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# **Influence of EDM Parameters on Taper Angle Generation Using Different Electrodes**

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**ABSTRACT:** Electrical discharge machining (EDM) is one of the non-traditional machining processes, based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. Researchers worldwide pursuing research in the area if EDM. This study focus on drilling of holes on difficult to cut material namely tungsten alloy using of different electrode materials. The experiments were conducted in ZNC sparkonix EDM. A different electrode material such as Brass and Copper is used to machine the work piece material (Tungsten Alloy - HDS-H21) of 3mm thickness. The dielectric used is EDM Oil (Honex 401). The objective of the experiment is to study the influence of pulse on time, discharge current and voltage on taper angle of the machined hole. The two different electrodes namely copper and brass electrode are considered for this study.

**KEY WORDS:** Electrode, Taper angle, hole, EDM

## **I. INTRODUCTION**

The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process. EDM has been replacing drilling, milling, grinding and other traditional machining operations and is now a well-established machining option in many manufacturing industries throughout the world. And is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas.

Patel et al. (2002) have performed experiments to determine parameters affecting surface roughness (SR) along with structural analysis of surfaces with respect to material removal parameters. Stefan Natarajan et al. (2013) studied material removal rate (MRR), tool wear rate (TWR) and overcut (OC) using effect of three controllable input variables namely pulse on time, discharge current, and voltage. Natarajan and Thanigaivelan (2014) investigated the optimization of process parameters of micro-holes machining in Electric Discharge Machining (EDM) for Stainless Steel grade 304 (SS304) on the machining characteristics using the Grey Relational Analysis (GRA) method. Alpesh Nogas and Desai (2013) have performed machining using different electrode Materials on cold work tool steel D3 workpiece with EDM process. The results show that the copper electrode gives higher MRR than other two Electrodes. Aluminum electrode gives lowest MRR among other two electrodes. Mohammadreza Shabgard et al (2011) conducted a comprehensive investigation on the influence of Electrical Discharge Machining (EDM) input parameters on the Characteristics of the EDM process. The process characteristics included machining features, embracing material removal rate, tool wear ratio, and arithmetical mean roughness, as well surface integrity characteristics comprised of the thickness of white layer and the depth of heat affected zone of AISI H13 tool steel as workpiece. The results of this study could be utilized in the selection of optimum process parameters to achieve the desired EDM efficiency, surface

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roughness, and surface integrity when machining AISI H13 tool steel. Raghu Raman S et al (2013) have investigated the optimal set of process parameters such as current, pulse ON and OFF time in Electrical Discharge Machining (EDM) process to identify the variations in three performance characteristics such as rate of material removal, wear rate on tool, and surface roughness value on the work material for machining Mild Steel IS 2026 using copper electrode. MohdAmriLajis et al (2009) have analyzed the effect of each parameter on the machining characteristics, and to predict the optimal choice for each EDM parameter such as peak current, voltage, pulse time duration and interval time. The analysis of the Taguchi method reveals that, in general the peak current significantly affects the EWR and SR, while, the pulse duration mainly affects the MRR. Experimental results are provided to verify this approach. Based on the literature review it is understood that worldwide many researchers are working in EDM and still in depth study is required for improving the machining speed and accuracy. This work focus on utilization of different tool electrode materials for drilling of holes on HDS H21 tungsten alloy.

## II. EXPERIMENTAL SETUP

A ZNC die sinking EDM was used to conduct experiments. Different electrode materials such as Brass and Cu of 3mm diameter is used to machine the work piece material (Tungsten Alloy -HDS-H21) of 3mm thickness. The experiments were conducted using the process parameters at different levels. The range of parameters was selected based on the previous experiments and review of available literature (Natarajan *et al.* 2013).

S.No	Current	Voltage	Pulse on Time	Taper angle produced by Brass electrode	Taper angle produced by Brass electrode
Unit	Amps	Volt/Unit	$\mu$ sec	Deg	Deg
1.	6	5	60	6.65	32.34
2.	6	5	90	6.65	7.59
3.	6	5	120	3.81	9.46
4.	6	5	150	4.76	10.38
5.	1.5	5	150	4.76	4.76
6.	3	5	150	5.71	9.46
7.	4.5	5	150	2.86	9.46
8.	6	5	150	6.65	10.38
9.	6	2	150	2.86	14.93
10.	6	3	150	1.90	12.22
11.	6	4	150	3.81	12.22
12.	6	5	150	8.06	13.13

## III. RESULTS AND DISCUSSION

### Effect of Pulse on Time on Taper Angle

It is evident from the graph that the taper angle increases with increase in pulse on time for the range of 90 to 150 $\mu$ s. The taper angle is more at lower pulse on time and decreases to the lowest value.

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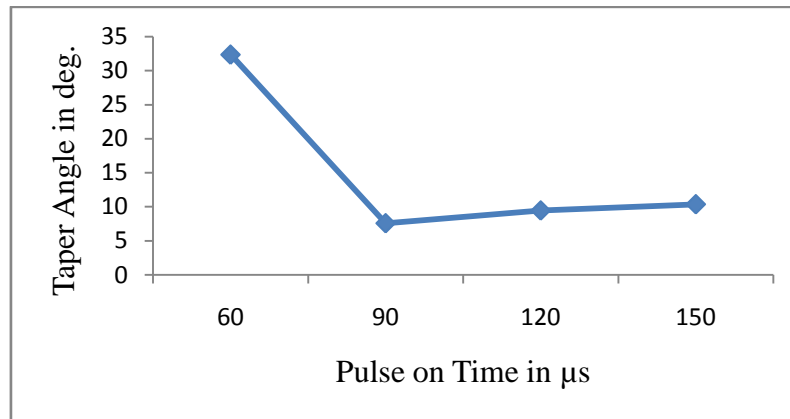
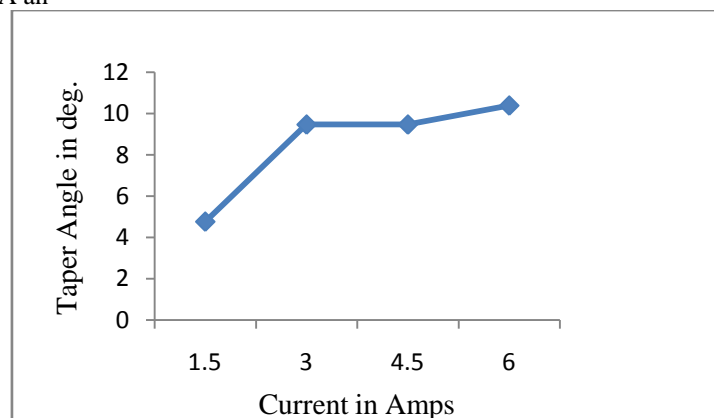


Fig.6 Pulse on Time Vs Taper Angle

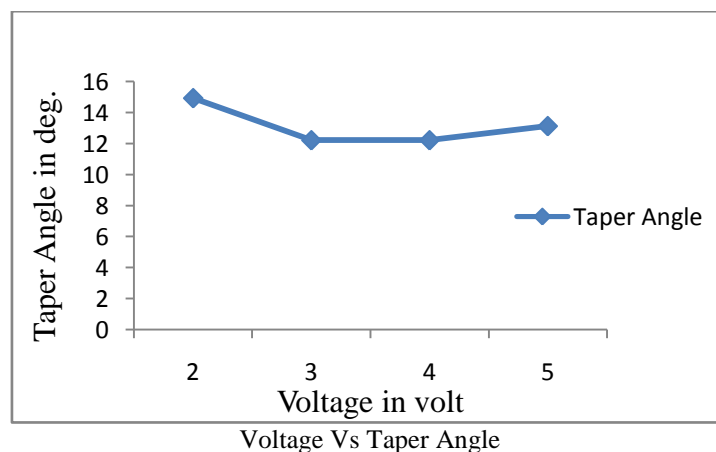
## Effect of current on Taper Angle

The taper angle found to increase drastically for the current range of 1.5 to 3 A and there is no significant increase in taper angle beyond 3 to 6A an



Current Vs Taper Angle

## 4.3.2 Effect of Voltage on Taper Angle



Voltage Vs Taper Angle

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It is evident from the figure that the taper angle decreases with increase in voltage. For voltage range of 3-4V the taper angle is remains constant and gradually increased with the range 4-5V.

## Effect of pulse on Taper Angle

Initially the pulse on time in the range of 60-90 $\mu$ s has no effect on taper angle and with increase in pulse on time the taper angle decrease and gradually increases. It is evident from the figure that pulse on time in the range of 90-120 $\mu$ s reduces the taper generation.

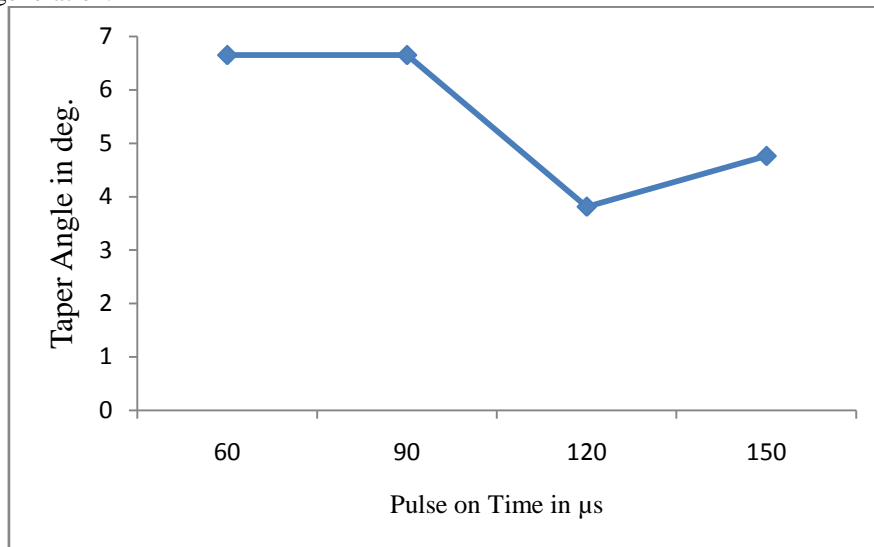


Fig. Pulse on Time Vs Taper Angle

## Effect of Current on Taper Angle

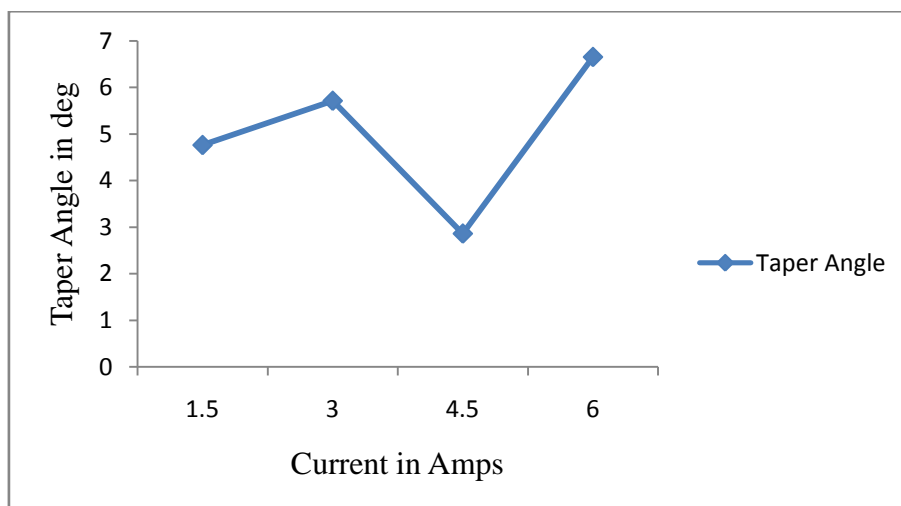


Fig. Current Vs Taper Angle

In this graph shows that current will increase the range (1.5 to 3A) means the taper angle will also increase gradually. The current range (3-4.5A) setting to the machine taper formation is less. At the range (4.5A) taper formation is high based on the input current

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## 4.7 EDX/EDS ANALYSIS

### 4.7.1 BASE METAL

Full scale counts: 8809

6061-TIG(20)\_pt1

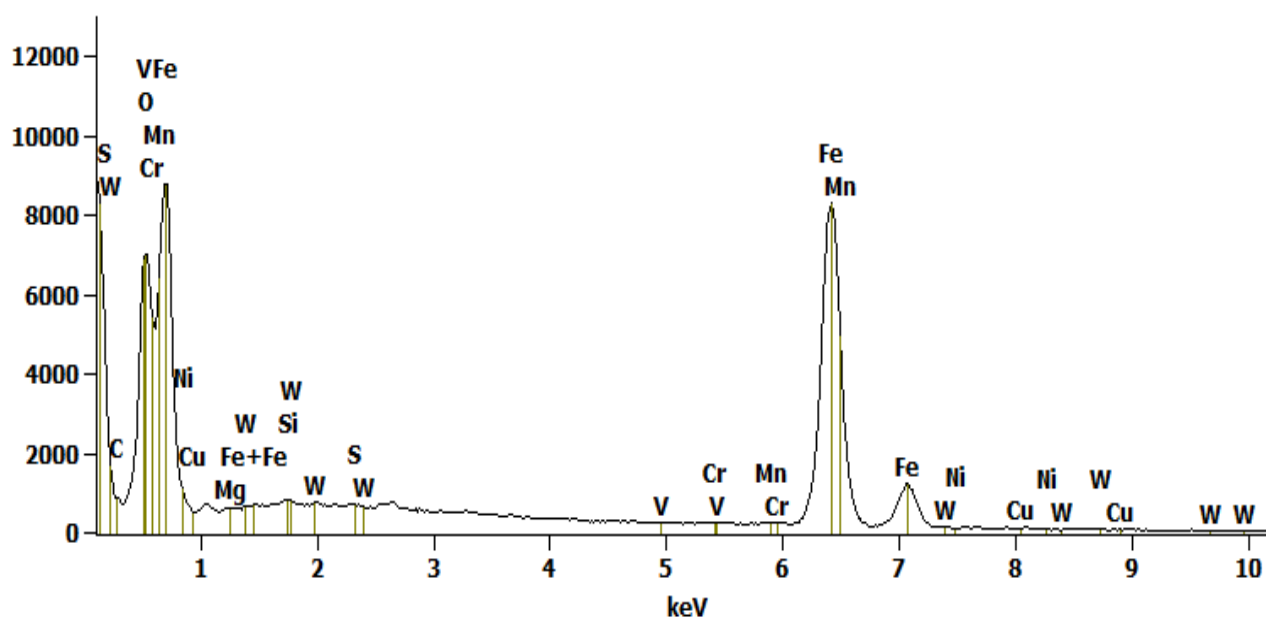


Fig.28 EDX Analysis of Base Metal

Element Line	Weight %	Weight % Error	Atom %
C	0.03	+/- 0.02	0.50
Mg	0.00	---	0.00
Si	0.53	+/- 0.03	0.94
V	0.11	+/- 0.05	0.10
Mn	1.06	+/- 0.10	0.95
Fe	93.08	+/- 0.58	81.99
Cu	2.05	+/- 0.20	1.02
W	0.00	---	0.00
Total	100.00		100.00

Table – 33 Weight composition of Workpiece

In EDS/EDX analysis is to determine the composition of the metal. In this experiment we found the composition of Tungsten alloy material. The compositions are listed above mentioned table.

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## 4.7.2 BRASS

Full scale counts: 8821

6061-TIG(19)

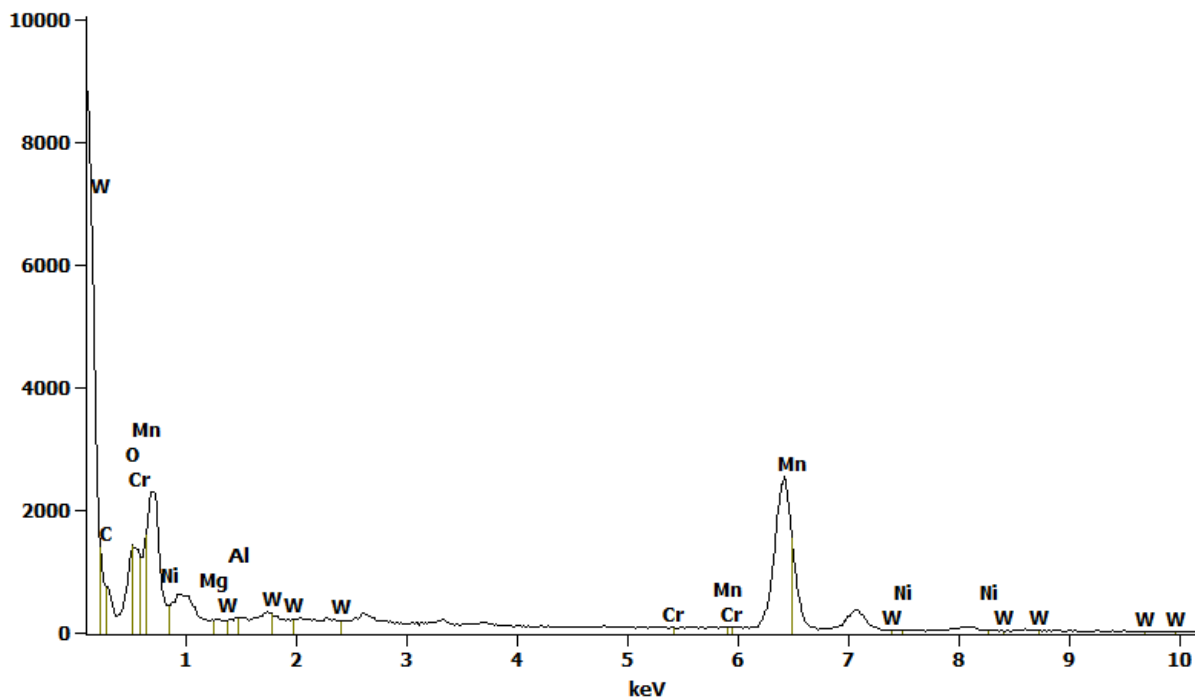


Fig.29 EDX Analysis of Machined hole using Brass Electrode

Element Line	Weight %	Weight % Error	Atom %
<i>Mg</i>	0.35	+/- 0.08	0.63
<i>C</i>	0.27	+/- 0.06	0.43
<i>Si</i>	0.88	+/- 0.06	1.36
<i>V</i>	0.08	+/- 0.09	0.07
<i>Cr</i>	0.12	+/- 0.10	0.10
<i>Mn</i>	1.24	+/- 0.19	0.98
<i>Fe</i>	86.46	+/- 0.92	67.51
<i>W</i>	6.00	+/- 0.06	28.65
<i>Total</i>	100.00		100.00

Table – 34 Weight composition of Machined hole using Brass Electrode

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In this EDX analysis shows the result of drilled hole (3mm) in the Tungsten alloy material by using Brass electrode. So the brass electrode particles are diffused in the machined hole surface.

## 4.7.3 COPPER

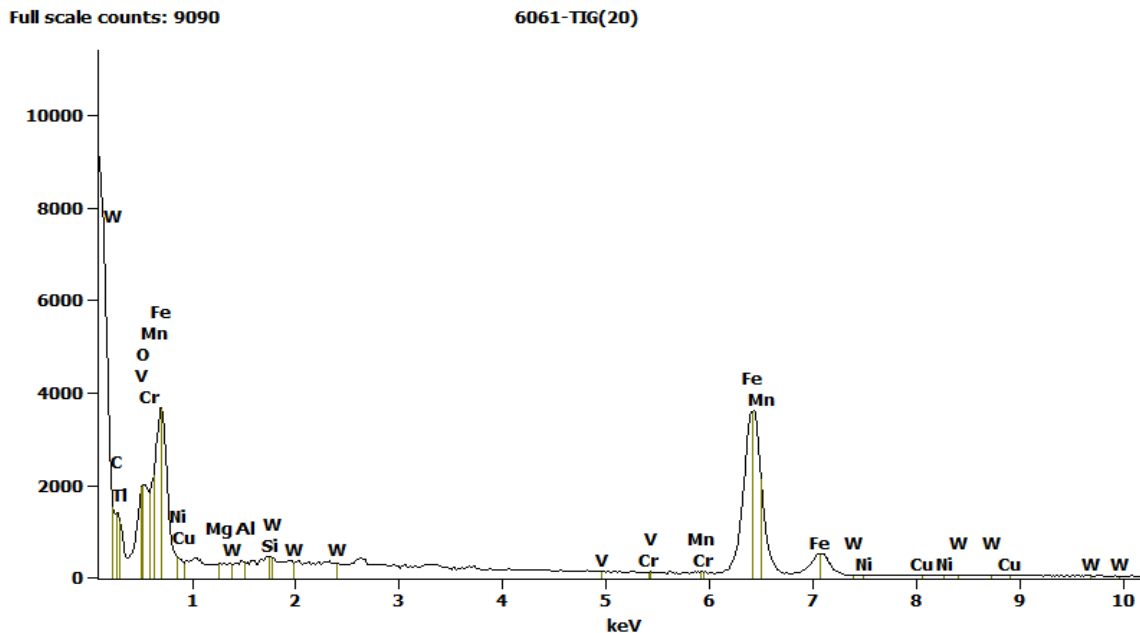


Fig.30 EDX Analysis of Machined hole using Copper Electrode

Weight %

Part	C	O	Si	Cr	Mn	Fe	Ni	C	W
6061-TIG(21)_pt1	0.05	0.00	1.17	1 1.41	0.87	88.06	0.00	8.49	0.98

Table – 35Weight composition of Machined hole using Copper Electrode

In this EDX analysis shows the result of drilled hole (3mm) in the Tungsten alloy material by using Copper electrode. So the copper electrode particles are diffused in the machined hole surface.

## IV. CONCLUSION

1. Based on the experiment the brass electrode having high taper formation for the input parameters such as current, voltage, pulse on time.
2. The copper electrode having low taper formation for the input parameters such as current, voltage, pulse on time.
3. Compared the results we found that copper electrode is suitable to machining tungsten alloy (HDS H21) material for lesser taper formation when compared to brass electrode.

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