ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

# Enhancing Micro EDM Machining Performances Using Carbon Nano Tubes

[1] Rajendra H. Shinde, [2] Dr. D. N. Raut, [3] Sachin M. Agrawal
[1] Assistant Professor D.I.E.M.S., [2] Professor V.J.T.I. Mumbai, [3] Assistant Professor D.I.E.M.S.

***Abstract:*** **-- Presently manufacturing industries are facing challenges from difficult-to-machine materials viz. Superalloys, ceramics and composites which require high precision and surface quality thereby increase machining cost. Electrical Discharge Machining (EDM) is a non-traditional machining process that has become a well-established machining option in manufacturing industries throughout the world. The analysis of surface characteristics like surface roughness, microcracks of workpieces shows excellent improvement in machined surface. Carbon nanotubes are generally of two types, single-walled varieties (SWNTs), which have a single cylindrical wall and multi-walled varieties (MWNTs) which have cylinders within cylinders. Carbon nanotubes are one of the most commonly mentioned building blocks of nanotechnology. With one hundred times the tensile strength of steel, thermal conductivity better than all but the purest diamond, and electrical conductivity similar to copper, but with the ability to carry much higher currents, they seem to be a wonder material.**

***Key words*: PMEDM, SWCNTs, MWCNTs.**

## I. INTRODUCTION

In new technology researchers mix Carbon Nano tube (CNT) with dielectric fluid in EDM process because of high thermal conductivity of CNTs. The analysis of surface characteristics like surface roughness, micro cracks of work pieces shows excellent improvement in machined surface. Carbon nanotubes are generally of two types, single-walled varieties (SWNTs), which have a single cylindrical wall as in figure 1, and multi-walled varieties (MWNTs), which have cylinders within cylinders as in figure 2. The lengths of both types vary greatly, depending on the way they are made, and are generally microscopic rather than nanoscopic, i.e. greater than 100 nanometers (a nanometer is a millionth of a millimeter). The aspect ratio (length divided by diameter) is typically greater than 100 and can be up to 10,000, but recently even this was made to look small. Carbon nanotubes are one of the most commonly mentioned building blocks of nanotechnology. With one hundred times the tensile strength of steel, thermal conductivity better than all but the purest diamond, and electrical conductivity similar to copper, but with the ability to carry much higher currents, they seem to be a wonder material.

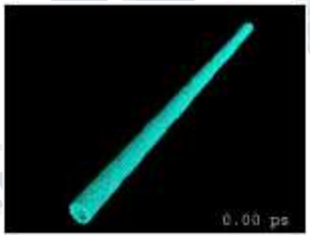


***Fig.1Single Walled Nano Tube***

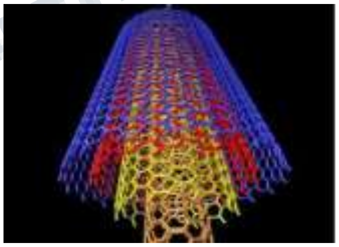

***Fig 2. Multi-Walled Nano Tube***

Micro-EDM is a derived form of EDM, which is generally used to manufacture micro and miniature parts and components by using the conventional electrical discharge machining principles. Similar to conventional EDM, material is removed by a series of rapidly recurring electric spark discharges between the tool electrode and the workpiece in micro-EDM. The basic physical characteristics of the micro-EDM process is essentially similar to that of the conventional EDM process with the main difference being in the size of the electrode used, the power supply (current and voltage), and the resolution of the X-, Y- and Z- axes movement. Micro EDM is a process based on thermoelectric energy between workpiece and electrode. In micro-EDM; pulse generator produces very small pulses within pulse duration of a few micro seconds or nano seconds. Because of this reason, micro-EDM utilizes low discharge energies (~joules) to remove small volumes (~µm) of material. Micro EDM in particular is an important micro manufacturing process because it is unconstrained by the hardness or material strength of the material being machined. One major reason for its wide implementation is that there is no direct contact of the electrode and machined component; hence no contact forces are induced during machining process.

## II. LITERATURE SURVEY

In order to improve the EDM machinability of materials, a number of researchers attempted adding conductive powders into dielectric fluids. For example, Yeo et al. (2007) added 45–55 nmsized SiC powders into dielectric and found that the surface craters became smaller than those produced in powder free dielectric fluid.
Chow et al. (2008) added SiC powders into pure water as dielectric fluid in the EDM of titanium alloy, and confirmed the improvement in surface quality and material removal rate. Added molybdenum disulfide ($MoS_2$) powders and improved the material removal rate and surface roughness of Cu, brass and Cu–W workpiece materials.
Gunawan et al. (2011) also tried suspending nano graphite powder in dielectric fluid with the combination of ultrasonic vibration. They found that the machining time was reduced up to 35%. Powder assisted EDM was also applied to the EDM of ceramic materials.
Jahan et al. (2010 a, b) studied the effect of adding graphite, aluminum and non-conductive alumina powders in EDM of tungsten carbide ceramics. They found that the graphite powder provided a smooth surface and the aluminum powder resulted in higher spark gap and higher material removal rate, whereas the alumina powder had little effect on the EDM performance.
Nevertheless, for low-conductivity or insulating ceramic materials, it was difficult to obtain good machining performance by powder addition. For example, Tani et al. (2002) used Al, Gr, Si, Ni, $ZrB_2$ powders to assist the EDM of insulating $Si_3N_4$ ceramics and found that even though the removal rate was increased, the surface roughness was barely improved. This was due to the generation of long pulse discharge in the EDM process.
Pay Jun Liew et al. (2013) proposed Carbon nanofiber assisted micro electro discharge machining and experiments were performed on reaction-bonded silicon carbide. The changes in electro discharging behavior, material removal rate, electrode wear ratio, electrode geometry, spark gap, surface finish, surface topography and surface damage with carbon nanofiber concentration were examined. It has been found that the addition of carbon nanofiber not only improves the electro discharge frequency, material removal rate, discharge gap, but also reduces the electrode wear and electrode tip concavity [1].
Although there has been extensive research on improving the surface finish of EDMed surface, very few works have been done in case of micro-EDM. Chow et al. has applied PMEDM for machining of micro-slit in a titanium alloy (Ti-6Al-4V) and has obtained better performance in terms of MRR and surface finish. However, although the study aims for fabricating micro-structures, they used conventional EDM machining conditions.
Tan et al.have investigated the effect of nano-powders additives on the surface roughness and discharge gap distances during the micro-EDM of AISI 420 stainless mould steel. It has been reported that SiC and $Al_2O_3$ nano-powders can reduce the surface roughness during the micro-EDM of stainless steel. In addition,
Jahan et al. studied on the graphite powder-mixed micro-EDM of SKH-51 tool steel and found that the surface finish improves. However, only one fixed concentration (2 g/L) was used in this study as conventional EDM suggests 2–4 g/L concentration provide improved surface finish. Nevertheless, the optimum concentration of micro-EDM may be different from that of conventional EDM and therefore the effect of concentration is important to study in micro-EDM

**2.2 EDM with Carbon Nano Tubes**

Researchers had made a lot of efforts on the conventional EDM to produce fine surface finish and to minimize the micro cracks and damage surface on work surface. Nano surface finish has become an important parameter in the semiconductor, optical, electrical and mechanical industries. The materials used in these industries are classified as difficult to machine materials such as ceramics, glasses and silicon wafers. Machining of these materials up to nano accuracy is a great challenge in the manufacturing industry. Finishing of micro components such as micro-moulds, micro-lenses and micro-holes need different processing techniques. Conventional finishing methods used so far become almost impossible or cumbersome. Generally EDM Dielectric is mixed with either aluminum (Al), chromium (Cr), copper (Cu), and silicon carbide (SiC) powder that reduces the insulating strength of the dielectric fluid and increases the spark gap between the tool and work piece, thus disperses the discharging energy to obtain superior surface finish. Conductive powders added to dielectric can increase the micro hardness, make the molten layer of material thinner and reduce cracks.
Experimental evidences show that multi-wall carbon nanotubes give better surface compared to the traditional EDM process. Thickness of recast layer is smaller when CNTs are used. Electrode

 

IFERP
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

Wear rate and material removal rate are improved due to the better flow of electricity, being the heat effectively absorbed by the dielectric fluid including the MWCNTs. A smoother surface is obtained when machining is performed at a lower pulse of energy. The result obtained in this preliminary study looks promising for some practical applications to improve the efficiency of the EDM process, although a deeper investigation is needed to define quantitative criteria to set up the machining parameters for a given concentration of MWCNTs in the dielectric.

**Effects of concentration of CNT powders on the surface roughness**

Figure 6 shows the effects of eight concentration levels of CNT powders on the surface roughness when the electrode with a 20-mm diameter was employed. The experimental results show that the EDM process with the CNT powder concentrations of 0.4 and 1.2 g/l had the finest surface roughness (Ra 0.09 µm), while the surface roughness with the kerosene dielectric was Ra 0.3 µm. The use of CNT powder mixed in the dielectric improved the surface roughness of the workpiece by 70%. The surface roughness became larger if more CNT powder was added. When the concentration was too high in the gap, the EDM process became unstable arcing or short-circuiting, which deteriorated the surface.

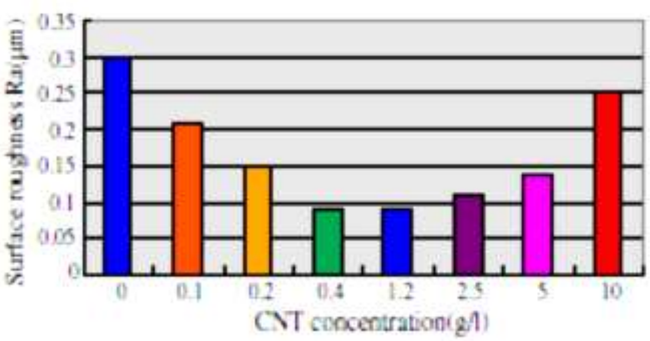


***Figure 3 Influence of the CNT concentration on the surface roughness***

Figure 4a shows micrographs of surfaces machined under kerosene and kerosene mixed with a 0.4 g/l concentration of CNT powder, while figure 7b shows surface profiles of the workpieces in the same EDM processes. It shows that the surface machined under kerosene mixed with CNT powder was smoother, with less micro- cracking, which is beneficial for the life of the workpiece.

Figure 5 shows the effects of a 0.4 g/l concentration of CNT powder on the surface roughness when electrodes of different sizes were employed. The surface roughness caused by EDM with a dielectric mixed with CNT powder varied from 0.09 to 0.16 µm when the diameter of the electrode varied from 20 to 55 mm, while the surface roughness varied from 0.3 to 0.78 µm with the kerosene dielectric. This result shows that the surface roughness deteriorated rapidly for larger electrodes machined under kerosene because of the effect of stray capacitance across the gap, while the surface roughness increased slowly for larger electrodes machined under a dielectric mixed with CNT powder.

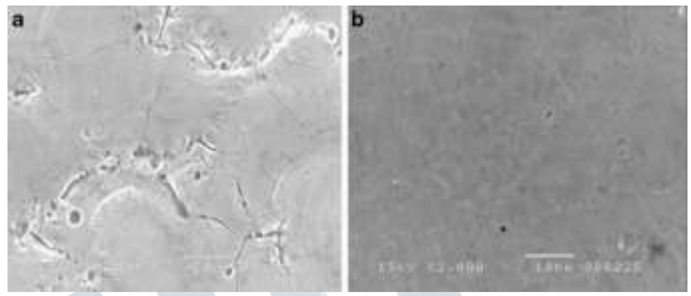


***Figure 4 SEM micrographs of the machined surface under various dielectrics: a kerosene and b kerosene+CNTs***

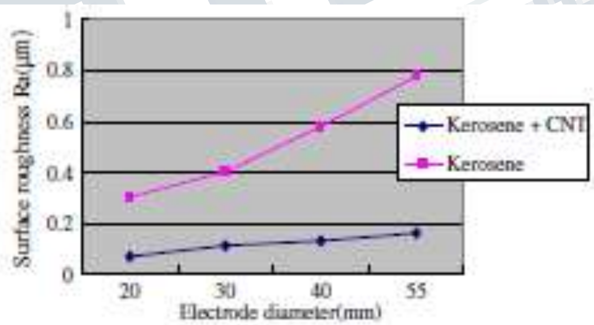


***Figure 5 Surface roughness resulting from the EDM process for different electrode sizes with a kerosene and b kerosene+CNTs***

**Key Findlings**

Effect of carbon nano tube on MRR for CNT + kerosene was 58.977 mm3/min and that of pure kerosene was 49.407 mm3/min from experimental result with carbon nano tube the average 19% of MRR increased with respect to input parameter as shown in figure 13. Effect of carbon nano tube on SR for CNT + Kerosene was 5.545 micro meter and that of pure kerosene was 7.346 micro meter from experimental result the CNT powder mixed in dielectric improved the surface roughness of the work piece as shown in figure 14. The average 30% of Surface finish was improved by using CNT mixed as dielectric fluid.

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

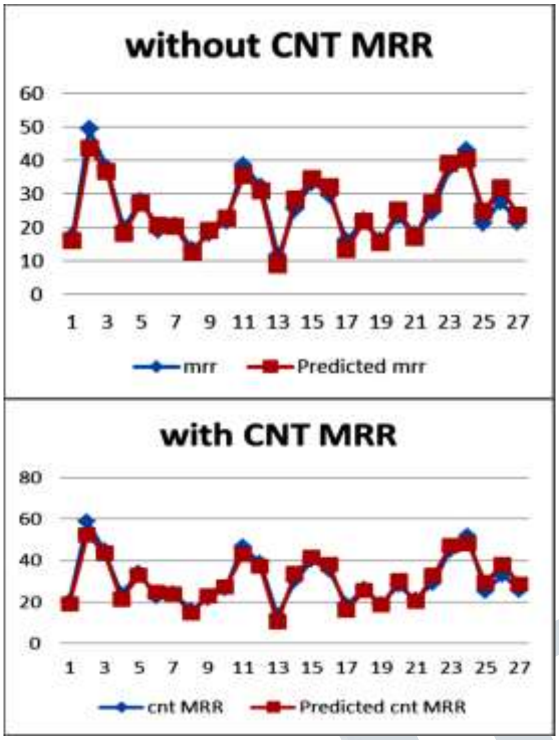


***Figure 13 Graphs showing error between actual MRR and predicted MRR.***

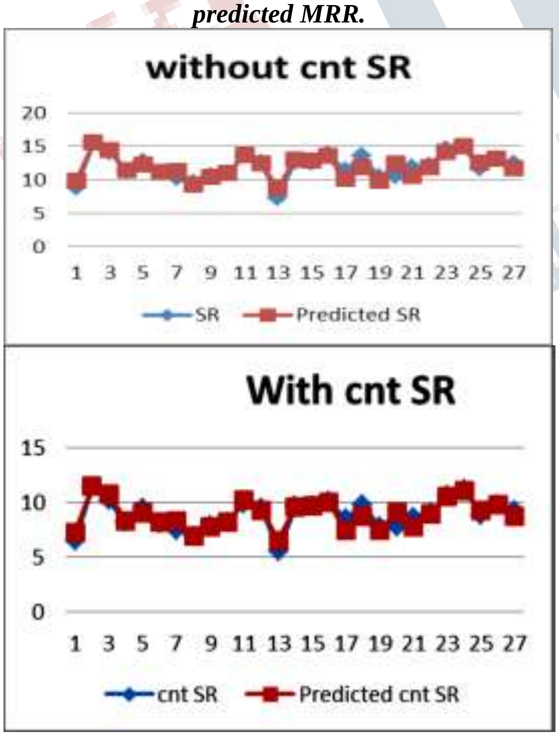


***Figure 6 Graphs showing error between actual SR and predicted SR.***

## IV. RESEARCH GAP

It has been concluded that PMEDM has the capability to achieve mirror like surface finish. After a thorough scrutiny of the published work, the following main conclusions can be drawn:

- Research is mainly focused on PMEDM of conventional materials such as die steels, alloys etc. Only few researchers have worked on CNT mixed EDM of MMCs, alloys etc.
- Few researchers have focused their attention towards non-electrical parameters such as workpiece rotation and electrode rotation. Hence, more studies on the effect of process parameters are needed.
- Surface modification with micro and nano powders and CNT has not been tried yet.
- No published research work on Finite element modeling and simulation of process parameters in PMEDM.

## V. CONCLUSIONS

From the Literature it is concluded that using carbon nano tube as dielectric in EDM process, surface finish can be enhanced to great level. The effect of carbon nanofiber addition on the electro discharge behavior, material removal rate, electrode wear ratio, electrode geometry, spark gap, surface roughness, surface topography, and surface damage was investigated. The major conclusions are summarized as follows:

- Adding carbon nanotubes into the dielectric fluid can significantly improve the electro discharge frequency, and in turn, improve the material removal rate and spark gap.
- The EWR drops significantly with the increase of carbon nanotubes concentration, especially under the time-controlling conditions.
- The surface roughness of the workpiece and the machining efficiency of EDM with CNT powder mixed into the dielectric were improved by 70% and 66%, respectively, compared with conventional EDM.
- Surface finish can be improved by adding carbon nanotubes in the dielectric fluid. The lowest surface roughness was achieved at a fiber concentration of 0.02–0.1 g/L.
- CNTs demonstrate better achievement than other powders.

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

## REFERENCES

[1] Pay Jun Liewa, Jiwang Yanb, "Tsunemoto Kuriyagawaa, Carbon nanofiber assisted micro electro discharge machining of reaction-bonded silicon carbide", Journal of Materials Processing Technology 213 (2013) 1076– 1087.

[2] C. Mai, H.Hocheng, S. Huang, "Advantages of carbon nanotubes in electrical discharge machining", (2011), International Journal of Advance Manuf acturing Technology.

[3] Muhammad Pervej Jahan & Mustafizur Rahman & Yoke San Wong, "Study on the nano-powder-mixed sinking and milling micro-EDM of WC-Co." Int J Adv Manuf Technol (2011), 53:167–180, DOI 10.1007/s00170-010-2826-9.

[4] T. Praveena, Dr.J. Prasanna, "Recent Advancements in EDM Process- A Review," International Journal of Power Control and Computation (2016) Vol 8, Pp.30-37.

[5] M. M Sari ,M. Y. Noordin , E. Brusa, "Role of multi-wall carbon nano tubes on the main parameters of the electrical discharge machining (EDM) process", International Journal, Advanced Manufacruring Technology (2013), vol. 68, pp. 1095-1102. - ISSN 0268-3768.

[6] Amandeep Singh, Neel Kanth grover, Parminderjit singh, "Surface modification of EDM process using Carbon Nano tubes-A Review." International Journal of Engineering Research and Development, e-ISSN: 2278-067X, Volume 10, Issue 7 (July 2014), PP.63-68.

[7] B. Kuriachen, J. Mathew, "Effect of Powder Mixed Dielectric on Material Removal and Surface Modification in Micro Electric Discharge Machining of Ti-6Al-4V," Materials and Manufacturing Processes (2015).

[8] Binayaka Nahak, "A Review on Optimization of Micro EDM Machining Performances" International Journal of Engineering Research, Volume No.6, Issue No.5, pp :242-246

[9] N. B. Gurule, S. A. Pansare, "Potentials of Micro-EDM," IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN(p) : 2320–334X, PP : 50-55.

[10] Pallavi Chaudhury, Sikata Samantaray, "Role of Carbon Nano Tubes in Surface Modification on Electrical Discharge Machining -A Review, Materials Today: Proceedings 4 (2017) 4079–4088.

[11] Prof. Yashesh A. Darji, "Multi-Parameter Analysis and Modeling of MRR & SR on Electro Discharge Machine with Multi Wall Carbon Nano Tube," International Journal of Science Technology & Engineering, Volume 3, Issue 05, November 2016