MACHINABILITY CHARACTERIZATION OF 3D PRINTED TITANIUM ALLOY BY MICRO EDM DRILLING

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OBJECTIVE:

- To investigate the machinability characterization of 3D printed Ti-6Al-5Zr at the micron level using micro Electrical Discharge Machining(EDM) drilling.

- The properties of the drilled surface are examined using Scanning Electron Microscope to analyzing at the micron level ,then we determine the material's surface roughness, and finally the dimensions are analyzed using a CMM equipment.

PROBLEM STATEMENT:

- 3D printing technology is currently one of the most popular and rising technologies. Although it has some design flaws, It cannot accurately create microholes at net near form.

- Therefore, we drill 3D printed material using an EDM drilling machine and use a Scanning Electron Microscope to examine the surface properties of the material at the micron level.

LITERATURE REVIEW:

NAME	AUTHOR	OUTCOME
An Overview on 3D Printing Technology: Technological, Materials, and Applications	N. Shahrubudin (2019)	3D printing technology has capability to produce aerospace parts by using nickel base alloys [29]. 3D-printed object produces using nickel base alloys can be used in dangerous environments. This is because, it has high corrosion resistance and the heat temperature can resistant up to 1200 °C [26]. such as ductility, good corrosion, oxidation resistance and low density. It is used in high stresses and high operating temperatures and high stresses, for example in aerospace components [31] and biomedical industry
Microstructural Evolution of Titanium alloy Ti-6Al-5Zr	Magrini(1999)	superalloy is normally used to describe multiphase and multicomponent alloys based on nickel, cobalt, or iron. The most important properties of the superalloys are long-time strength at high temperatures (above 650 °C) and resistance to hot corrosion and erosion. Nickel-base superalloys are widely employed in gas turbine engines (Ref 1) because of their good behavior at high temperature

LITERATURE REVIEW:

NAME	AUTHOR	OUTCOME
OPTIMIZATION OF EDM SMALL HOLE DRILLING PROCESS USING TAGUCHI APPROACH	MFF Ab. Rashid, WS Wan Harun and SA Che Ghani	It has proved valuable and effective in machining of super tough, hard, high strength and temperature resistance of conductive material. These metals would have been difficult to machine by conventional methods
Processing behavior and surface quality control of the engine fuel nozzle precision machining	Junye Li, Jinbao Zhu, Xu Zhu	In order to improve the inner surface quality of the engine fuel nozzle, optimize the ejection quality and atomization performance of the nozzle, and realize the precision machining surface of the nozzle

LITERATURE REVIEW

NAME	AUTHOR	OUTCOME
Materials for Gas Turbine Engines: Present Status, Future Trends and Indigenous Efforts	Swati biswas(2012)	The UDIMET alloy series are super alloys that have nickel or iron or cobalt as their base metal. Super alloys are known for their high-performance at extremely high temperatures or under high mechanical stress. Super alloys are subjected to special hardening techniques in order to achieve high performance at extreme conditions

LITERATURE REVIEW:

NAME	AUTHOR	OUTCOME
Copper desktop micro-electrical discharge machining (micro-EDM) system; cut-side micro-tool; micro-holes	Yung-Yi Wu 1 , Tzu-Wei Huang 2 and Dong-Yea Sheu 2	This testing aimed to develop a low-cost desktop micro-EDM system for fabricating micro-holes in copper materials Micro-holes with a diameter of 0.07 mm and thickness of 1.0 mm could be drilled completely by cut-side micro-tools. The roundness of the holes were approximately 0.001 mm and the aspect ratio was close to 15.

LITERATURE REVIEW

NAME	AUTHOR	OUTCOME
Micro-EDM Machine tool Diesel injector nozzle Taper hole drilling Assisted vibration	Tong Haoa,∗, Li Yonga, Zhang Longa, Li Baoquanb	Micro electro discharge machining (EDM) has the advantages of less cutting force, without burrs, and even finish machining after heat treatment, so it fits for machining micro holes on metal alloy materials. In this study, a micro EDM equipment was developed for drilling the spray holes. Key technologies were discussed including an electrode feed head, a workpiece positioning mechanism and process control method.

REASON FOR CHOOSING UDIMENT-720 MATERIAL :

1. **High-Temperature Resistance**: Udimet 720 is known for its excellent high-temperature strength and resistance to creep and oxidation. Nozzles in gas turbines operate at extremely high temperatures, and this alloy can maintain its mechanical properties and integrity even under these extreme conditions.
2. **Corrosion Resistance**: Udimet 720 has good resistance to corrosion and oxidation, making it suitable for use in aggressive environments where nozzles may be exposed to combustion gases, hot exhaust gases, and other corrosive elements.
3. **Creep Resistance**: Nozzles in gas turbines are subjected to constant thermal cycling and high stresses, which can cause creep deformation over time. Udimet 720's resistance to creep deformation is crucial for maintaining the dimensional stability of the nozzle.
4. **Mechanical Properties**: This alloy exhibits excellent mechanical properties, including high tensile and yield strength, which are essential for withstanding the mechanical loads and pressures experienced in nozzle applications.
5. **Thermal Stability**: Udimet 720 maintains its properties over extended periods of high-temperature exposure, making it a reliable choice for long-term nozzle applications.

REASON FOR CHOOSING Ti-6Ai-5Zr MATERIAL :

- Ti-6Al-5Zr is a near-alpha titanium alloy with 6% aluminum, 5% zirconium, and the rest titanium. It is also known as TIMETAL 685 or IMI 685. It has good creep strength, high-temperature stability, and weldability. It is mainly used for aerospace engine components that require high strength and resistance to high temperatures[12].
- Ti-6Al-5Zr has a high specific strength of about 1000 MPa, which is comparable to Ti-6Al-4V, the most widely used titanium alloy.
- Ti-6Al-5Zr has a low density of 4.48 g/cc, which reduces the weight and cost of the final product.
- Ti-6Al-5Zr has excellent corrosion resistance in many environments, such as seawater, acids, and chlorides. It also has good biocompatibility and can be used for implants and prosthetics.
- Ti-6Al-5Zr can be heat treated to tailor its properties, such as hardness, ductility, and fatigue resistance. It can also be formed and machined by various methods, such as forging, rolling, extrusion, cutting, drilling, and milling.

REASON FOR CHOOSING Ti-6Ai-5Zr MATERIAL :

- Ti-6Al-5Zr can be 3D printed by different techniques, such as selective laser melting, electron beam melting, direct metal laser sintering, and laser metal deposition.

- Ti-6Al-5Zr has some disadvantages, such as high cost, low thermal conductivity, poor wear resistance, and susceptibility to hydrogen embrittlement. These can be overcome by using proper processing conditions, surface treatments, or alloy modifications.

Top –view and back view of drilled surfaces

COMPARISON :

S.NO	DISCRIPTION	Titanium alloy (Ti6Al4V)	Ti-6Al-5Zr
1.	Density	4.43	4.48
2.	Melting point	1649	1650
3.	Thermal Conductivity	6.7 W/(m·K)	6.5-7W/(m-k)
4.	Tensile	897 Mpa	850-1050
5.	Hardness	38 HRC	40HRC
6.	Temperature resistance	400℃	450-550℃
7.	Coefficient of Thermal Expansion	8.6 x 10^-6 per degree Celsius	9.0 x 10^-6 per degree Celsius

TOOLS AND INSTRUMENTS REQUIRED:

- Micro EDM Drilling Machine
- Scanning Electron Microscope
- Coordinate Measuring Machine
- Surface Roughness Tester
- Copper Electrode

METHODOLOGY

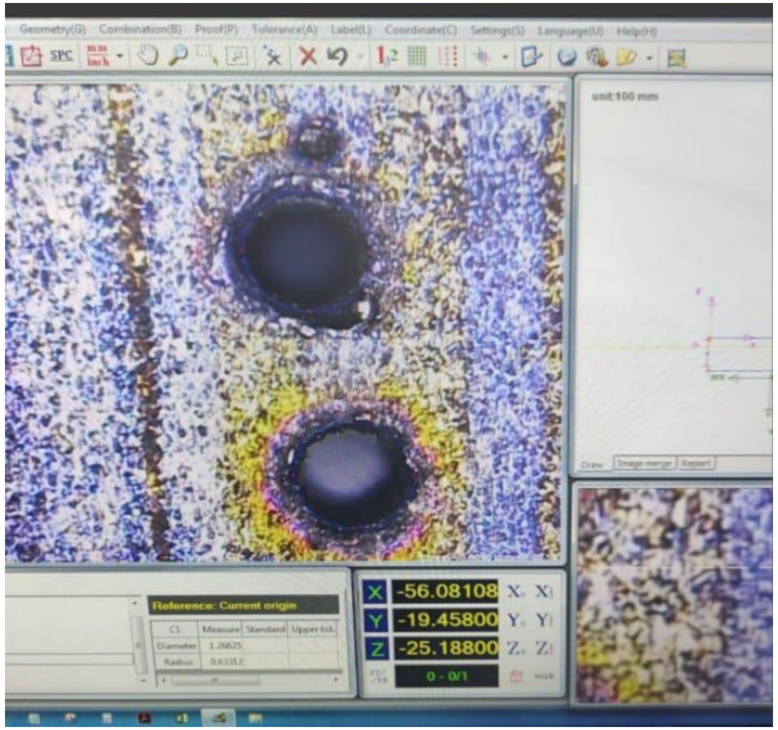
1. LITERATURE REVIEW
2. SOLUTION FOR THE PROBLEM STATEMENT
3. MATERIAL PURCHASING
4. DRILL USING MICRO EDM DRILLER
5. ANALYSE USING SCANNER ELECRON MICROSCOPE
6. ANALYSE WITH SURFACE ROUGHNESS TESTER
7. MEASURE THE INTERNAL DIMENSION USING CMM MACHINE
8. PAPER PUBLISHING

ENVIRONMENT AND SUSTAINABILITY:

- The Materials and energy input we use in this project are as inherently non-hazardous as possible.
- It is eco-friendly and harmless.
- The Materials volume will be consumed at an optimum level in order to prevent wastage.
- This project is targeted towards durability of the material.
- We implement life cycle assessment through out the process to resource efficiency and decreasing liability.

VISION MEASURING MACHINE:

- VMM can stand for Vision Measuring Machine. It's a non-contact measuring machine that uses optics to inspect parts. VMMs are best for measuring small, lightweight components with high accuracy.



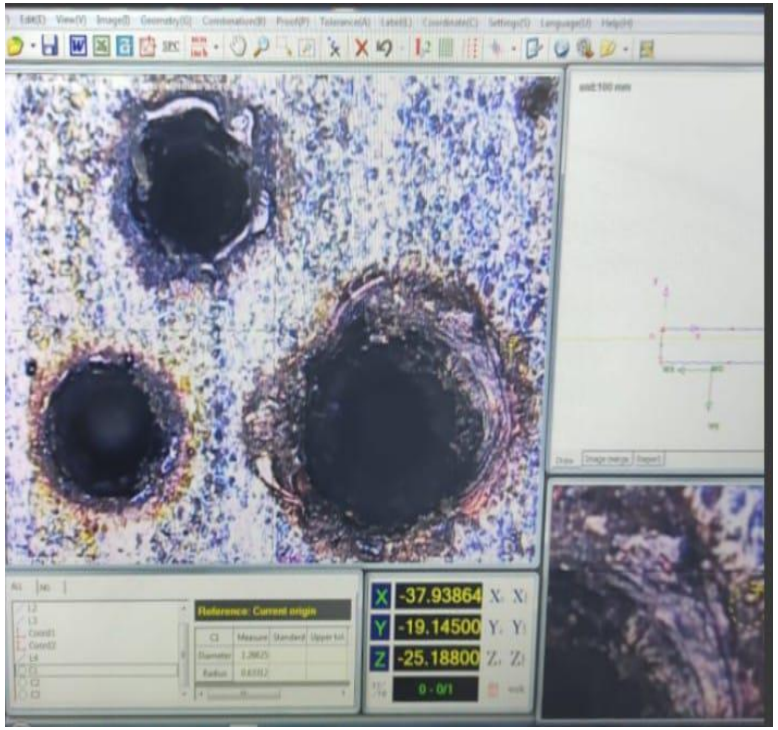


PLATE BOTTOM:

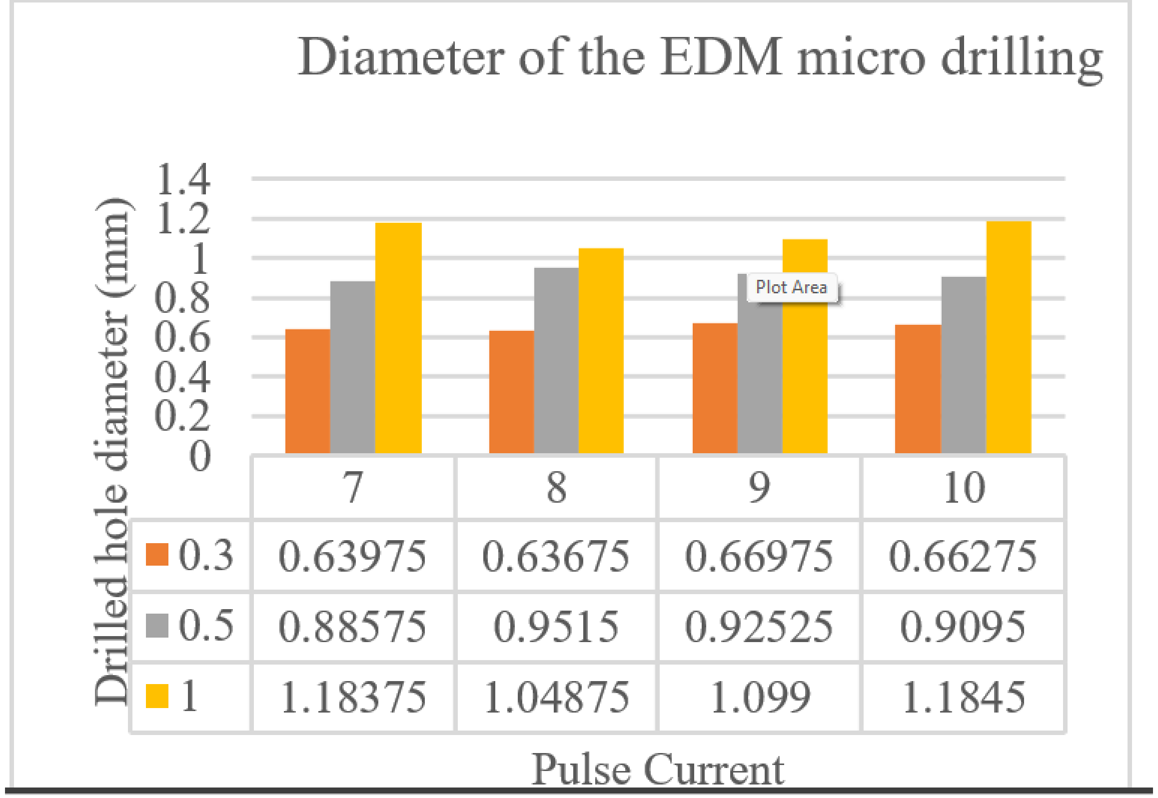
S.No	LAYOUT NO or PARAMETER	MEASURED
1	DIA-01	0.651
2	DIA-02	0.699
3	DIA-03	0.774
4	DIA-04	0.942
5	DIA-05	1.013
6	DIA-06	0.742
7	DIA-07	1.14
8	DIA-08	0.74
9	DIA-09	0.259
10	DIA-10	0.919
11	DIA-11	0.92
12	DIA-12	0.859
13	DIA-13	0.715
14	DIA-14	1.101
15	DIA-15	0.59
16	DIA-16	0.938
17	DIA-17	0.702
18	DIA-18	1.129
19	DIA-19	0.981
20	DIA-20	0.331
21	DIA-21	0.939
22	DIA-22	0.803
23	DIA-23	0.824
24	DIA-24	0.714
25	DIA-25	1.011

S.No	LAYOUT NO or PARAMETER	MEASURED
25	DIA-25	1.011
26	DIA-26	0.668
27	DIA-27	0.87
28	DIA-28	1.566
29	DIA-29	0.44
30	DIA-30	1.177
31	DIA-31	0.872
32	DIA-32	1.14
33	DIA-33	0.842
34	DIA-34	0.915
35	DIA-35	0.903
36	DIA-36	0.997
37	DIA-37	1.01
38	DIA-38	0.784
39	DIA-39	0.921
40	DIA-40	1.046
41	DIA-41	1.159
42	DIA-42	0.967
43	DIA-43	1.004
44	DIA-44	0.991
45	DIA-45	1.386
46	DIA-46	1.145
47	DIA-47	1.04
48	DIA-48	0.909

PLATE TOP :

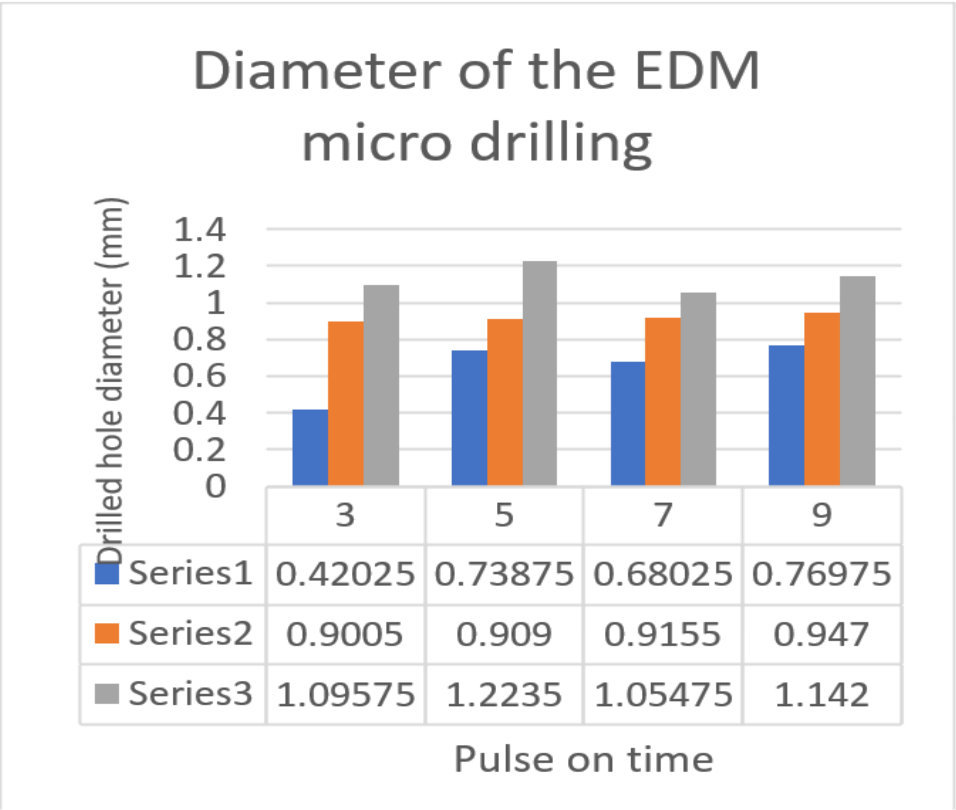
S.No	LAYOUT NO or PARAMETER	MEASURED
1	DIA-01	0.907
2	DIA-02	1.73
3	DIA-03	1.059
4	DIA-04	1.308
5	DIA-05	1.105
6	DIA-06	0.488
7	DIA-07	1.139
8	DIA-08	0.629
9	DIA-09	1.122
10	DIA-10	0.318
11	DIA-11	0.567
12	DIA-12	1.47
13	DIA-13	0.675
14	DIA-14	0.9
15	DIA-15	0.302
16	DIA-16	0.801
17	DIA-17	0.627
18	DIA-18	0.262
19	DIA-19	1.003
20	DIA-20	0.231
21	DIA-21	1.22
22	DIA-22	0.254
23	DIA-23	0.735

S.No	LAYOUT NO or PARAMETER	MEASURED
25	DIA-25	1.006
26	DIA-26	0.275
27	DIA-27	1.252
28	DIA-28	1.266
29	DIA-29	0.457
30	DIA-30	1.259
31	DIA-31	1.215
32	DIA-32	1.168
33	DIA-33	1.259
34	DIA-34	2.322
35	DIA-35	1.415
36	DIA-36	1.332
37	DIA-37	1.233
38	DIA-38	1.212
39	DIA-39	1.25632
40	DIA-40	1.384
41	DIA-41	1.222
42	DIA-42	1.954
43	DIA-43	1.676
44	DIA-44	1.265
45	DIA-45	1.231

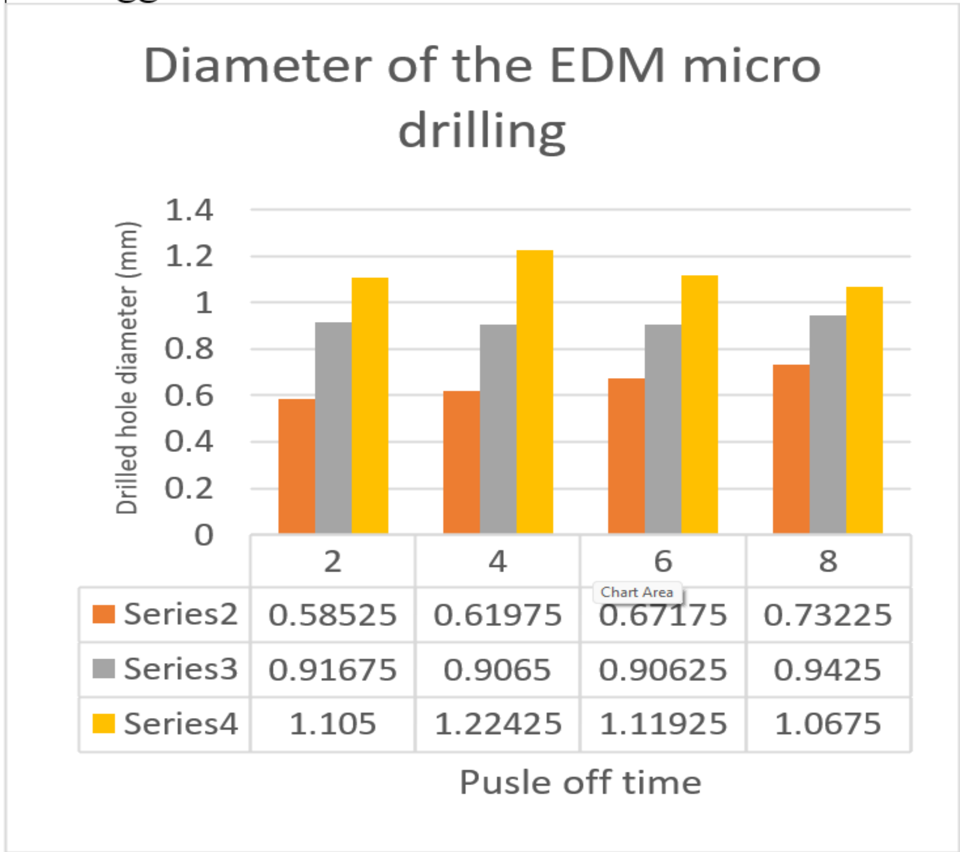


	7	8	9	10
0.3	0.63975	0.63675	0.66975	0.66275
0.5	0.88575	0.9515	0.92525	0.9095
1	1.18375	1.04875	1.099	1.1845

The diameter of the drilled hole created by EDM micro drilling is plotted versus the pulse current used in the graph. The electrical spark's intensity is controlled by the pulse current setting on the EDM equipment. On the x-axis, "Pulse current" is written, and on the y-axis, "Drilled hole diameter (mm)".



The EDM machine's pulse current setting regulates how strong the electrical spark is. "Pulse Current" is written on the x-axis, while "Drilled hole diameter (mm)" is written on the y-axis. The graph shows four data series, each represented by a separate line.



The EDM machine's pulse current setting regulates how strong the electrical spark is. "Pulse Current (A)" is written on the x-axis, while "Drilled hole diameter (mm)" is written on the y-axis. The graph shows four data series, each represented by a separate line.

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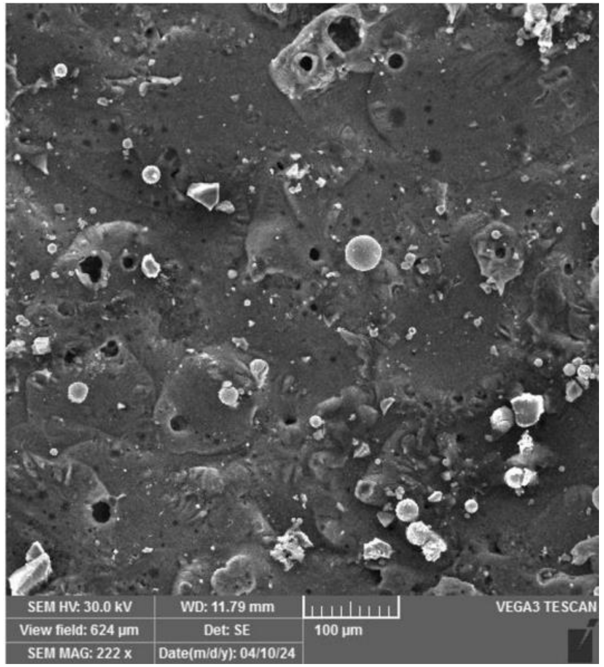
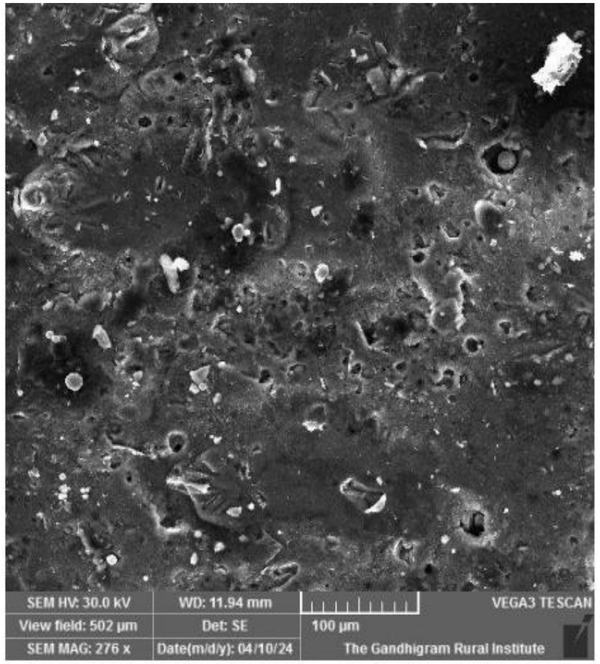
SEM ANALYSIS :

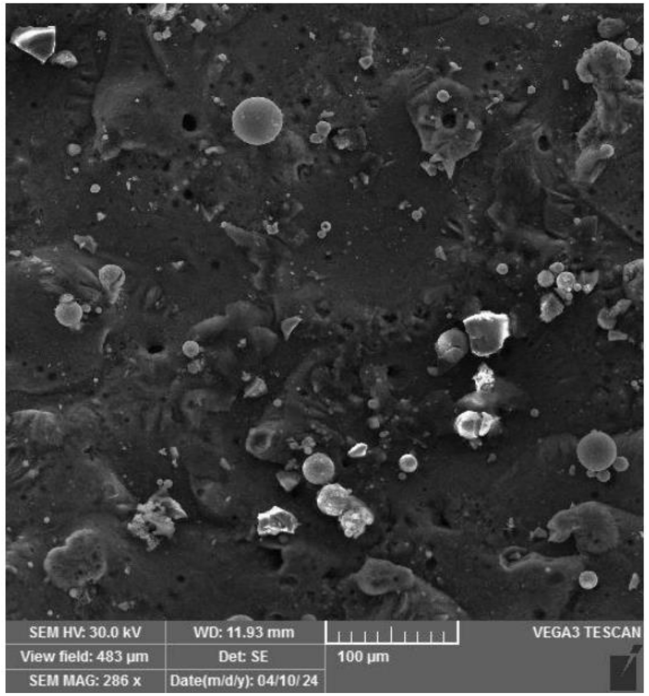


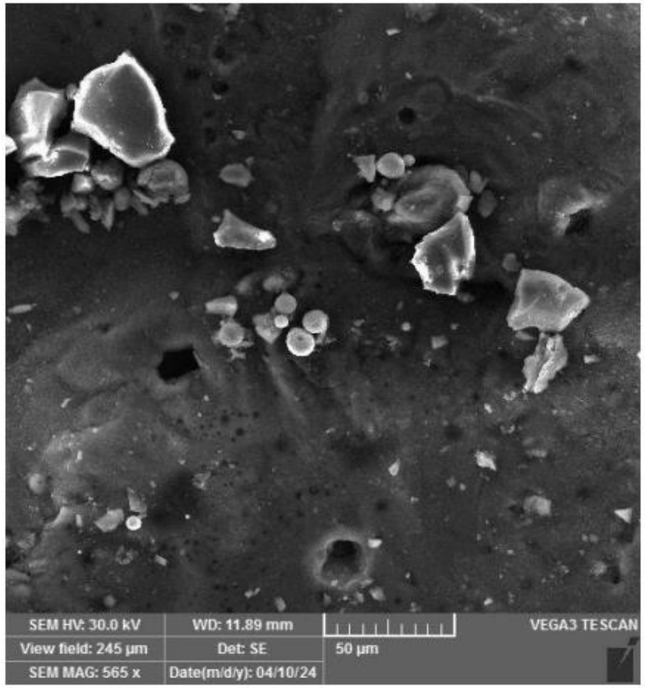


The SEM image displays a titanium alloy surface treated with electrical discharge machining (EDM), revealing a rough texture with recast material and resolidified droplets. EDM induces high temperatures, melting and vaporizing the alloy, resulting in a distinctive surface texture influenced by pulse current and duration.

Surface characteristics vary based on micro-EDM parameters like pulse current (8A), pulse on time (5 microseconds), and pulse off time (3 microseconds) Higher currents induce more heat, potentially causing rougher surfaces. Longer pulse on times also increase heat, while shorter pulse off times limit cooling, affecting surface smoothness.

LEARNING AUGMENTED

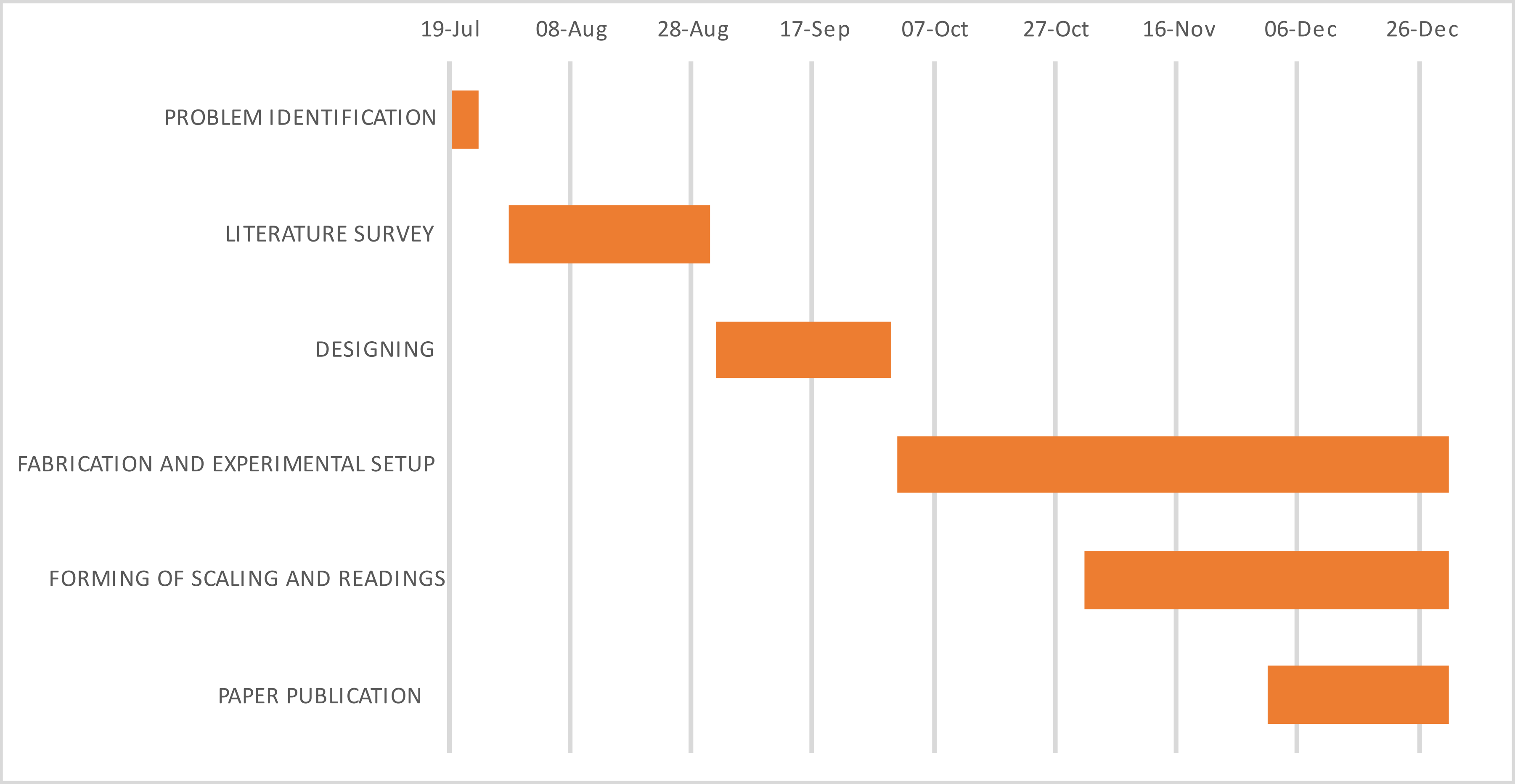




This texture is attributed to the parameters employed: a high pulse current (9A), prolonged pulse on time (7 microseconds), and short pulse off time (6 microseconds). These conditions foster extreme heat, leading to material melting and vaporization, while inadequate cooling exacerbates surface roughness, evident in the observed recast layer.

Extended heat exposure permits deeper material penetration, enlarging the molten zone. This results in a substantial recast layer and rougher surface post-solidification. Efficient debris removal, facilitated by dielectric fluid, prevents redeposition of molten material, crucial for surface quality. Rapid cooling post-pulse concludes in a distinct recast layer formation with altered microstructure and properties.

GANTT CHART:


19-Jul
08-Aug
28-Aug
17-Sep
07-Oct
27-Oct
16-Nov
06-Dec
26-Dec
PROBLEM IDENTIFICATION
LITERATURE SURVEY
DESIGNING
FABRICATION AND EXPERIMENTAL SETUP
FORMING OF SCALING AND READINGS
PAPER PUBLICATION

Tips

Blue light is basically the rays that are emitted by the digital screen, which may cause severe health problems. Flux software for PCs, Twilight app for Smartphones can act as blue light filters.

Microcosm
The Co-existing Architecture

Kumaraguru Eco Campus

Annually, the **4200 trees** inside the Kumaraguru Campus, on an average, releases **10,92,000 pounds** of oxygen inhaled by **42,000 humans**.

Wellness 360

Find ways to structure and optimize your time for when and where you learn best and keep your **learning on track**

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