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Designing and Manufacturing of Alloy Wheel using 3d Printing Technology

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ABSTRACT
3D printing is the type of Additive manufacturing, has the potential to vastly accelerate innovation, compress supply chains, minimize materials and energy usage, and reduce waste. Originally developed at the Massachusetts Institute of Technology in 1993. 3D printing technology forms the basis of Z Corporation's prototyping process. 3DP technology creates 3D physical prototypes by solidifying layers of deposited powder using a liquid binder. By definition 3DP is an extremely versatile and rapid process accommodating geometry of varying complexity in hundreds of different applications, and supporting many types of materials. Z Corp. pioneered the commercial use of 3DP technology, developing 3D printers that leading manufacturers use to produce early concept models and product prototypes. Utilizing 3DP technology, Z Corp. has developed 3D printers that operate at unprecedented speeds, extremely low costs, and within a broad range of applications.

Alloy wheels are automobile wheels which are made from an alloy of carbon epoxy, E-glass epoxy and S-glass epoxy is tested individually or sometimes a mixture of both among them best one is chosen. Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the car. Alloy wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. Alloy is an excellent conductor of heat, improving heat dissipation from the bakes, reducing the risk of brake failure under demanding driving conditions.

In this project, parametric model is done in Catia V5R20 and 3D- printing is done in Idea maker software.

KEYWORDS: *Alloy wheel, Carbon-epoxy, E-glass epoxy, S-glass epoxy, Catia V5R20, Idea maker software*

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1. INTRODUCTION

3D printing is the type of 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. 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 AM at the time. In 1990, the plastic extrusion technology most widely associated with the term "3D printing" 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.[1]

Additive manufacturing is the official industry standard term for all applications of the technology. It is defined as the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. Synonyms are additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, and freeform fabrication. The primary applications of additive fabrication are design/modeling, fit and function prototyping, and direct part production. Around the world, AM is changing the way organizations design and manufacture products. When used correctly, it can save impressive amounts of time and money. Companies maintain that AM has helped trim weeks, even months, of design, prototyping, and manufacturing time, while avoiding costly errors and enhancing product quality.[2]

2. LITERATURE SURVEY

Alexandru Pirjan Dana-Mihaela Petroşanu in his journal “The impact of 3D Printing technology on the society and economy” concluded in this paper, we have presented and analysed 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.[3]

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. [4]

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.[5]

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, as end users 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.[6]

K. Srinivasa Rao and et.al in his paper “Design and Analysis of Alloy wheels” concluded that from the analysis came to know that all three designs are safe and are within the standard limits. Among the three designs simple rim design is more promising than centrifugal rim followed by pentagonal rim. Among the three-materials steel alloy is the best material followed by aluminium and magnesium. Magnesium occupies last position as it has more deformation for the same loading condition. From this result we can then why magnesium alloy material is only used for pretty shorter period restricted to racing cars only. From the fatigue analysis aluminium alloy has got more life than that of the steel alloy. Even though the safety factor is almost equal for both the materials aluminium is subjected to less damage compared to steel (for same loading conditions). From the above results we define a new material (Al-Mg alloy) which is more promising than other two i.e. these has got less deformations like Aluminium and more lifelike Magnesium. Under the influence of radial load, the rim tends to vocalize about the point of contact with maximum displacement occurring at the location of bead seat. The inside bead seat reveals the greatest deflection and is concurrently prone to loss of air pressure due to dislodgement of the tyre on the rim. Actually, failure of alloy wheel occurs mostly at the areas where there is max stress values occurs (predicted by analysis software). More deformed areas are also in agreement with theoretical values.[7]

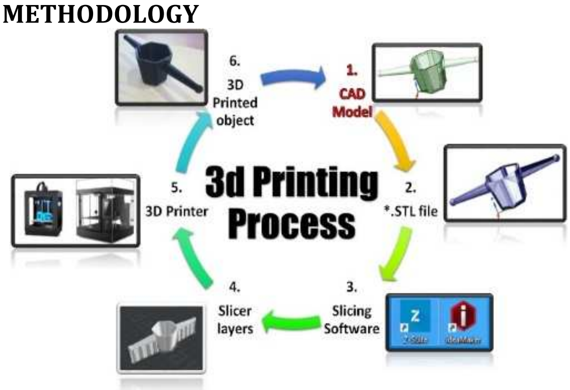
M. Suguna in her paper titled “Comparative Analysis of Automotive Wheel Rim by using different materials” concluded that the modelling is done by using CATIA and import the file into ANSYS for software analysis. The results are tabulated by comparing in the above table. Hereby we came to know that Mg alloy having less stress compared other two materials. The wheel design with Mg alloy material is optimised in order to withstand the existing load of the vehicle with factor of safety with least quantity of manufacturing cost and losses. IN this the life expectancy will increase and we are having the flexibility and efficiency to resist the impact forces. When weight of the rim reduced the overall efficiency will be increased.[8]

Nandigam Dayakara Rao and B. Kishore Kumar from his journal titled “Design and Analysis of Alloy wheel” concluded that Brief study about alloy wheel its construction, type, materials is done in this project. By using 3d modelling software CATIA V5 alloy wheel is modelled. Catia Model of alloy wheel is saved as IGES (neutral) file and transferred to ANSYS work bench 14.5 software. Static structural analysis is performed of alloy wheel by applying the pressure load of 1.5 MPA. Static structural analysis is performed on five different materials on same boundary condition. Analysis result is noted and tabulated. According to result table magnesium alloy showing least stress value compare to other four materials. Meanwhile magnesium alloy is also least dense material, i.e. its weight ratio is lowest than other four materials. So, we can conclude that magnesium alloy is best material for alloy wheel compare to other four materials, because of its least weight and least stress value on load conditions. Design and analysis on alloy wheel is done.[9]

Jitendra Shinde and et.al in his paper titled" Review Paper on Design and Analysis of Automotive Wheel Rim Using Finite Element Analysis" concluded that it is necessary to carry out experimental and finite element analysis of wheel rim to avoid the failure of the rim by improving the geometry and material optimization with the help of design of experiment. Results are to be validate by radial load test on wheel rim to check its fatigue life.[10]

Rahul K. Jape and S. G. Jadhav in their paper entitled "CAD Modelling and FEA Analysis of Wheel Rim for Weight Reduction" concluded that load acting on the alloy wheel rim is calculated as per Japanese industrial standard given by the company. The modelling is done as per drawings given by the company and made changes to reduce the weight. Finite element analysis is performed on both wheel rim i.e. base wheel rim and optimized wheel rim the stresses and fatigue life of the wheel is calculated which is satisfying company criteria. The weight of the wheel is reduced from 7.7 Kg to 7.5 Kg by using this finite element analysis approach of weight optimization. On trying on these two cases with varying dimensions, one model is finally reached at with a total of 3% (200gm) mass reduction without compromising its performance. The wheel International Journal of Engineering Science and Computing, on subjection to Cornering Fatigue Test and radial fatigue test is observed to pass through all the requirements. There is a mass reduction of 200gm per wheel is achieved which mounts to 1kg per car considering the spare wheel. This mass reduction results in two benefits. Decrease in total weight of the car and decrease in cost of production. Optimization techniques help largely in reducing the mass of solid components which results in overall body weight reduction and thus lesser cost. Lesser weight in turn gives better performance and better fuel efficiency. These result in many indirect benefits to mankind which includes conservation of natural resources to some extent, reduction in air pollution etc.[11]

3. METHODOLOGY



There are some procedures for printing. First you must create a computer model for printing the object. For creating that, you can use Computer Aided Design Software like AutoCAD, 3DS Max etc. After the object file is created, the file needs to be modified. The object file contains numerous amounts of curves. Curves cannot be printed by the printer directly. The curves have to be converted to STL (Stereo lithography) file format. The STL file format conversion removes all the curves and it is replaced with linear shapes. Then the file needs to be sliced into layer by layer. The layer thickness is so chosen to meet the resolution of the 3D printer we are using. If you are unable to draw objects in CAD software, there are many websites available which are hosted by the 3D printing companies to ease the creation of 3D object. The sliced file is processed and generates the special coordinates. These coordinates can be processed by a controller to generate required signal to the motor for driving extruder. This layer by layer process generate a complete object.

4. DESIGN

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 database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

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.

The **alloy wheel** that is to be printed in this project is designed in one of the popular CAD software, **CATIA.**

The alloy wheel is designed in Catia in the following way:

- ➢ In Catia, part modelling is to be selected first. Then, by selecting one of the three planes, the following 2-d sketch is drawn using appropriate measurements.

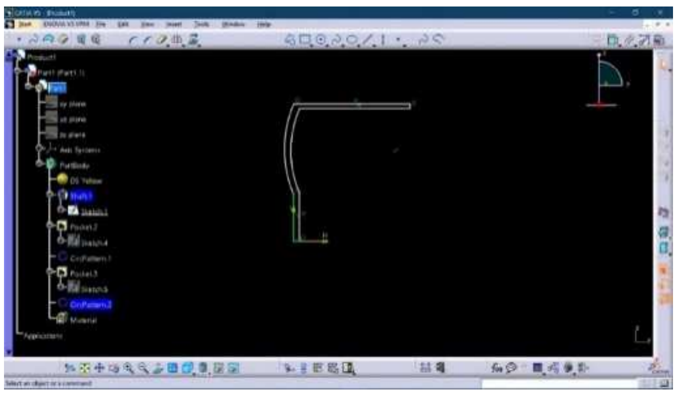


Fig.9 Catia (sketch 1)

- ➢ Using the **revolve** or **shaft** command, revolve the selected sketch through 360° about the central axis.

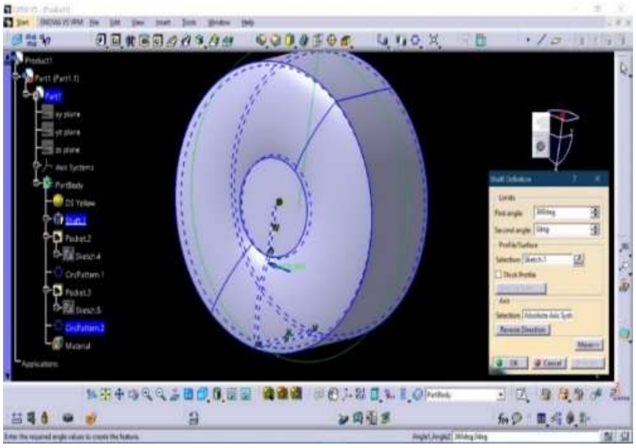


Fig.10 Catia (revolve/shaft command)

- Now select one of the faces and select **sketch** option. Draw the 2-dimensional spoke profile of the alloy wheel.

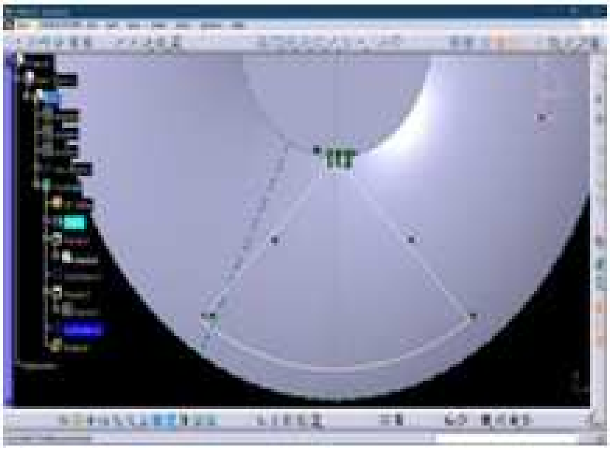


Fig.11 Catia (sketch 2)

- Using **pocket** command, cut through the previously revolved surface to form one part of the alloy wheel.

Fig.12 Catia (pocket command)

- Select **circular pattern** and specify the angular spacing of each spoke of alloy wheel and the total number of spokes on the profile.

Fig.13 Catia (circular pattern command)

- Select the required face and draw 2D sketch

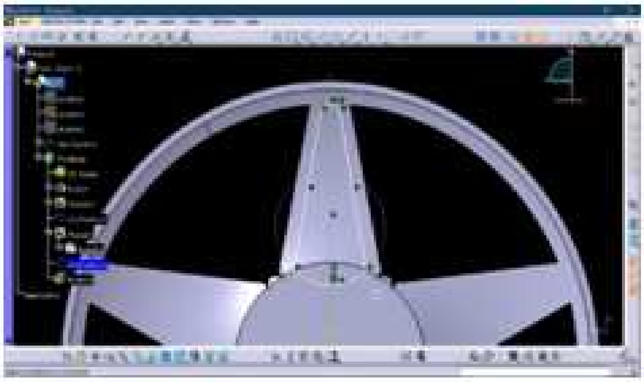


Fig.14 Catia (sketch 3)

- Using the **pocket** command, cut the sketched part of the spokes.

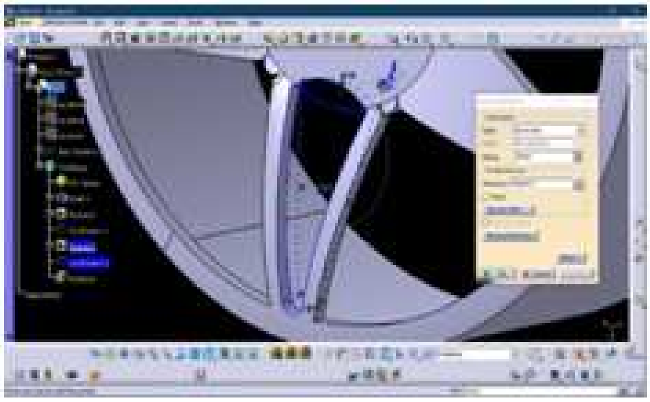


Fig.15 Catia (pocket command)

- Select **circular pattern** and specify the angular spacing of lug holes of alloy wheel and the total number of lug holes on the profile.

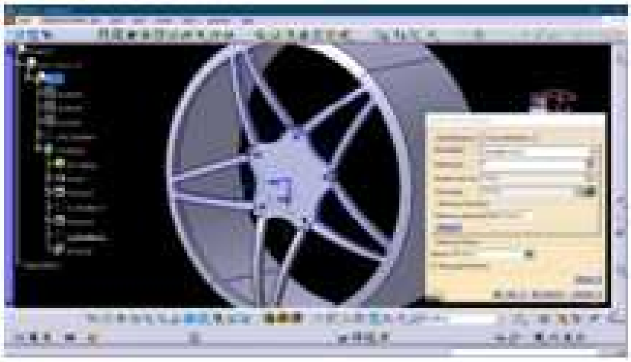


Fig.16 Catia (circular pattern command)

- Choose and apply the material to the part body if needed and save the part body in the desired folder.

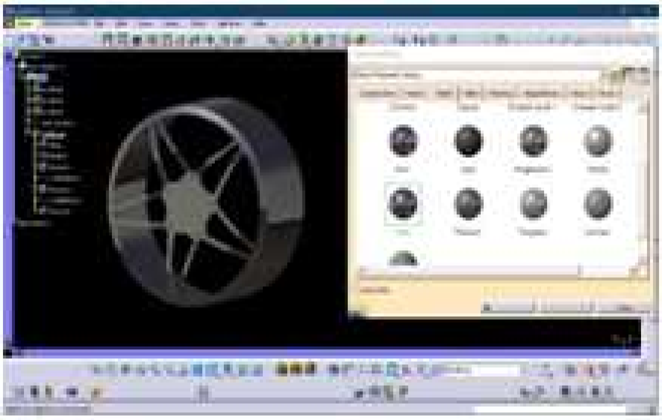


Fig.17 Catia (material selection)

The alloy wheel that is to be 3-d printed is designed and saved in the computer and it has to be modified further to print it in a 3-d printer

Fig.18 Alloy wheel 3-D model

4.1. Conversion to STL File Format:

The object (alloy wheel, in this case) can be converted to STL format file by the following procedure:

- Open the previously saved design file in the CAD software (CATIA, in this case) and find '**File**' on the menu.

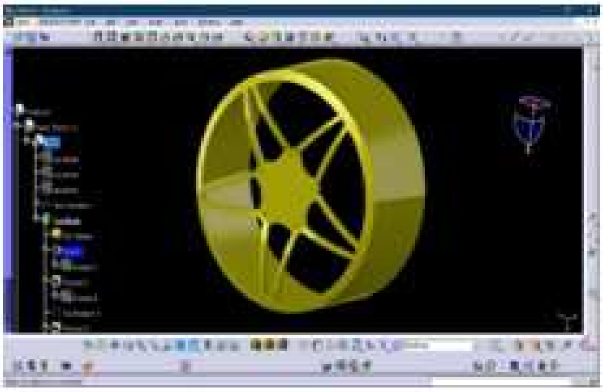


Fig.19 Catia (file menu)

- Click on the '**File**' menu and select '**Save as**' as shown in the figure below.

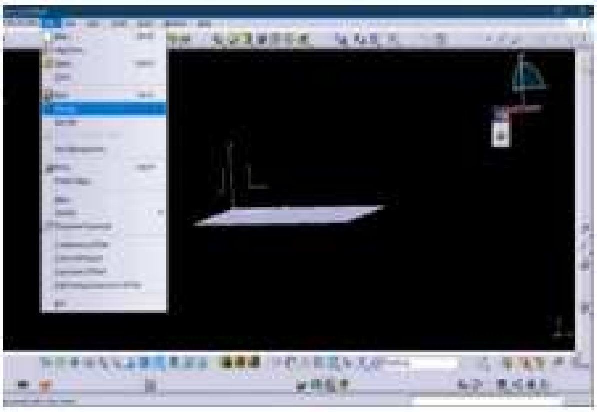


Fig.20 Catia (save as)

- After selecting '**Save as**', the following window appears.

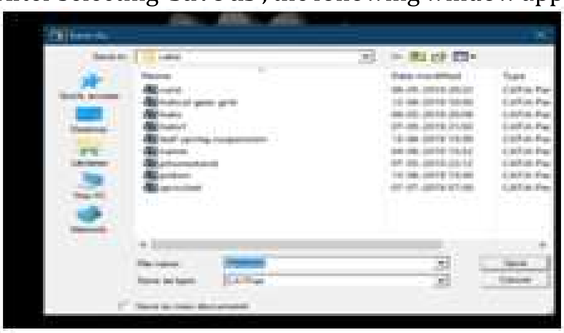


Fig.21 Saving part file

- Now select '. **Stl**' from the list of options to save the file.

Fig. 22 Selecting STL format

- Save the file in the respective folder.

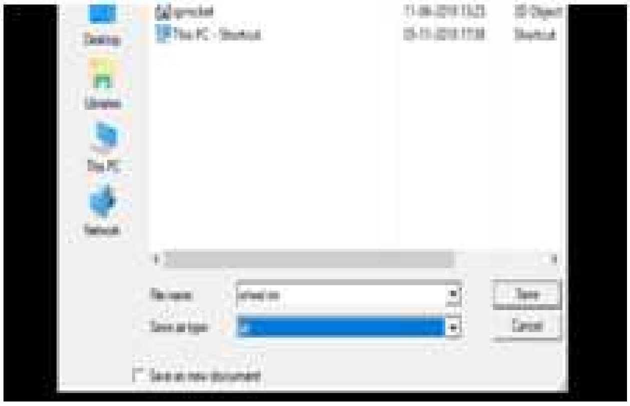


Fig. 23 Saving .stl file

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.

5. RESULTS

Fabrication of product is done with the help of 3d printing by using Fused Deposition Modelling and PLA material.

Fig 34 3D printed product of alloy wheel

6. CONCLUSION

In this project modelling of ALLOY WHEEL is carried out with tha 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 idea maker 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 alloy wheel is done.

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