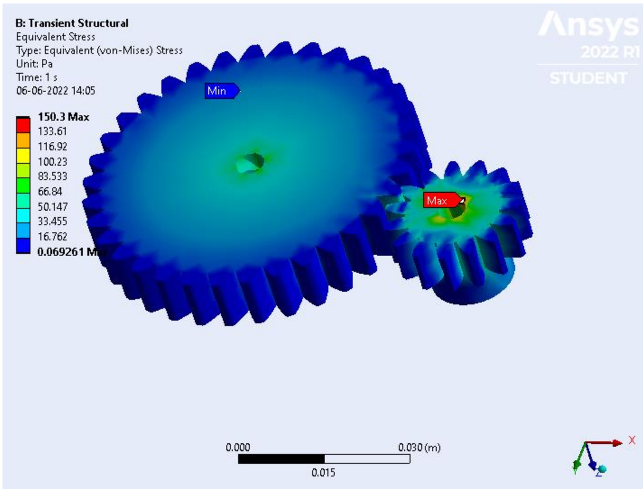

Fig -11: Equivalent stress 1

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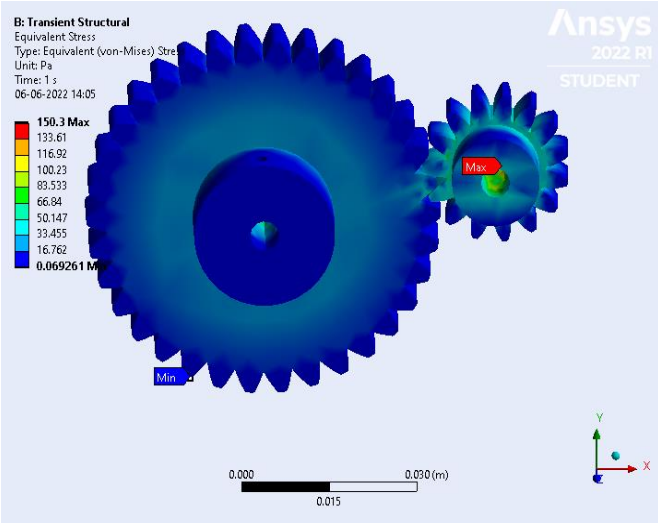

Fig -12: Equivalent stress 2

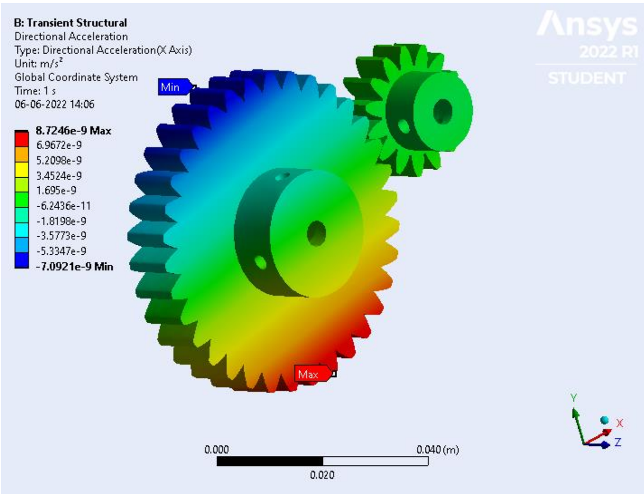

Fig -13: Directional Acceleration

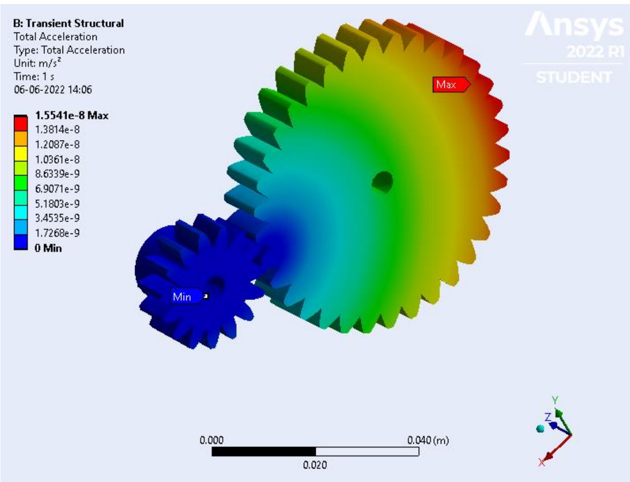

Fig -14: Total Acceleration

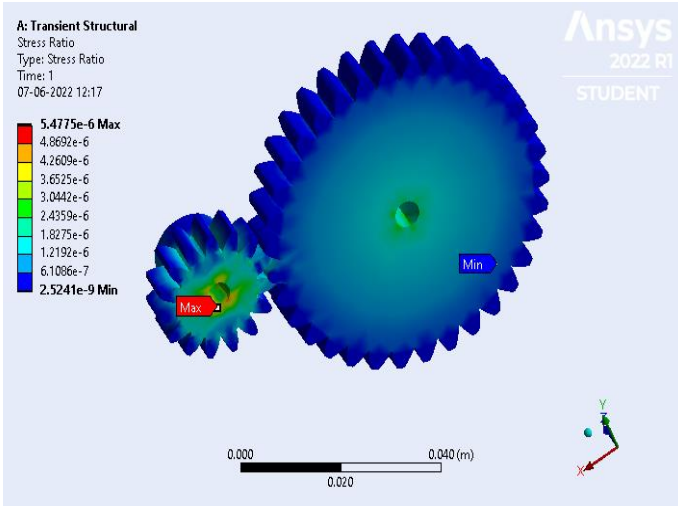

Fig -15: Stress ratio

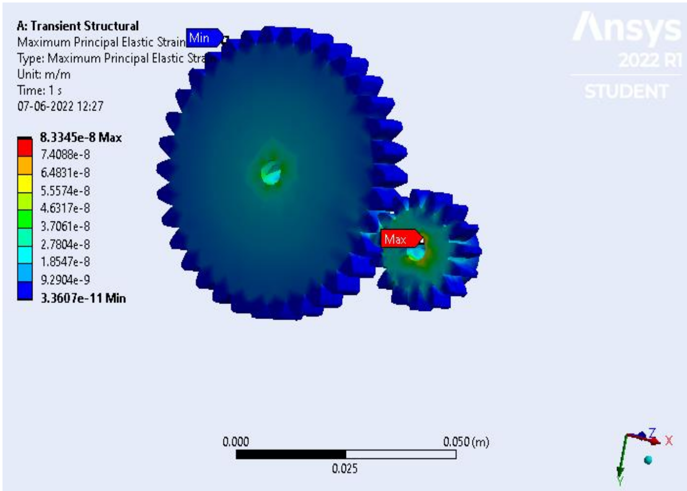

Fig -16: Maximum principal strain

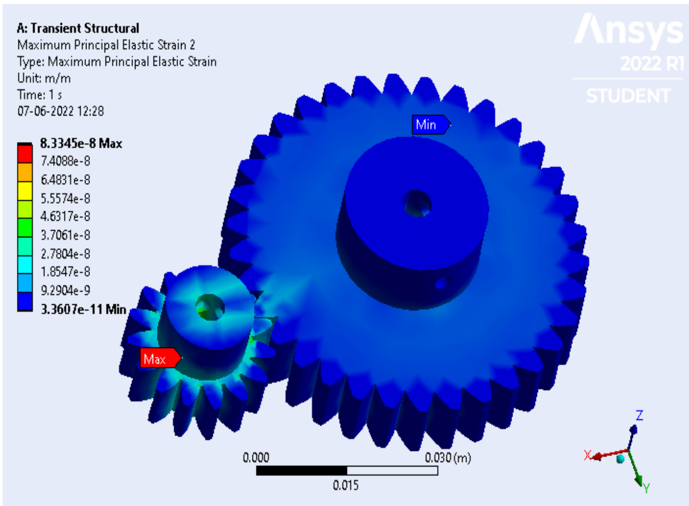

Fig -17: Maximum principal strain 2

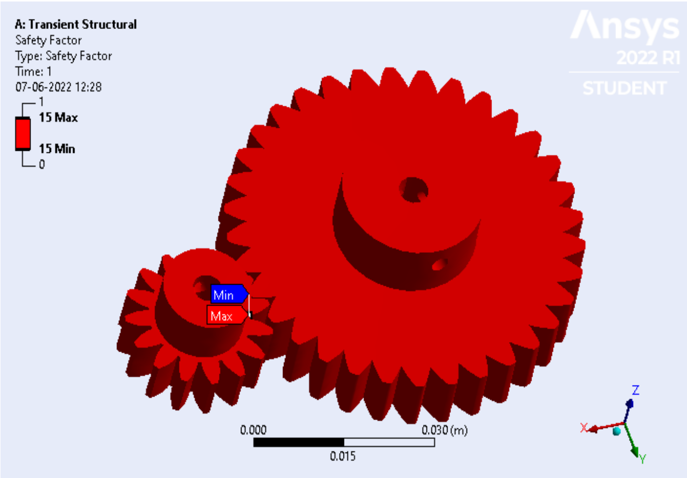

Fig -18: Safety factor

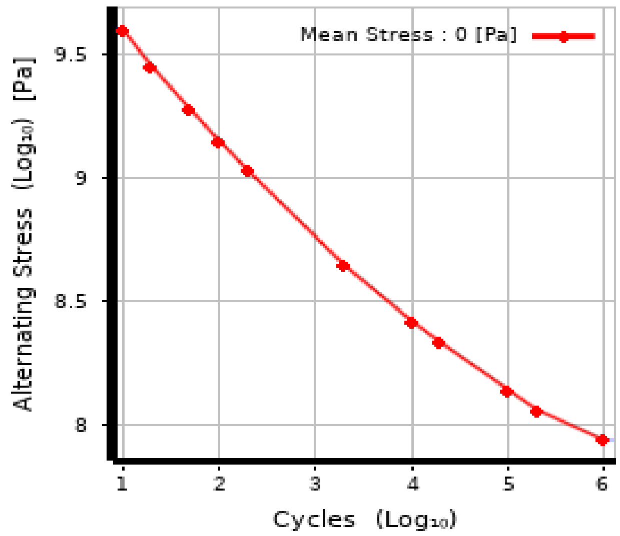

Fig -19: Alternative stress (before)

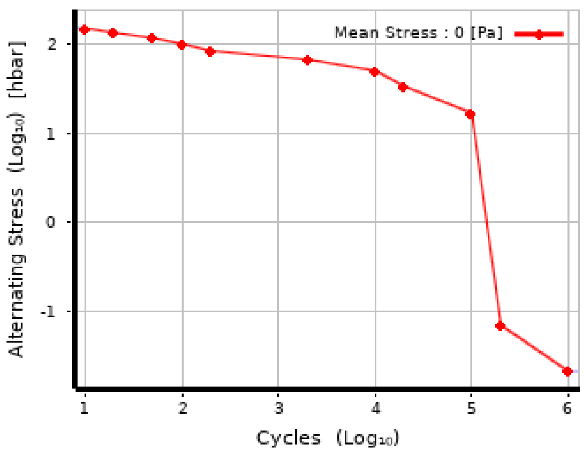

Fig -20: Alternative stress (after)

Table -1: Result gear analysis (ABS material)

Results	Minimum	Maximum	Units	Time (s)
Directional Deformation	-3.5756e-009	4.3987e-009	m	1.
Directional Velocity	-7.0921e-009	8.7246e-009	m/s	1.
Equivalent Elastic Strain	6.8015e-011	9.3718e-008	m/m	1.
Equivalent Stress	6.9261e-002	150.3	Pa	1.
Directional Acceleration	-7.0921e-009	8.7246e-009	m/s²	1.
Total Acceleration	0.	1.5541e-008	m/s²	1.
Safety Factor	15.	15.	Units Unavailable	1.
Safety Margin	14.	14.	Units Unavailable	1.
Stress Ratio	2.5241e-009	5.4775e-006	Units Unavailable	1.
Maximum Principal Elastic Strain	3.3607e-011	8.3345e-008	m/m	1.
Maximum Principal Elastic Strain 2	3.3607e-011	8.3345e-008	m/m	1.

4. FUSED DEPOSITION MODELING

4.1 Fused Deposition Modelling (FDM)

Method a movable (x-y movement) nozzle onto a substrate deposits thread of molten polymeric cloth. The construct fabric is heated slightly above (about 0.5c) its melting temperature so that it solidifies within a very brief time (approximately zero.1 s) after extrusion and bloodless-welds to the preceding layer as shown in discern various critical elements need to be taken into consideration and are regular nozzle and cloth extrusion charges, the addition of aid systems for overhanging functions and speed of the nozzle head, which affects the slice thickness.

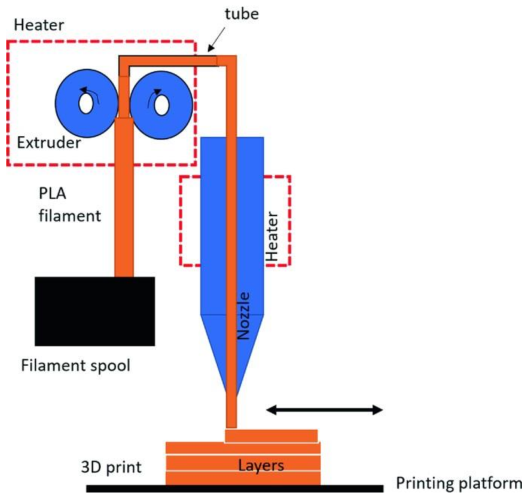

Fig -21: Fused deposition modeling (a)

Greater latest FDM structures consist of two nozzles, one for component cloth and different for guide fabric. The guide cloth is exceedingly of negative high quality and may be broken without difficulty once the complete component is deposited and removed from the substrate.

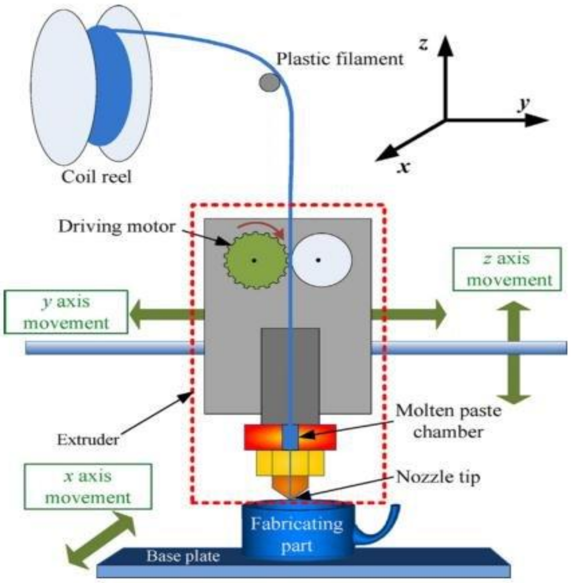

Fig -22: Fused deposition modeling process (b)

In the latest FDM generation, water-soluble support structure material is used. Help structures can be deposited with lesser density in comparison to component density by imparting air gaps among consecutive roads.

4.2 Significance

No intermediate process is required (like SLA styles in case of silicone rubber molding or RP styles for generating steel tools) and gear may be made directly from CAD data. Time-saving as an intermediate step of sample-making isn't required.

Gear made out of FDM is more potent, not pricey, clean to manufacture, and has a longer life than current silicone rubber molding. Complex elements that are not viable to be made the usage of Silicone rubber molding are viable using FDM.

4.3 FDM 3D Printer

The fused deposition modeling printer used is the Prusa i3, from Prusa studies. This printer prints most of its plastic components. All parts of this 3D printer are Open source and are part of the RepRap mission. The nozzle is able to circulate in the Y path whilst the platform has stages of freedom shifting in the X and Z guidelines.

Table -2: Printer Specification

Printing Material	ABS or PLA
Material Color	Red, White
Nozzle Type	Duel Nozzle
Bed Size	225 X 150 X 150
Resolution	70 – 400 Microns
Extrusion Temperature	ABS : 240-270°c , PLA : 200°c
Platform Temperature	60-100°c

The printer may be taken into consideration as 3 important components: the filament or spool, the extruder, and the platform.

The filament is the material that is used to create the item, the extruder heats and extrudes the material and the platform is in which the fabric is deposited. By way of an aggregate between the extruder and Platform movements, the device is capable of creating any 3D form.

4.4 3D Printing with ABS Plastic

Acrylonitrile Butadiene Styrene (ABS) is certainly one of the most popular thermoplastics for three-D printing. Thanks to its sturdiness, high warmness, and wear resistance in addition to its notably low cost, ABS is commonly used in a variety of consumer and business applications.

ABS is likewise acknowledged to be stronger and more durable than PLA, another favored thermoplastic, although a little bit trickier to work with.

Nowadays academics will look at the blessings and limitations of 3D printing with ABS, and additionally deliver a few hints for how to triumph over not unusual difficulties and make 3-D printing with ABS as simple a technique as possible.

4.5 Why 3D print with ABS?

Strong mechanical properties: ABS possesses first-rate mechanical houses, especially in comparison to PLA. Its longevity, durability, and ductility make it a wonderful fabric for "put on and tear" programs. In contrast to PLA, ABS can also resist high temperatures and has better elongation at destruction.

Post-processing: ABS lends itself nicely to various publish-processing techniques. Sanding, portray (with acrylic paints), gluing, milling, drilling, and reducing – all of these post-processing steps may be accomplished with an ABS component. As an acetone-soluble plastic, ABS also can be smoothed by means of acetone to acquire a smooth floor end.

New materials: ABS can be used to create substances with better homes. Such substances include homes like biocompatibility, conductivity, and translucency, to name some. Like nylon, ABS also can be mixed with other materials for greater mechanical residences, e.g. G. Computer-ABS (polycarbonate-ABS) with superior strength and warmth resistance.

Accuracy: 3-D printing with ABS can create dimensionally correct components. , ABS prints have a tendency to be dimensionally correct with minimum functions as small as 1.2 mm, even though it needs to be cited that printer settings and the complexity of a part particularly decide the level of accuracy.

What are the limitations of 3D printing with ABS?

ABS is hygroscopic, which means it absorbs moisture from the air. If not stored efficaciously, humid ABS filaments can lead to both a negative first-rate maybe to a failed printing technique because of clogging of a nozzle.

ABS materials can be broken via extended publicity to sunlight, with the intention to negatively affect the exceptional of a print. So for the programs that will be exposed to direct ultraviolet light, it's better to pick a UV-resistant filament, for instance, ASA.

While running with ABS, the proper temperature placement is needed to ensure that a print cools down slowly. A gradual cooling manner prevents the cracking of an element and is also liable for higher layer adhesion. Handling the proper temperature, however, can be a little time-consuming and might contain some trial and error.

When heated, ABS emits severe and pungent fumes which can also cause infection and headaches. Consequently, three-D printing with ABS requires a running area with true airflow. But, many to-be-had FDM 3D printers are geared up with both an enclosure or a filter out and a fan for fume extraction.

Rapid temperature modifications at some point in the printing method also can motivate printing issues like warping and shrinkage.

However, those effects may be minimized by way of following the suggestions we'll discuss below.

4.6 Common Applications

ABS is a superb filament for popular-purpose three-D printing. Commonplace packages for the fabric include useful prototyping, idea modeling, and production of tooling in addition to some quit-use parts.

ABS properties like thermal balance, ductility, and machinability make it perfect for the production of low-fee prototypes and architectural models for engineers or studies departments, and also low-fee medical prostheses, tool handles, or even plug holders for electric-powered motors. This fabric can also be determined in some three-D revealed toys, like LEGO bricks.

Thanks to its electric-powered insulation houses, ABS filaments can be used to create digital enclosures. The automobile industry makes use of ABS to provide tools like jigs and furniture as well as customizing indoor automobile components. Again in 2014, local automobiles even 3D revealed the entire body and body of a car with ABS strengthened with carbon fibre.

Extruder temperature: 220-250 °C

Print mattress temperature: ninety-hundred and ten °C

Enclosure: extraordinarily endorsed

Print bed protecting: encouraged (Kapton tape, ABS Slurry) ABS is sensitive to temperature modifications, and this may cause the material to be reduced.

Because of this, a heated print bed is a need to have when printing with ABS.

Ensure that the print mattress is heated to a hundred and tenº C to save you from shrinking. It's also beneficial that a 3D printer has an enclosure to prevent any speedy temperature adjustments.

Almost always of thumb, it's miles commonly proper exercise to print the first few layers of your element with a temperature 10 to 20 stages higher to ensure that the layers nicely adhere to the print bed.

For better layer adhesion also keep in mind masking the print mattress with Kapton Tape. This may also make it simpler to easily the print mattress afterward. Another option can be an ABS slurry: mix a bit little bit of ABS filament with acetone and unfold it over the print mattress earlier than printing.

Large ABS prints also can be plagued by using warping. To save you this, component a further brim around the lowest edges into the layout of your component.

A brim adds several rings of cloth which might be connected to the element on the primary few layers. Brims aid in better layer adhesion and save you curling. Once the item is complete, a brim can be without problems.

As ABS produces nerve-racking fumes when heated, make sure that you print in a nicely ventilated region.

On account that ABS filaments soak up moisture, don't divulge them to air and water for lengthy intervals of time. It's crucial to store the filament rolls in sealed bins in cool, dry places to prevent degradation.

3-D printing with ABS may also start with making an effort and attempt you locate the right settings on your utility. But, despite this, ABS possesses an extensive range of benefits which, coupled with its low value, make it a go-to fabric for patron-grade in addition to commercial packages.

Table -3: Material properties of ABS

Plastic, ABS (high-impact)

Density	1030	kg/m³
Structural		
Isotropic Elasticity		
Derive from	Young's Modulus and Poisson's Ratio	
Young's Modulus	1.628e+09	Pa
Poisson's Ratio	0.4089	
Bulk Modulus	2.9784e+09	Pa
Shear Modulus	5.7776e+08	Pa
Isotropic Secant Coefficient of Thermal Expansion	0.000184	1/°C
Tensile Ultimate Strength	3.626e+07	Pa
Tensile Yield Strength	2.744e+07	Pa
Thermal		
Isotropic Thermal Conductivity	0.1997	W/m·°C

Geometry | Engineering Data: Material View

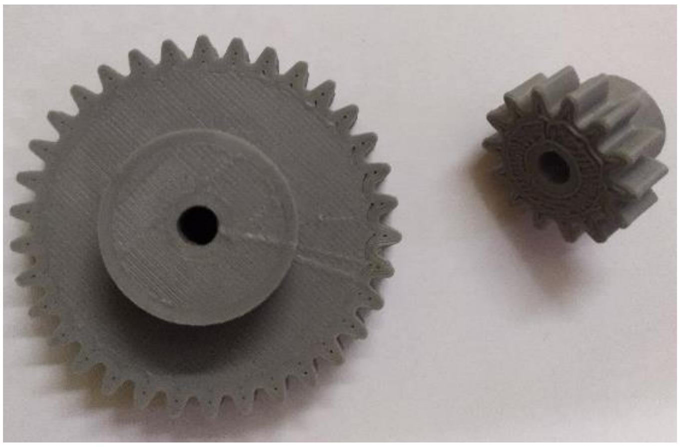

Fig -23: **3D Printed gear**

4.7 Software used

In this project, we can be the usage of Cura software which is a 3-D printer cutting utility. Cura has been launched below the open-source License. Cura is the favored slicer software program for Ultimaker three-D printers, however, may be used with other printers as well.

4.8 Direct Manufacturing Method

For programs requiring a small variety of units, injection molding won't be a feasible choice. Because of the reality that the initial cost of tooling layout for injection molding may be very high, the approach is simplest and price effective while very massive numbers of parts are required to be synthetic.

So as to check the feasibility of using 3-D printing as a way for immediate manufacturing for small volume manufacturing us will layout spur equipment and manufacture it using 3-D printing and examine the cost with injection molding to find out a breakeven factor below which we will don't forget that without delay production is greater cost-powerful.

5 CONCLUSION

We concluded that many complex designs are designed inside the modeling using the Solidworks software within the gift advanced era. All the components are designed in CAD utility known as Solidworks and assembled within the constraint obstacles. Man or woman components of the product are three-D printing. Spur equipment prototype modal developed in 3D printer the use of FDM technique. The modal structural analysis in ANSYS software program. Deformation, strain, and pressure are decided in the equipment model. Equipment published in a three-D printing system using ABS fabric. Tools electricity is ideal, the usage of small industries strength transmission applications (e.g. G. Robotic kits, grippers).

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BIOGRAPHIES

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