

# Design and Modelling of a Leaf Spring using 3D Printing Technology

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## ABSTRACT

3D printing technology forms the basis of corporation's prototyping process. 3D printing technology creates 3D physical prototypes by solidifying layers of deposited power by using a liquid binder. 3D printing is an versatile process accommodating geometry of varying complexity in hundreds of different applications, and supporting many types of materials. By eliminating production steps and using substantially less material, additive process could be able to reduce waste and save more than 50% of energy compared to today's subtractive manufacturing process and reduce material cost upto 90%. The use of additive manufacturing can potentially benefit a wide range of industries including defence, aerospace, automotive, biomedical, consumer products and metal manufacturing.

A leaf spring is a simple form of spring, normally used for the suspension in wheeled cars. Leaf springs are long and narrow plates attached to the body of a trailer that rests above or under trailer's axle. For safe and cozy using, to prevent the street shocks from being transmitted to the car components and to guard the guard the occupants from the road shocks it's miles important to determine the maximum safe strain and deflection. The objective is to find the stresses and deformation in the leaf spring via making use of static load on it. One of a kind of special materials with mechanical properties are taken into consideration for the structural static evaluation.

All leaf spring has linear characteristics; there is a linear dependence between force and deflection this means that the 3D printed springs could be used as machine elements in different applications.

**KEYWORDS:** 3D printing, design, modelling

## 1. INRODUCTION

3D printing or Additive manufacturing is any of various processes for making a three- dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control. A 3D printer is a type of industrial robot.[1]

Early AM equipment and materials were developed in the 1980s. In 1984, Chuck Hull of 3D Systems Corp, invented a process known as stereo lithography employing UV lasers to cure photopolymers. Hull also developed the STL file format widely accepted by 3D printing software, as well as the digital slicing and infill strategies common to many processes today. Also, during the 1980s, the metal sintering forms of AM were being developed (such as selective laser sintering and direct metal laser sintering), although they were not yet called 3D printing or A Matthe time. In 1990, the plastic extrusion technology most widely associated with the term "3Dprinting" was commercialized by Stratasys under the name fused deposition modelling (FDM). In 1995, Z Corporation commercialized an MIT-developed additive process under the trademark 3D printing (3DP), referring at that time to a proprietary process inkjet deposition of liquid binder on powder.

AM technologies found applications starting in the 1980s in product development, data visualization, rapid prototyping, and specialized manufacturing. Their expansion into production (job production, mass production, and distributed manufacturing) has been under development in the decades since. Industrial production roles within the metalworking industries achieved significant scale for the first time in the early 2010s. Since the start of the 21st century there has been a large growth in the sales of AM machines, and their price has dropped substantially. According to Wohlers Associates, a consultancy, the market for 3D printers and services was worth \$2.2 billion worldwide in 2012, up 29% from 2011. Applications are many, including architecture, construction (AEC), industrial design, automotive, aerospace, military, engineering, dental and medical industries, biotech (human tissue replacement), fashion, footwear, jewellery, eyewear, education, geographic information systems, food, and many other fields.

## 2. LITERATURE SURVEY

**Brogan Rylands and et.al** in his paper "3D Printing - To print or not to print? Aspects to consider before adoption - A supply chain perspective" has concluded that There is much complexity around 3D printing, which brings about the need to essentially re-engineer value streams. It is a collaborative

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attempt across the whole organization and there are many aspects to be considered, stemming not only from a business and technical perspective but also social and environmental aspects that require consideration.

This paper provided an overview of what 3D printing is, examples of industries that it is currently deployed in, how it can influence supply chains and aspects for consideration before adoption. It highlighted the need for increased awareness and collaboration in the area and future challenges and opportunities.

However, how does a company prepare for such a change? How does it educate itself? How can the fire for 3D printing be sparked in industry? When is the right time to adopt 3D printing? What additional aspects are managers currently considering when facing the 3D adoption challenge? Are all aspects of equally important or can even some aspects be disregarded? How has 3D printing impacted on manufacturing and the wider supply chain today? How will 3D printing impact manufacturing and the wider supply chain in future? How well is Australia positioned when compared to their international counterparts in regards to 3D printing? How does 3D supply chain costing compare with traditional manufacturing supply chain costing? How mature does your supply chain need to be in order to deploy 3D technology meaningfully and harvest its benefits?

It is expected that this research will contribute to academia/theory and practice. A conceptual model or framework incorporating major aspects to be considered for businesses before pursuing 3D printing has been developed that will need to be verified through case study/ field research in industry. It is further expected that businesses will benefit from the model through informed and improved decision making prior to deploying such cutting edge technology on their production line.[13]

**Alexandru Pirjan Dana-Mihaela Petroşanu** in his journal "The impact of 3D Printing technology on the society and economy" concluded that, we have presented and analyzed the impact of 3D printing technology on the society and economy. After presenting, in the introduction, a brief history of 3D printing, in the second section we have depicted the additive technology and the materials used in rapid prototyping. In the third section, we have highlighted the main advantages and limitations of the 3D printing technology, while in the fourth section we have made a survey of the most significant existing 3D printing solutions. We have compared these 3D printing solutions, taking into account their technical specifications and prices. One can conclude that the 3-D printing technology's importance and social impact increase gradually day after day and significantly influence the human's life, the economy and modern society.[14]

**Vinod G. Gokhare and et.al** in his paper titled "A Review paper on 3D-Printing Aspects and Various Processes Used in the 3D-Printing" conclude that Introduction part is about the brief history of 3D printing, in the next section we have depicted the 3D-printing and the processes used in 3D-printing and the properties of the 3Dprinter materials. In the third section, we have highlighted the main advantages and limitations of the 3D printing technology. One can conclude that the 3-D printing technology's importance and social

impact increase gradually day by day and influence the human's life, the economy, and modern society. 3D Printing technology could revolutionize the world. Advances in 3D printing technology can significantly change and improve the way we manufacture products and produce goods worldwide. An object is scanned or designed with Computer Aided Design software, then sliced up into thin layers, which can then be printed out to form a solid three-dimensional product. As shown, 3D printing can have an application in almost all of the categories of human needs as described by Maslow. While it may not fill an empty unloved heart, it will provide companies and individuals fast and easy manufacturing in any size or scale limited only by their imagination. 3D printing, on the other hand, can enable fast, reliable, and repeatable means of producing tailor-made products which can still be made inexpensively due to automation of processes and distribution of manufacturing needs.[15]

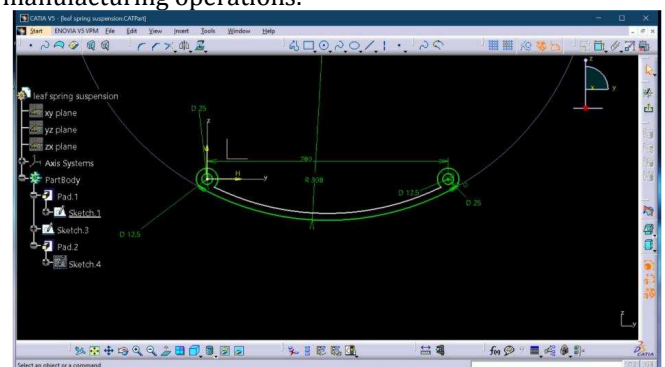
**Thabiso Peter Mpofu and et.al** from his journal paper titled "The Impact and Application of 3D Printing Technology" concluded that The 3D printing industry is set on a growth trajectory as evidenced by the growth forecasts. The applications of 3D printing are increasing as more and more research is carried out. 3D printing will change the way people acquire products as evidenced by the Amazon proposed model. The field is definitely a game changer with lots of prospects to look out for.

**Baljinder Singh Shahi** in his paper titled "Advanced Manufacturing Techniques(3D Printing)" concluded that Additive manufacturing, starting with today's infancy period, requires manufacturing firms to be flexible, ever-improving users of all available technologies to remain competitive. Advocates of additive manufacturing also predict that this arc of technological development will counter globalization; a sensduser will do much of their own manufacturing rather than engage in trade to buy products from other people and corporations. The real integration of the new additive technologies into commercial production, however, is more a matter of complementing traditional subtractive methods rather than displacing them entirely.[17]

### 3. PROCEDURE FOR 3D PRINTING

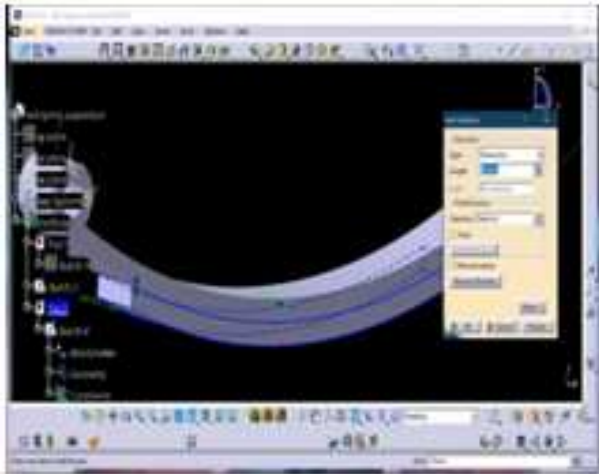
#### 3.1. Designing in CATIA

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a data base for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.



**Fig1. Design of leaf spring**

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions. Fig CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space. CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer



**Fig2.extrude of sketch**

animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.



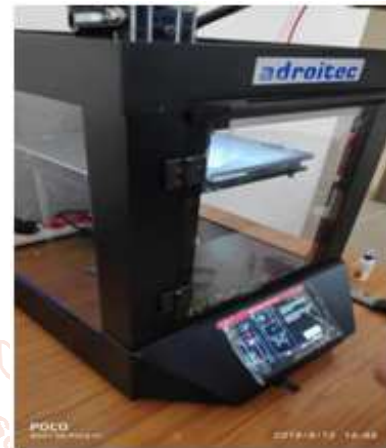
**fig3.final design**

The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD). Unexpected capabilities of these associative relationships have led to a new form of prototyping called digital prototyping. In contrast to physical prototypes, which entail manufacturing time in the design. That said, CAD models can be generated by a computer after the physical prototype has been scanned using an industrial CT scanning

machine. Depending on the nature of the business, digital or physical prototypes can be initially chosen according to specific needs.

### 3.2. 3D printer

3D-Printer is a machine reminiscent of the Star Trek Replicator [4], something magical that can create objects out of thin air. It can "print" in plastic, metal, nylon, and over a hundred other materials. It can be used for making non sensical little models like the over-printed Yoda, yet it can also print manufacturing prototypes, end user products, quasi-legal guns, aircraft engine parts and even human organs using a person's own cells.



**Fig4. 3d printer**

We live in an age that is witness to what many are calling the Third Industrial Revolution[5]. 3D printing, more professionally called additive manufacturing, moves us away from the Henry Ford era mass production line, and will bring us to a new reality of customizable, one-off production.

3D printers use a variety of very different types of additive manufacturing technologies, but they all share one core thing in common: they create a three-dimensional object by building it layer by successive layer, until the entire object is complete. It's much like printing in two dimensions on a sheet of paper, but with an added third dimension : UP The Z-axis.

Each of these printed layers is a thinly-sliced, horizontal cross-section of the eventual object. Imagine a multi-layer cake, with the baker laying down each layer one at a time until the entire cake is formed .3D printing is somewhat similar , but just a bit more precise than 3D baking.

In the 2D world, a sheet of printed paper output from a printer was "designed" on the computer in a program such as Microsoft Word. The file - the Word document which contains the instructions that tell the printer what to do.

### 3.3. conversion of CAD file to STL file

An STL file is a triangular representation of a 3D surface geometry. The surface is tessellated logically into a set of oriented triangles (facets). Each facet is described by the unit outward normal and three points listed in counter clockwise order representing the vertices of the triangle. While the aspect ratio and orientation of individual facets is governed by the surface curvature, the size of the facets is driven by the tolerance controlling the quality of the surface representation in terms of the distance of the facets from the surface. The choice of the tolerance is strongly dependent on the target



application of the produced STL file. In industrial processing, where stereolithography machines perform a computer-controlled layer by layer laser curing of a photo-sensitive resin, the tolerance may be in order of 0.1 mm to make the produced 3D part precise with highly worked out details. However much larger values are typically used in pre-production STL prototypes, for example for visualization purposes.

The native STL format has to fulfil the following specifications:

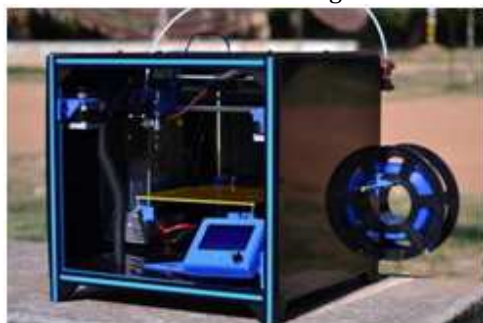
1. The normal and each vertex of every facet are specified by three coordinates each, so there is a total of 12 numbers stored for each facet.
2. Each facet is part of the boundary between the interior and the exterior of the object. The orientation of the facets (which way is "out" and which way is "in") is specified in two ways which must be consistent. First, the direction of the normal is outward. Second, the vertices are listed in counter clockwise order when looking at the object from the outside (right-hand rule).
3. Each triangle must share two vertices with each of its adjacent triangles. This is known as vertex-to-vertex rule.
4. The object represented must be located in the all-positive octant (all vertex coordinates must be positive).

However, for non-native STL applications, the STL format can be generalized. The normal, if not specified (three zeroes might be used instead), can be easily computed from the coordinates of the vertices using the right-hand rule. Moreover, the vertices can be located in any octant. And finally, the facet can even be on the interface between two objects (or two parts of the same object). This makes the generalized STL format suitable for modelling of 3D non-manifold objects after converting to stl file then it is 3d printed.

### 3.4. Printing the model

Before printing the 3-D model file, the 3d printer should be connected to the pc or the laptop, on which you have been working and the software like **CURA** from **Ultimaker** or **Ideamaker** has to be pre-installed on the computer.

- The filament used to print the 3-D model of LEAF SPRING in this case is **PLA**.
- The specifications of the PLA filament are:
  - Diameter of filament: 1.75mm
  - Certification: Roots approved
  - Printing temperature: 190° to 210°C
  - Bed temperature: 50° to 60°C
  - Colour: White
- Now open the Idea maker or Cura software and load the STL file that has been saved using CAD software.



**Fig5. mounting material in to the machine**

- Necessary modifications should be done after the file has been loaded, like rotating and scaling (since the maximum printing capacity of most of the printers is 20cm×20cm×20cm, along X, Y and Z axes).

The printing process has to be set to the following settings from the available options, that the software has to offer.

- Layer height: 0.1mm
- Fill density: 8%
- Shell thickness: 2%
- Extruder temperature: 200°C
- Heat bed temperature: 50°C
- Printing speed: 60mm/s



**Fig6. Leaf spring is being printed on the surface**

After the settings have been done, the following information regarding the model to be printed will be displayed:

- Dimension (mm): 59.4×9.0×58.9 (in mm)
- Triangle: 2822
- Edges: 1015
- Non-manifold edges: 0
- Error orientation faces: 0
- Layers: 88
- Steps: 271
- Time duration; 1 hr 1min
- Left filament: ---
- Right filament: 240°C
- Price: \$1
- Estimated amount: 5.3g
- Length: 1.96m

### 4. Result

The leaf spring is manufactured with the PLA material by fused deposition modeling using 3d printing machine.

### 5. Conclusion

In this project modelling of LEAF SPRING is carried out with CATIA V5R20 software by using various commands. After creating model we save the component in '.stl' file. Import the component into the 3D Printing machine by using cura software, by using FDM (Fused Deposition Modelling) method with PLA material (Poly Lactic Acid). And then we get the component. Design and 3D Printing of sprocket is done.

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