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Analysis of M10 Bolt Using Additive Manufacturing and Subtractive Manufacturing

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Abstract

3D Printing or Additive manufacturing is a novel method of manufacturing parts directly from digital model by using layer by layer material build-up approach. This tool-less manufacturing method can produce fully dense metallic parts in short time, with high precision. Features of additive manufacturing like freedom of part design, part complexity, light weighting, part consolidation and design for function are garnering particular interests in metal additive manufacturing for aerospace, oil & gas, marine and automobile applications. Powder bed fusion, in which each powder bed layer is selectively fused by using energy source like laser, is the most promising additive manufacturing technology that can be used for manufacturing small, low volume, complex metallic parts. This review presents overview of 3D Printing technologies, materials, applications, advantages, disadvantages, challenges, economics and applications of 3D metal printing technology.

In this project, we have focused on the comparison of additively manufactured product versus substractively manufactured product with the help of some testing methods and their properties. We will also discuss possibilities of 3D printing and its advantages and disadvantages

Keywords: 3D printing, additive manufacturing, subtractive manufacturing

I..INTRODUCTION

3D Printer

A 3d printer is an additive manufacturing technique where 3D objects and parts are made by the addition of multiple layers of material. It can also be called as rapid prototyping. It is a mechanized method where 3D objects are quickly made as per the required size machine connected to a computer containing blueprints of any object. The additive method may differ with the subtractive process, where the material is removed from a block by sculpting or drilling. The main reason to use 3d printer is for 90% of material utilization, increase product life, lighter and stronger. 3D printing is efficiently utilized in various fields such as aerospace, automobile, medical, construction.

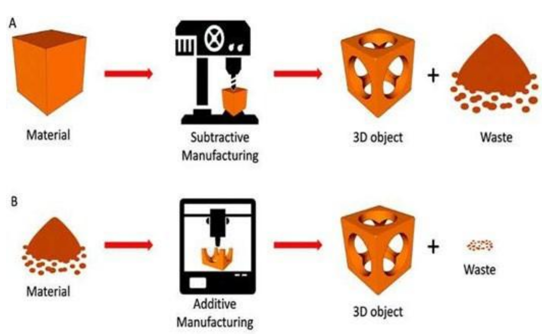


Figure 1: DISTINCTION BETWEEN AM & SUBTRACTIVE MACHINING

2 LITERATURE REVIEW

Rapid Prototyping and manufacturing: A review of current technologies.

-Hugo I. Medillin [1]

The operating principal and features of new technology of AM. The idea to develop processes capable to produce physical components quickly and without requiring tooling, led to the development of the "free form fabrication" (FFF) or "rapid prototyping" (RP) technologies in the early 1980s. RP systems generally build up a prototype directly from the computer-aided design (CAD) data by using an additive "layer by layer" method. The RP technologies have brought several advantages to the manufacturing industry in such a way that these technologies are evolving toward the production of end-use parts. This paper presents a review of rapid proto typing and manufacturing (RP&M) technologies from their origins. The review includes commercially available RP systems and RP technologies that are still at the development stage or that have been proposed. The operating principles and the features of these technologies are presented. Process parameters such as accuracy, layer thickness, operation speed are given. An extended classification of RP&M technologies is also included in this paper.

A Review of Additive Manufacturing Technology.

-Mostafa Yakout, and E. Mohamed [2]

The authors have provided the review of key technologies for Metal additive manufacturing process. Additive manufacturing is a layer based manufacturing process aimed at producing parts directly from a 3D model.

This paper provides a review of key technologies for metal additive manufacturing. It focuses on the effect of important process parameters on the microstructure and mechanical properties of the resulting part.

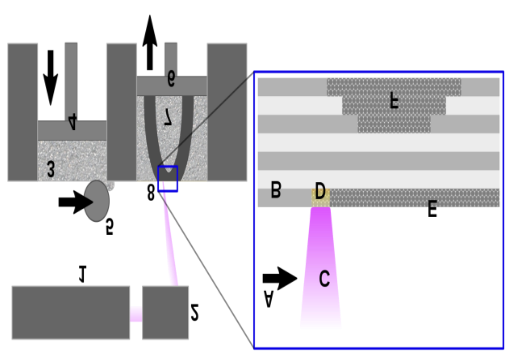
Several materials are considered including aerospace alloys such as titanium (TiAl6V4 "UNS R56400"), aluminum (AlSi10Mg "UNS A03600"), iron- and nickel- based alloys (stainless steel 316L "UNS S31603", Inconel 718 "UNS N07718", and Invar 36 FeNi36 "UNS K93600").

3 PROBLEM I DENTIFICATION

Problem Identification and Definition The manufacturing industry is always looking at new and innovative ways of working and in recent years, 3D printing has been at the forefront. Advancements In the 3D printing technology, equipment and materials has resulted in the costs being driven down, making it a more feasible option to general manufacturing use. Traditional manufacturing has to deal with the ever-growing demands of the world but it has some restrictions. That is where 3D printing can step in to take over. 3D printing for manufacturing comes with a number of exciting and unique advantages when compared with traditional manufacturing.

Low volume manufacturing Moving across to 3D printing will make it possible for businesses to consider short-run part production, where focused product teams can launch new products more frequently. They will be able to work beyond the realms of their imagination and certainly beyond the restraints that come with traditional methods. It delivers an agile development process for physical parts and has the ability to accelerate the production and the time it takes to get to market.

High volume manufacturing 3D printing is a technology that is developing and growing faster than most other technologies due to the way it can influence manufacturing processes and help businesses perform to a higher level. A production line that is set up for 3D printing is easier to alter than that of a production line for traditional manufacturing, making 3D printing a feasible option for many reasons. The whole production line can be adjusted and adapted with the speed of the printing production line. Therefore, improvements to machinery, adjustments to the print speed or even a change of product can be made almost instantly. When you consider this against older methods, it can take several weeks or months to make the changes and then begin



producing again. It is inevitable that the capabilities that come with 3D printing and the way in which technology is evolving will enable businesses to adopt this new way of producing products or parts and it is likely that this adoption is going to grow well in the future.

4 TECHNOLOGY

An additive manufacturing layer technology, SLS involves the use of a high power laser (for example, a carbon dioxide laser) to fuse small particles of plastic, metal, ceramic, or glass powders into a mass that has a desired three-dimensional shape. The laser selectively fuses powdered material by scanning cross- sections generated from a 3-D digital description of the part (for example from a CAD file or scan data) on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness, a new layer of material is applied on top, and the process is repeated until the part is completed. Because finished part density depends on peak laser power, rather than laser duration, a SLS machine typically uses a pulsed laser. The SLS machine preheats the bulk powder material in the powder bed somewhat below its melting point, to make it easier for the laser to raise the temperature of the selected regions the rest of the way to the melting point.[6] In contrast with SLA and FDM, which most often require special support structures to fabricate overhanging designs, SLS does not need a separate feeder for support material because the part being constructed is surrounded by un sintered powder at all times. This allows for the construction of previously impossible geometries. Also, since the machine's chamber is always filled with powder material the fabrication of multiple parts has a far lower impact on the overall difficulty and price of the design because through a technique known as 'Nesting', where multiple parts can be positioned to fit within the boundaries of the machine. One design aspect which should be observed however is that with SLS it is 'impossible' to fabricate a hollow but fully enclosed element. This is because the un sintered powder within the element could not be drained. Since patents have started to expire, affordable home printers have become possible, but the heating process is still an obstacle, with a power consumption of up to 5 kW and temperatures having to be controlled within 2°C for the three stages of preheating, melting and storing before removal.

5 PROJECT SETUP

Fig *2.*Rapid Prototyping - Metal RPT

Configuration- EOSINT M 270

1. Build Envelope (XYZ) : 250 X 250 X 215 mm (9.58 x 9.85 x 8.5 in)
2. Material l Options: Stainless Steel, Maraging Steel
3. Achievable Accuracy: Small parts +/- 40 - 60 Microns, Larger Parts +/- 0.2 %.

6 SUBTRACTIVE MANUFACTURING

Fig 3 Lathe machine

Machining is a manufacturing term encompassing a broad range of technologies and techniques. It can be roughly defined as the process of removing material from a work piece using power-driven machine tools to shape it into an intended design. Most metal components and parts require some form of machining during the manufacturing process. For the manufacture of bolt we have used the lathe machine and a solid piece of mild steel on which first we have done facing, turning and threading on the lathe machine.

7 METHODOLOGY

Selective Laser Sintering (SLS)

- Layer by layer fine powder is spread.
- The coater arm is used to create level of powder.
- A focused laser beam is then precisely directed at the powder layer and scans over the cross-section of the part.
- The build platform is lowered and the process is repeated until all layers have been printed ..

8 RESULTS

We have manufactured the M10 bolt using lathe machine and 3D printing and compared the both on the basis of following tests.

Tensile Strength

A. For normal bolt

Parameter	Unit	Result
Diameter	mm	9.25
Area	Sq. mm	67.17
Ultimate tensile load	kN	36.65
Ultimate tensile strength	N/sq. mm	545.63

B. For 3D printed bolt

Parameter	Unit	Result
Diameter	mm	9.25
Area	Sq. mm	67.17
Ultimate tensile load	kN	43.80
Ultimate tensile strength	N/sq. mm	652.08

Chemical composition

A. For normal bolt

Element	Percentage
Carbon	0.12
Manganese	0.34
Silicon	0.11
Phosphorous	0.025
Sulphur	0.015
Nickel	0.017
Chromium	0.036
Molybdenum	0.0052

B. For 3D printed bolt

Element	Percentage
Carbon	0.015
Nickel	17.19
Molybdenum	5.2
Cobalt	8.5
Silicon	0.1
Aluminum	0.15
Titanium	0.6

Hardness test

For normal bolt: 94, 95, 96 HRBW

For 3D printed bolt: 115, 115, 116 HRBW

Macrostructure

A. For normal bolt

A	No porosity found
B	Dendritic grain growth not seen
C	No center segregation seen
D	Forging flow in proper direction seen
Observation	Forged structure with proper grain flow

A. For 3D Printed Bolt

A	Average Porosity (94.4 ±4.3%)
B	Dendritic grain growth not seen
C	No center segregation seen
Observation	Layer can be seen as a thinly sliced cross-section of object.

9 CONCLUSION

After the tests performed on the substantively manufactured bolt and 3D printed bolt we see that tensile strength vary for both the products. For that normal Bolt is 545.63 N/mm^2 and for 3D printed Bolt is 652.08 N/mm^2. So the tensile strength of 3D printed bolt is greater than the normal bolt. We can see that the hardness of the 3D printed bolt is greater than normal bolt which gave advantage to it in various applications. Also there is slight variation in the composition. Though the cost of 3D printed bolt is more, it uses less material and gives better performance.

10 FUTURE SCOPE

While there is a marked increase in the level of awareness about 3D printing all over the country, one major challenge we are facing is the lack of clarity on what this technology can provide. On one hand, those users familiar with hobby-level 3D printing have dismissed this technology as being unsuitable for any serious applications because of the mediocre quality produced by low-end machines. On the other, there are quite a few myths surrounding this technology among those who have heard fantastic stories about 3DP, and people often ask us if we can print live kidneys and livers. Research in this direction is definitely showing positive results, and we will soon see a day where commercially available, medically proven organs can be 3D printed in hospitals are common place. Yet, the status of 3d printing is a tad bit different at present.

The Indian Automotive sector players were first to adopt this technology which helped zip the New Product Development (NPD) life cycles significantly. Jewellery manufacturing is another major industry that has completely integrated technology as part of its process chain. In these areas India is surely at par with the rest of the world.

Education is another area that is waking up to the potential of this technology and is working towards incorporating it in the curriculum as a teaching aid as well as a mandatory skill. Overall, 3D printing is here to stay and is becoming a mainstream process which will most definitely help democratize design and manufacturing, and impact many more industries and lives. Our biggest challenge is to spread awareness and set a realistic level of expectations for anyone who wants to work around it.

3D Printing is a revolutionary technology that is changing the way we make things, and it is our constant endeavour to make this technology accessible to everyone in India. At Imaginaries, we like to say that the only constraint to making something wonderful is that of human imagination.
along these lines sparing cores of outside economic forms.

REFERENCES

[1] Rapid Prototyping and manufacturing: A review of current technologies by Hugo I. Medillin

[2] A Review of additive manufacturing Technology by Mostafa Yakout, and E. Mohamed