Evaluation of Metal Cutting Forces using Drilling Tool Developed Using Additive Manufacturing Method DMLS

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Abstract - The cause of this studies is to make use of the Additive Manufacturing Technique Direct Metal Laser Sintering – DMLS approach for growing a system device that could utilized in metallic slicing throughout drilling operation. In the existing paintings an strive is to expand the device for drilling operation and to assess the metallic slicing forces throughout operation. The Direct Metal Laser Sintering (DMLS) are the maximum applied approach with inside the improvement of device and the forces from the dynamometer suggests the little version in the use of the AM device and may be used effectively. DMLS is a sintering manner wherein elements to be designed are constructed up layer with the aid of using layer from the lowest up the use of one-of-a-kind metallic powder materials. A laser beam scans the powder mattress fills in every layer's CAD-picture with the aid of using heating the chosen powder sample to fuse it. The CAD Model may be evolved the use of Autodesk Fusion 360 & Autodesk NetFabb for reducing and information education the CAD Model after which the prototype may be evolved the use of DMLS and may be examined on a traditional drilling operation to assess the metallic slicing forces the use of dynamometer. The outcomes have been in comparison with traditional device with identical machining parameters in drilling operation. From the experimental outcomes it may be concluded that the AM device may be utilized in region of traditional device in order that hardness of the device may be stepped forward below identical machining parameters in addition to AM technique may be utilized in production equipment from tough materials.

***Key Words*: Drilling Tool, RPT Technique, Additive Manufacturing Technique, Direct Metal Laser Technique, Direct Laser Melting**

1.INTRODUCTION

1.1 Introduction of Metal 3D Printing

Due to additive strategies development, metallic three-D printing has full-fledged massively in current time. Many start-ups, marketers and producers have followed latest & an increasing number of low priced metallic three-D printing methods which permits extra well-matched materials. Metal three-D printing have become considerable in lots of industries, which includes the automotive, aerospace, and clinical industries, because it permits the fabrication of complicated components for a notably low value in comparison to standard methods. Recently, there had been many upgrades made to metallic three-D printers. Hybrid systems, metallic deposition, healing materials, and plenty of different revolutionary tasks imply the manner is extra green than ever. Therefore, we created this manual to assist provide an explanation for the entirety to do with Metal three-D printing, the principle organizations involved, the programs of metallic three-D printing, and extra! Benefits & Limitations of Metal 3D printing

It is crucial to recognize that material 3D printing is an effective device that incorporates many particular benefits. Yet, its contemporary barriers do now no longer usually make it the pleasant alternative in relation to production of material parts. Here we summarized the maximum crucial benefits and downsides of material 3D printing. Use them to recognize in which material 3D printing stands nowadays and in which it's far headed with inside the close to future.

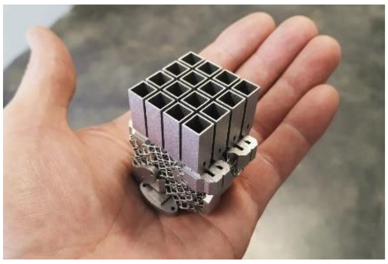
Benefits of Metal 3D Printing	Limitations of Metal 3D Printing
1. Geometric complexity at no extra cost 2. Optimized lightweight structures 3. Increased part functionality 4. Merging assemblies into a single part 5. Simpler manufacturing supply chains 6. Excellent material properties	1. Higher cost than traditional manufacturing 2. Limited economies of scale 3. A unique set of design rules 4. Post-processing is almost always required

Table -1: Benefits & Limitations of Metal 3D printing

1.2 Applications of Metal 3D Printing

Metal 3D printing is presently utilized in enterprise to create device additives and completed elements in sectors which includes the aerospace and automobile sectors. 3D printing can produce plane additives or rocket motors, saving weight and decreasing costs. Metal 3D printing additionally has makes use of with inside the scientific quarter which includes in developing implants to analyses, particularly in dental. Metal additive production may even be used with inside the marine quarter to layout boat propellers!

- Space & Aeronautical Industry
- Automotive & Transportation Industry
- Healthcare & Biomedical Industry
- Industrial Tooling Applications


Optics Micro-Antenna


3D Printed Hip Cup Implant


Bracket for Formula Car


A printed metal casting mould


Lumenium IC Engine Parts

Figure 1 Application of Metal Printed Parts

1.3 Materials For Metal 3D Printing

Among the maximum typically used substances in material 3D printing, there's first off aluminum, specially utilized in alloy form. Aluminum is beneficial because it gives suitable resistance while being light. It is specially used whilst preserving weight down is essential, which includes with inside the aeronautics and car industries. Material is likewise famous, specifically in business applications. Material gives robust mechanical homes and a very good floor finish. Due to this, it's the maximum famous material utilized in 3D printing. In addition, there also are material which includes gallium, cobalt-chrome for clinical uses, and titanium because of its suitable corrosion resistance and biocompatibility for clinical applications. Precious metals are specially utilized in jeweler. Despite its excessive cost, gold, silver, and bronze are all used with 3D printing to create complicated portions of jeweler. The fundamental demanding situations inside this but is with inside the finish. Conclusion is that the range of material fabric to be had for material 3D printing is developing rapidly. Engineers can these days pick out from alloys including:

Stainless Materials	Nickel-Based Super alloys
Tool Materials	Cobalt-Chrome Alloys
Titanium Alloys	Copper-Based Alloys
Aluminum Alloys	Precious Metals (Gold, Silver, Platinum etc.)

Table -2: Materials for Metal 3d Printing

1.4 Metal 3D Printing vs Traditional Manufacturing

Always start with a Cost Vs Performance analysis, while you are selecting among a material 3D printing and a subtractive (CNC machining) or formative (material casting) technology. Generally speaking, the producing value is specifically linked to the manufacturing volume, at the same time as the overall performance of an element relies upon significantly on its geometry. The key energy of material 3D printing is its cap potential to create elements with complex & optimized geometries. This approach that it is right for production excessive-overall performance elements. On the alternative hand, it does now no longer scale in addition to CNC machining or material casting at better volumes. As a rule of thumb, the excessive value of material 3D printing may be handiest financially justified if it's miles linked to a good sized boom in overall performance or operational efficiency. Of course, every material 3D printing method meets one-of-a-kind commercial requirements. Use the pointers underneath as well-known tips to apprehend which method is the maximum appropriate for you: DMLS/SLM is the best solution for parts with high geometric complexity (organic, topology optimized structures) that require excellent material properties for increasing the efficiency of the most demanding applications.

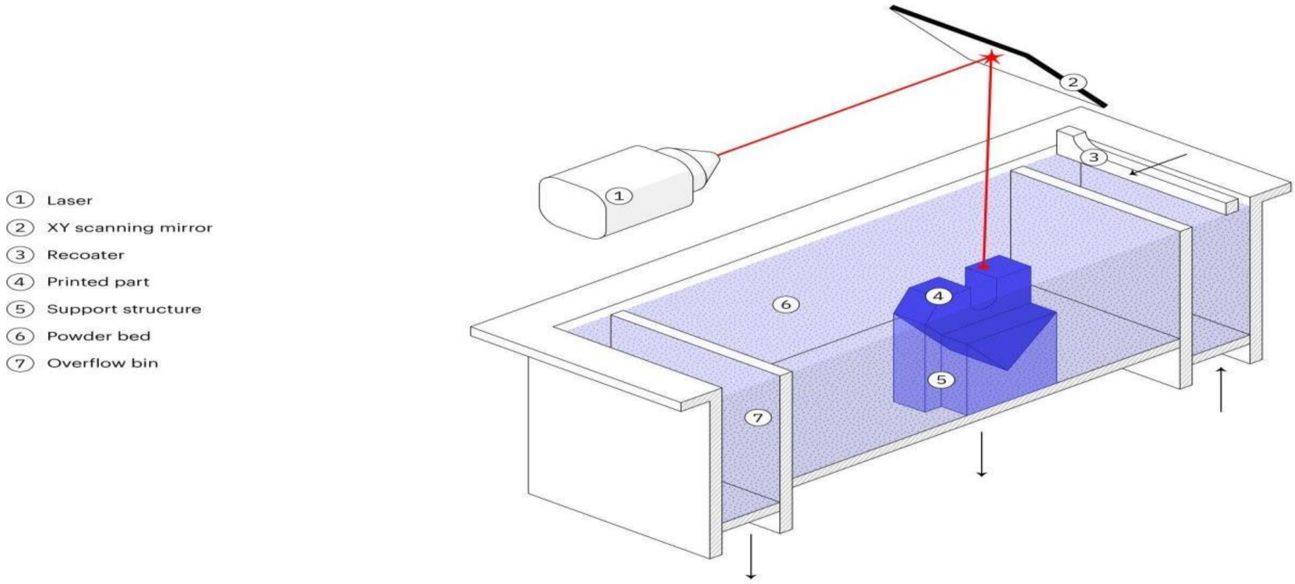


Figure 2 Working Principle of DMLS / SLM

Binder Jetting is the best solution for low-to-medium batch production that cannot justify the large economic investment of a formative method and for parts with geometries that cannot be efficiently manufactured with a subtractive method.

2. METHODOLOGY

2.1 Work Methodology

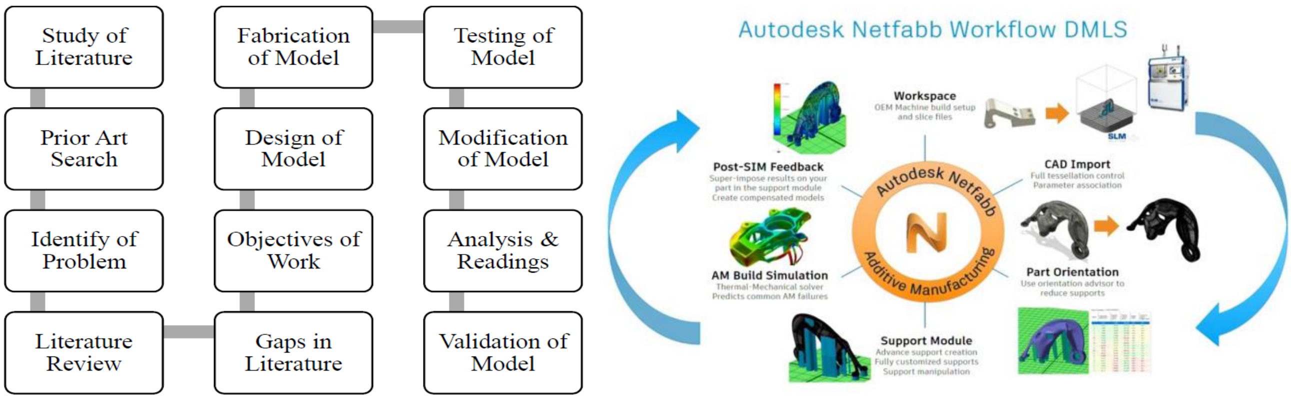
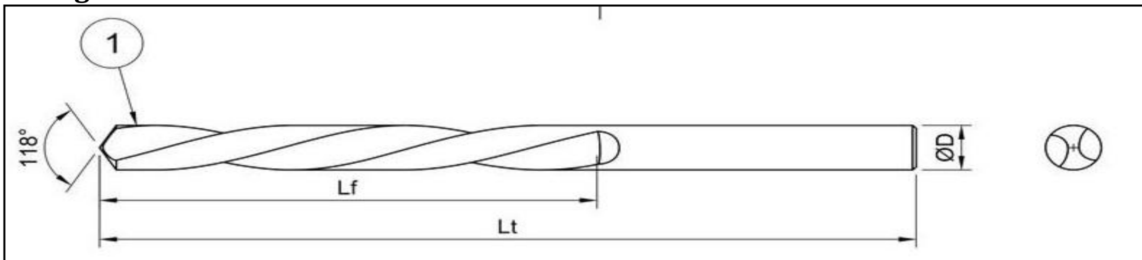


Figure 3 Work Methodology

2.2 Objective

- To model & develop the drilling tool bit using Direct Metal Laser Sintering (DMLS) type additive manufacturing (AM) technique.
- To identify the pre-build errors during additive manufacturing of the part before actual metal printing on the machine using simulation techniques.
- To evaluate of Metal Cutting Forces using additive manufactured Drilling Tool to compare with conventionally manufactured drill bit.

2.3 Design of Drill Bit



Catalogue Number	Grade	Flute Length Lf (mm)	Total Length Lt (mm)	Shank Diameter D (mm)
B041A08000CPG	KC7325	41	77	8
B041A10000CPG	KC7325	47	87	10
B041A12000CPG	KC7325	55	100	12

Figure 4 Drill Bit Variants

2.4 CAD Modelling of Drill Bit

The 3D CAD Model of Drill Tap is created using Autodesk Fusion 360. Autodesk Fusion 360 is a powerful tool for CAD / CAM & CAE which provides the various workspaces to model designs, surfaces, sheet metal components as well as separate workspace for rendering, simulation, animation & drafting documentation.

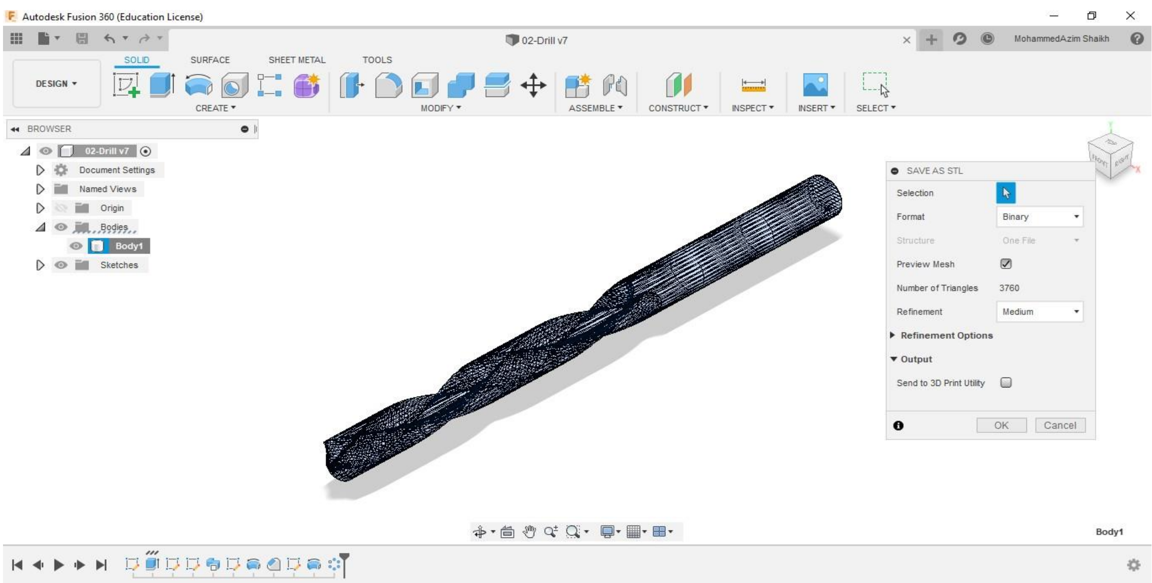


Figure 5 Mesh Conversion for STL

2.5 Calculation of Part Building Time Estimation

Time to complete a single layer

$$Ti = \frac{Ai}{v \times D} + Td$$

Where, Ti = Time to complete layer

Ai = Cross-sectional area of the layer

v = Average scanning speed of laser beam at surface

Ds = Diameter of spot size

Td = Delay time between layers to reposition of worktable

Part Building Time Calculation

$$Tc = \sum_{i=1}^{n_i} Ti$$

Where, Tc = STL build cycle time

n_i = No. of layers used to build the part

Part Building Time Calculated By Simulation Software

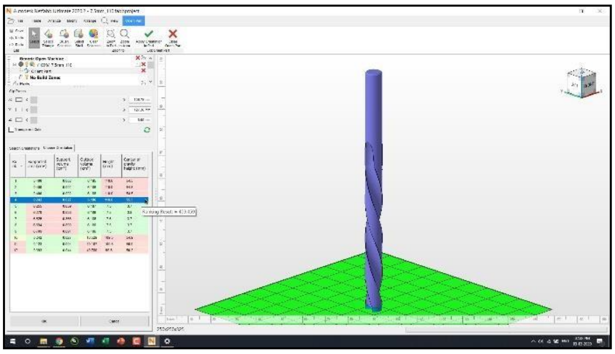
Tc = 22,432 sec

Tc = 22432 / 60 = 373.87 minutes

Tc = 373.87 minutes = 6.2311 hours

Tc = 6 hours 13 minutes 52 seconds

2.6 Data Preparation with Autodesk Netfabb



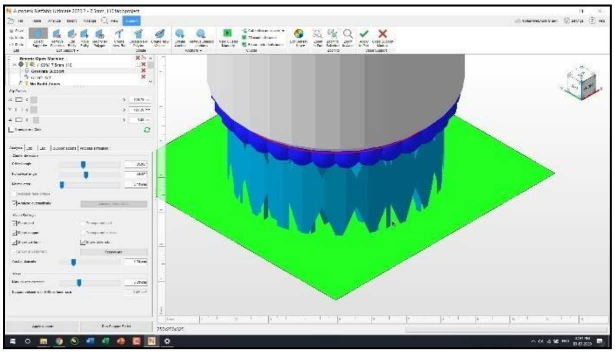


Figure 6 Data Preparation with Autodesk Netfabb

3. CONCLUSIONS

In rapid prototyping using additive fabrication, the physical, real and therefore the virtual components all have similar features are often manufactured. In the current undertaking AM strategy is utilized to build up the cutting tool and utilized in drilling operation. By the appliance of the developed AM model it's been observed the tool with more rigid performing an equivalent function as that of conventional. It has been noticed that the measured cutting forces from the dynamometer with and without Additively Manufactured Tool is around 3%. Thus, the drill bit developed from the AM Technique is additionally rigid and supply good rigidity during machining operations.

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