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Experimental Study of Static and Rotary Electrode on Electrical Discharge Machining (EDM) using Graphite Electrode

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Abstract: *Electro-discharge machining is a machining process that is most widely used for machining different types of hard materials, especially electrically conductive materials. Electrical discharge Machining produces a complex profile that is not possible by traditional machining processes. In the electro-discharge machining process, the w/p and electrode both must be electrically good conductive. Graphite, copper and brass are mostly used for making the electrode due to high electrical conductivity. In this paper, a Graphite electrode used for machining of Copper Nickel alloy (grade Cu70Ni30) with a stationary and rotary electrode and analysed the MRR, Ra and TWR and compared the MRR, Ra and TWR between the static electrode and rotary electrode. In this research paper, the value of the discharge current changed during the experiment and study the consequence of the discharge current on MRR, Ra and TWR in both conditions (static and rotary electrode).*

Key-words : EDM, Static and Rotary Electrode, Graphite Electrode, MRR, TWR, Ra

1. INTRODUCTION

When a spark is generated between two electrically conductive materials then a small amount of material removed from the w/p and if the w/p and tool both submerge into the dielectric then it localised into a small portion which is can be controlled by various methods used This technique for machining the varies hard materials which are not possible to machining by traditional machining process. In electrical discharge machining, short-duration spark and high frequency are used for good machining and it is suitable for obtaining a good surface finish. In the EDM dielectric sparks can be concentrated into small areas and due to this meter machining is possible[1]. Electro discharge machining is one of the best machining processes for machining very hard materials because EDM is a non-contact machining process in which the tool and w/p never touch each other during the machining, when high voltage which is in pulse form and low current is applied on small electrode gap (10 μm to 70 μm) which is submerged in dielectric then very high thermal energy having spark generates which melt the material and vaporise and this process continue when pulse on and pulse off respectively. When the pulse is off, the removed material is flushed out by the dielectric fluid which flows on the machining surface with high pressure [2]. In electro-discharge machining electrical energy is transformed into thermal energy. When the spark is generated between the electrode and w/p then high energy is released which localised a small area due to the high energy w/p's surface melt and vaporise and machining takes place. High heat energy is released when a spark is generated at approximately 8000 to 12000 degrees Celsius [3-4].In the EDM when material removes then a small portion of the material from the electrode is also removed which is called Tool wear sometimes this material is deposited on the w/p and this is called modification of electro-discharge machining surface which increases the w/p material wear and erosion resistance [5-6]. In the EDM, the electrode is called a tool, and when machining takes place, a replica of the tool (electrode) design is obtained on the w/p. In the EDM any electrical conductive material with any type of mechanical properties like hardness, strength, modulus of elasticity etc having materials can be machined very easily. For machining any type of material by the EDM process, only two important properties are required: first electrical conductive and second thermal conductive and other mechanical properties are not important. All new advance materials and alloys which have better electrical and thermal properties can be machined by the EDM process very easily which is not possible to machine by another machining process. [7-8]. Nowadays, many companies, particularly those that make moulds and dies, submarine, ship, automobile and aerospace industries all use the EDM process for machining advanced alloy materials [9]. In the EDM process tool material and its mechanical properties play a very important role. For good and accurate machining, choosing electrodes with excellent electrical and mechanical properties is essential. The selection of electrode depends on the mechanical properties of the w/p material and based on the required surface finish, MRR[10]

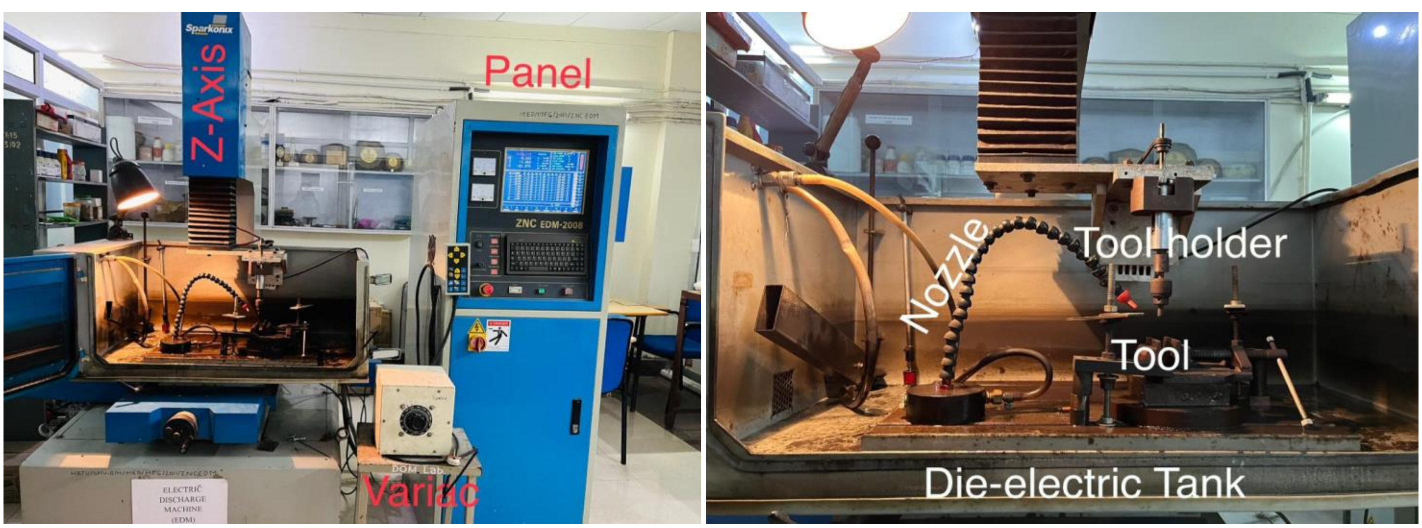
2. LITERATURE REVIEW

Apiwat Muttamara [11] use graphite electrode in EDM machining and conclude that Graphite electrode makes more surface roughness as compared to other electrodes. Shusong Zana [12] used graphite electrodes and tried to find out the TWR in the EDM process. He found that low porosity graphite electrodes have low TWR when submerged in the water-based dielectric. he tried to compare the tool wear by taking different types of dielectric which have different percentages of carbon. the researchers absorb that if carbon deposition is more then tool wear is less during the machining process. Hardeep Singhet al. (2021)[13] used copper, graphite and brass electrodes in their experiment, During the experiment researchers absorbed that if the peak current and pulse on duration then MRR also increases and we get a higher MRR. C. Pavan (2019)[14] experimented on the machinability of nickel alloy material and used the Taguchi method by using copper, and brass electrodes. The researchers absorb that in the EDM process discharge current is a predominant factor which affects the MRR during the machining. A. Torres (2014)[15] investigated the surface finish and MRR of Inconel material in the EDM process by taking different variable parameters like discharge current, and pulse on time. The researchers absorb that the discharge current and pulse on time are the most dominant process parameters that affect the machining surface and MRR. During the machining of Inconel material in the EDM process if the peak current and the pulse are on time then it is absorbed and the MRR and surface roughness are also increased. Abhishek Thakur et al.[16] (2020) used different process parameters during their experiment in the EDM process such as discharge current, pulse on time and pulse off time on the Ti-6246 material and used graphite electrode as a tool. the researchers used the roundness surface method technique to analyse the surface finish of the material. the researchers absorb that surface finish decreases when the discharge current and pulse on time increase. R. L. Balaji et al. [17](2016) used Monel material as a w/p and copper electrode as a tool in their experiment, the researchers absorb that discharge current affects the surface roughness (72.6%), pulse on time affects the surface roughness (5.2%) and pulse off time affect the surface roughness (3.4%). S. Gowthaman et al. [18](2018) investigated the machining of Monel material by the GRA and used copper electrodes as a tool. The researchers absorb that discharge currents play a very major role in MRR and Ra (surface roughness). Discharge current consequence on MRR and Ra (surface roughness) is 71% and 81% respectively

This paper, investigate the consequence of static and rotary Graphite electrode in Electro discharge machining on Copper-nickel alloy analyses and study the consequence of discharge current variation on MRR, TWR and Ra with the static electrode and rotary electrode and compares its results

3.EXPERIMENTAL WORK

Sparkonix ZNC (Z axis numerical Control Machine) 2008, model number S 50 ZNC electrical discharge machine used for experimentation.



Sparkonix ZNC (Axis Numerical Control Machine)

Table 1. Experimental condition

Discharge Current	1.5, 3, 4.5, 6, 9, 12, 15, 21, 30, 45 Ampere
Pulse on time	90 μs
Pulse off time	30 μs
Polarity	Straight
Servo System	AC Servo
Dielectric	EDM oil 500PL
Dielectric flashing	Side flashing 5 kg/cm^2 pressure
Electrode rotation speed	900 RPM

Copper Nickel alloy Grade Cu70Ni30 material was used for the experiment and a graphite electrode was used as a tool for machining.

Table no.2 gives the chemical composition of copper-nickel alloy, and Table no.3 gives some mechanical properties of copper-nickel alloy, and table no.3 gives some properties of graphite electrodes.

Table No 2

Chemical composition of Copper Nickel(Cupronickel) Alloy

Alloy Grade	Elements	Percentages
Cu70Ni30	Copper (Cu) Nickel (Ni)	70 30

Table No 3

Copper Nickel Alloy has some Mechanical properties

Mechanical Properties	**Nickel Alloy (Grade Cu70Ni30)**
Density	8.95 kg/dm^3
Melting point	1170-1240 °C
Specific Heat	377 J/KGK
Thermal conductivity	29 W/mK
Electrical resistivity	34 Micro-ohm/cm
Elasticity constant	152 GPa
Rigidity constant	56 GPa

TABLE 3.

Graphite Electrode Properties

material	Density (gm/cm^3)	Specific electrical Resistance (ohm-m)	Thermal conductivity (W/mK)	liquefaction point (◦C)
Graphite	2.19	2.51×10^{-6}	133.064	3600

$$MRR = \frac{(M_i - M_f) \times 1{,}000}{\rho \times t} \frac{mm^3}{min} \quad \text{Eq (1)}$$

M_i – Initial weight in grams (w/p)

M_f – final weight in grams (w/p).

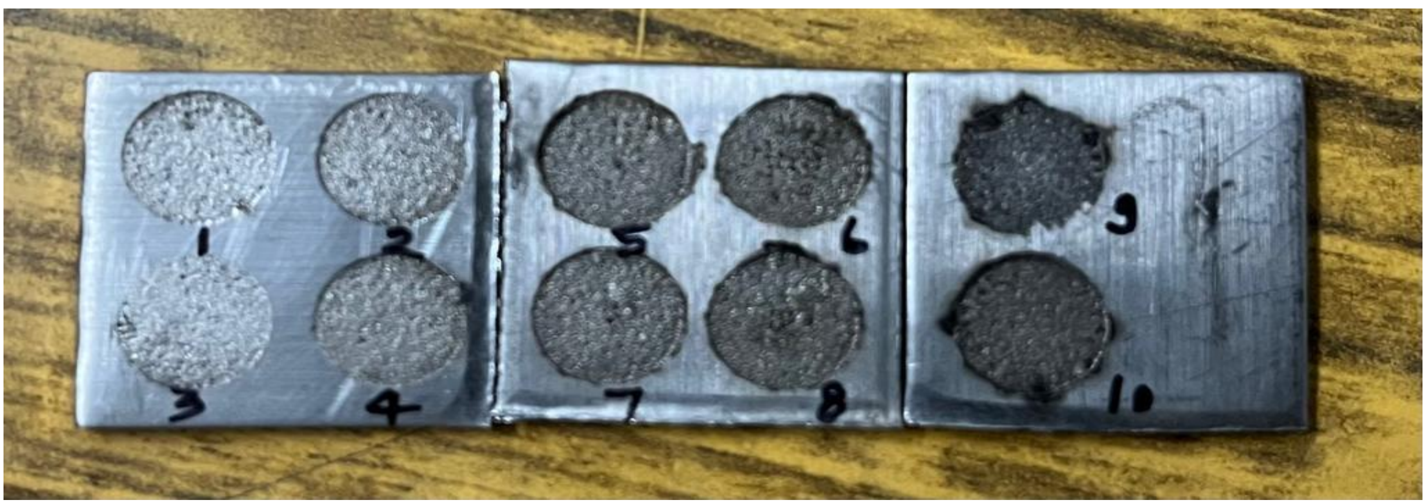
ρ – Density in gram/cc (w/p)
t- Total machining time (minute).

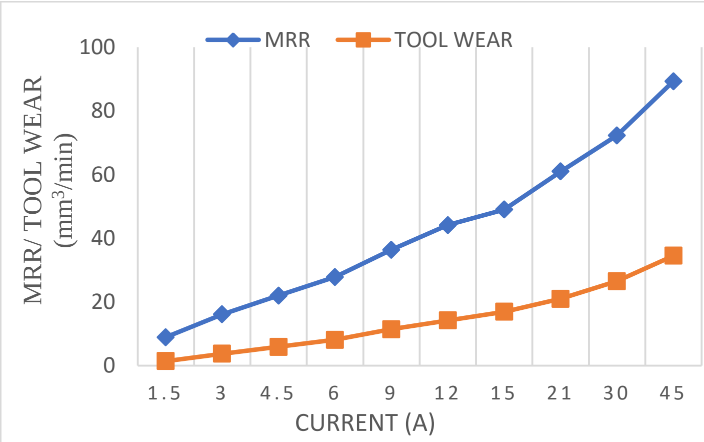
$$TWR = \frac{(T_i - T_f) \times 1{,}000}{\rho \times t} \frac{mm^3}{min} \quad \text{Eq (2)}$$

T_i – Initial weight in grams (electrode)
T_f – Final weight in grams (electrode)
ρ – Density in gram/cc (electrode)
t- Total machining time (minute)

4.EXPERIMENTAL ANALYSIS WITH STATIONARY ELECTRODE

The consequence of discharge current on MRR TWR and Ra with Stationary Electrodes are analysed during the experiment. The obtained output is given below.





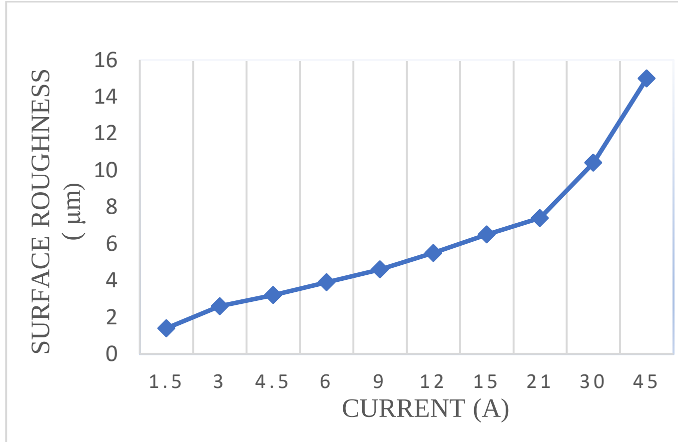


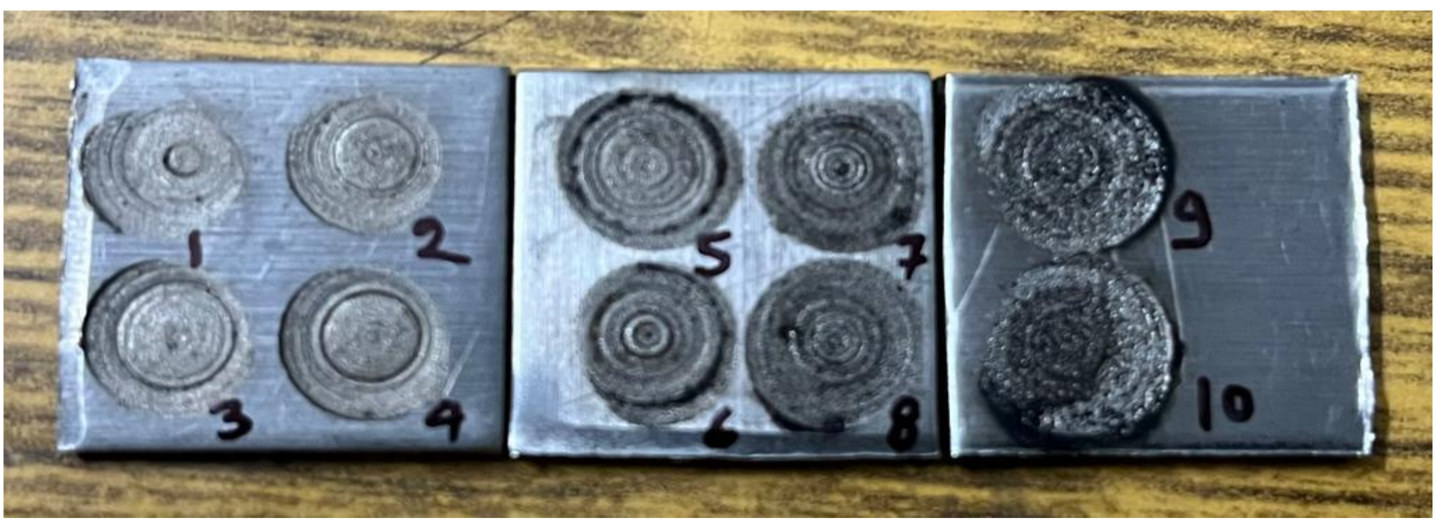
Figure 1. The consequence of discharge Current on MRR, TWR and Ra with Stationary Electrode

Figure 1. Shows the consequence of discharge current on MRR, TWR and Ra with Stationary Electrode. The experiment shows that MRR and TWR are very low when the discharge current is small because when the discharge current is small then discharge energy is small and when the discharge current increase then discharge energy also increase due to this MRR and TWR also increase gradually. The experiment shows that a small variation in discharge current does not affect the MRR and tool wear is negligible but when the discharge current is greater, MRR and TWR increase rapidly and with high discharge current it is observed that carbon deposition on the w/p starts that affect the machining and surface roughness of the w/p.

The experiment shows that MRR gradually increases when the discharging current increases, It is absorbing that the Ra of the w/p is good when the discharging current lies between 3 to 15 Ampere and if the discharge current is greater than 15 ampere then the surface roughness increases rapidly.

5. EXPERIMENTAL ANALYSIS WITH ROTARY ELECTRODE

The consequence of discharge current on MRR, TWR and Ra with Rotary Electrodes analyses during the experiment. The obtained output is given below.



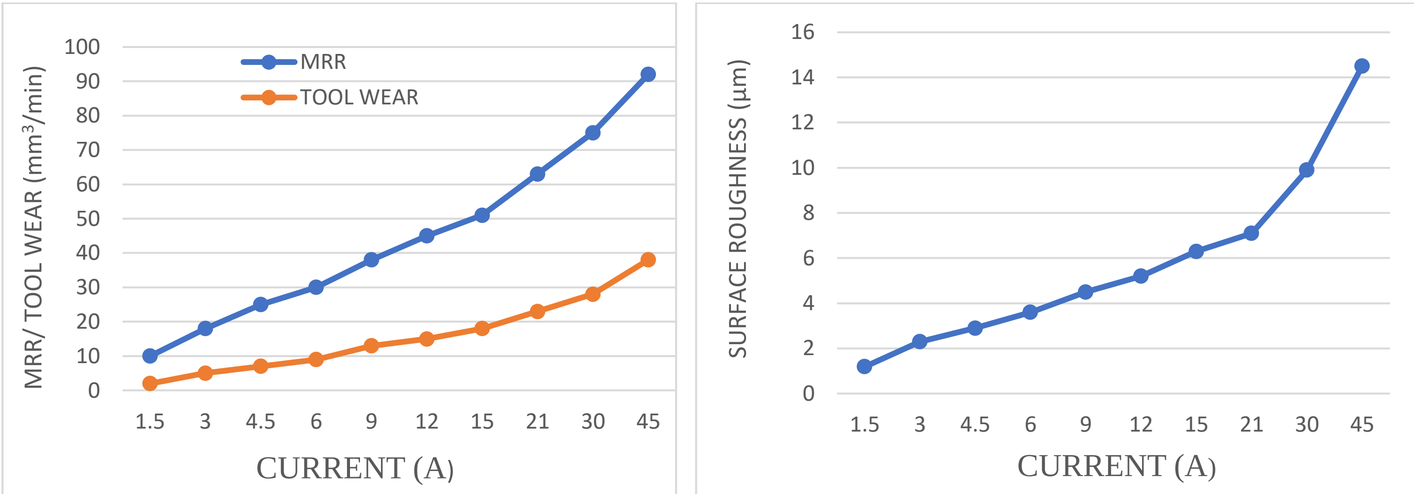


Fig. 2. The consequence of Discharge Current on MRR, TOOL WEAR and Ra with Rotary Electrode

Figure 2. Shows the consequence of discharge current on MRR, TWR and Ra (surface roughness) with Rotary Electrode. The experiment shows that MRR and TWR with Rotary Electrode are more as compared to Stationary Electrodes. MRR and TWR are more with rotary Electrode because when the electrode (tool) rotates then it exerts more pressure on the w/p and pressure becomes high between w/p and electrode and this creates a greater vortex as compared to a stationary electrode and it spreads more heat flux due to this more heat flow on the w/p and more material melt and vaporised.

The experiment shows that the Surface Roughness of the w/p with a rotary electrode is less as compared to the Stationary Electrode. It is absorbed that when the Electrode rotary RPM is low then surface roughness is also low and a smooth surface is obtained.

6. CONCLUSIONS

By the analysis of the above experimental results, some important conclusions are given below

1.MRR and TWR both increase when the discharge current increases, MRR and TWR decrease with decreasing the discharge current.

2.Surface Roughness (Ra) increases when the discharging current increase and it decrease when the discharging current decrease.

3.Rotary electrode having greater MRR and TWR as compared to the stationary electrode

4.Rotary electrodes provide better surface quality as compared with static electrodes.

Based on the above analysis Graphite electrode with rotation provide good surface quality and have higher MRR (material removal rate) but graphite electrode with rotation also have high TWR as compared to the stationary electrode so rotary electrode is suitable when high material removal is required.

REFERENCES

1. Advanced Machining Processes By V.K. Jain (page 126)
2. E.C. Jameson, “Description and development of electrical discharge machining (EDM), Electrical Discharge Machining,” Society of Manufacturing Engineers, Dearborn, Michigan,2001, pp. 16.

3. Singh, Shankar, S. Maheshwari, and P. C. Pandey. "Some investigations into the electric discharge machining of hardened tool steel using different electrode materials." Materials Processing Technology (2004)

4. Dauw, D. F. "Charmilles technologies: facing the future." Paper Presented During the Inauguration of CT Japan. 1989.

5. Ho, K. H., and S. T. Newman. "State-of-the-art electrical discharge machining (EDM)." *International Journal of Machine Tools and Manufacture* 43.13 (2003): 1287-1300.

6. Lee, Hwa-Teng, and Jiahn-PiringYur. "Characteristic analysis of EDMed surfaces using the Taguchi approach." Materials and Manufacturing Processes 15.6 (2000): 781-806.

7. Stovicek, D. R. "The state-of-the-art EDM science." Tooling and Production, Nelson Publishing Inc., Ohio, US 59.2 (1993): 42.

8. Marafona, Jose, and Catherine Wykes. "A new method of optimising MRR using EDM with copper–tungsten electrodes." International Journal of Machine Tools and Manufacture 40.2 (2000): 153164.

9. Tsai, Kuo-Ming, and Pei-Jen Wang. "Semi-empirical model of surface finish on electrical discharge machining." International Journal of Machine Tools and Manufacture 41.10 (2001): 1455-1477

10. Tsai, H. C., B. H. Yan, and F. Y. Huang. "EDM performance of Cr/Cu-based composite electrodes." International Journal of Machine Tools and Manufacture 43.3 (2003): 245-252.

11. Apiwat Muttamara, "Consequence of Graphite Electrode to Surface's Characteristic of EDM January 2016

12. Shusong Zana "Study of Graphite Tool Wear in EDM with Water-based Dielectrics and EDM Oil" 20th CIRP Conference on Electro-Physical and Chemical Machining (ISEM 2020)

13. Hardeep Singh, Jujhar Singh, Shubham Sharma, S. P. Dwivedi, and Ahmed J. Obaid: Journal of Green Engineering, 11 (2021) 922-938

14. C. Pavan, N. Sateesh, and R. Subbiah: Materials Today: Proceedings, 46 (2020) 9281-9286.

15. A. Torres, I. Puertas, and C. J. Luis: Precision Engineering, (2014) 2334-2340.

16. A. Thakur, P. Sudhakar Rao, and Mohd. Y. Khan: Materials Today: Proceedings, 44 (2020) 838-847.

17. R. L. Balaji, and J. P. Kumar: Journal of Engineering, Scientific Research and Applications, (2016) 2455-3964

18. S. Gowthaman, K. Balamurungan, P. M. Kumar, S. K. Ahamad Ali, K. L. Mohan Kumar, and N. V. Ram Gopal: Procedia Manufacturing, 20 (2018) 386- 391.