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Micro Manufacturing Technology – A study of Micro Electric Discharge Machining

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Abstract: Micro electric discharge machining(micro EDM) is a Non-conventional machining process.Micro tool is used in micro EDM as compared to EDM process. Micro electrical discharge machining is one of the most Precise Technique for the fabrication of microstructures.Micro electric discharge machining is used for making very small parts 50 to 100 Micrometers.Precisely controlled spark is occurs in between electrode and workpiece. Dielectric fluid is used in between wire and workpiece for providing insulation and ionization effect at specific voltage. This paper describes about the principal, types of EDM process and different aspects of micro EDM technology.

***Index Terms*–Micro EDM,Non-Conventional, Microstructure.**

1. INTRODUCTION

In recent years, there has been an increasing demand for micromachining, due to the need for miniaturization and lighter weight in products [1]. Micromachining techniques use precision machining to manufacture micro-components within very close tolerances. Micro electrical discharge machining (micro EDM) can be used to machine almost every conductive material, regardless of its hardness. It has been widelyusedinprocessestofabricatemicroscalestructuresand componentssuchasmicroinjection,formicrodie/molds,fuel nozzles, micro probes, photo-masks, and micro tools [2]. Since EDM is a non-contact machining process, there are no physical cutting forces between the work-piece and the electrode, which makes the method very effective for micromachining with a thin electrode. This makes it easy to produce micro-parts without distortion due to physical force [3]. Micro EDM is becoming increasingly important for the manufacture of micro- and miniature parts and structures and in the development of micro-electro mechanical systems [4]. Over the next four years, the Microsystems market, including Micro-Structure Technologies (MST) and Micro-Electro-Mechanical Systems (MEMS), is predicted to grow at a rate of 16% per year from $12 billion in 2004 to $25 billion in 2009 across a spectrum of 26 MEMS/MST products [5]. Conventional processes are increasingly being improved for use in micro- machining. The most common processes are micro milling, laser machining and more specifically micro EDM, which is being applied in many micro applications [6]. In EDM, the machining of conductive materials is performed by a sequence of electrical discharges occurring in an electrically insulated gap between a tool electrode and a workpiece. During the discharge pluses, a high temperature plasma channel is formed in the gap, causing evaporation and melting of the workpiece. Debris of material is removed by the resulting explosion pressure, enabling the machining of the workpiece [7]. The characteristics of the electrical discharge pulses are linked with a set of machining parameters, which control the energy and frequency of discharges and thus the power in the gap. Consequently, the chosen set of parameters affect the material removal rate (MRR), surface roughness and relative electrode wear rate. In the case of conventional sinking EDM, machining strategies using roughing and finishing paths are well established and a number of studies offer guidelines for machining parameters selection [8].

2. Principle of Micro EDM

Micro EDM is a non-conventional machining process which is applied to all conductive materials without considering its hardness, toughness and strength. In this process material is removed as small particles called debris by precisely controlled spark in between tool and the workpiece submerged in dielectric fluid. In a container workpiece is placed on a fixture, a micro tool with servo motor which maintain gap between tool and workpiece and the DC source which is connected to the tool and workpiece with negative and positive potential. Container is filled with the dielectric fluid used as an insulator at the starting and then at a specific voltage it will ionize into ions and providing help in the spark in the metal removal. DC source will supply negative to the tool and positive to the workpiece then electrons will go towards the workpiece and metal ions will go towards the tool from the workpiece and at the specific voltage dielectric fluid will be ionized into the ions and ionization takes place. A spark is created in between tool and workpiece and this spark will remove the metal from the workpiece and create a heating effect on the workpiece so this is the process in micro electric discharge machining from which we can make very small parts with precise manner.

Discharge occurs at high frequencies between and hertz since the metal removal per discharge is very small. For every pulse, discharge occurs at a particular location where the electrode materials are evaporated or ejected in the molten phase then a small crater is generated both on the tool electrode and workpiece surfaces. The removed material are then cooled and re-solidified in the dielectric liquid forming several hundreds of spherical debris particles which will be flushed away from the gap by the dielectric flow. At the end of the discharge duration, the temperature of the plasma and the electrode surfaces that is in contact of the plasma rapidly drops, resulting in the recombination of ions and electrons also the recovery of the dielectric breakdown strength. To obtain stable condition in EDM, it is important for the next pulse discharge occur at a spot distanced sufficiently far from the previous discharge location. This is because the previous location will result in having a small gap and it is contaminated with debris particles which may weaken the dielectric breakdown strength of the liquid. The time interval for the next discharge pulse should be long so that the plasma that is generated by the previous discharge can be fully de-ionized and the dielectric breakdown strength around the previous discharge location can be recovered by the time the next voltage charge is applied. If happens that the discharges occurs at the same location, resulting in thermal overheating and non-uniform erosion of the workpiece.

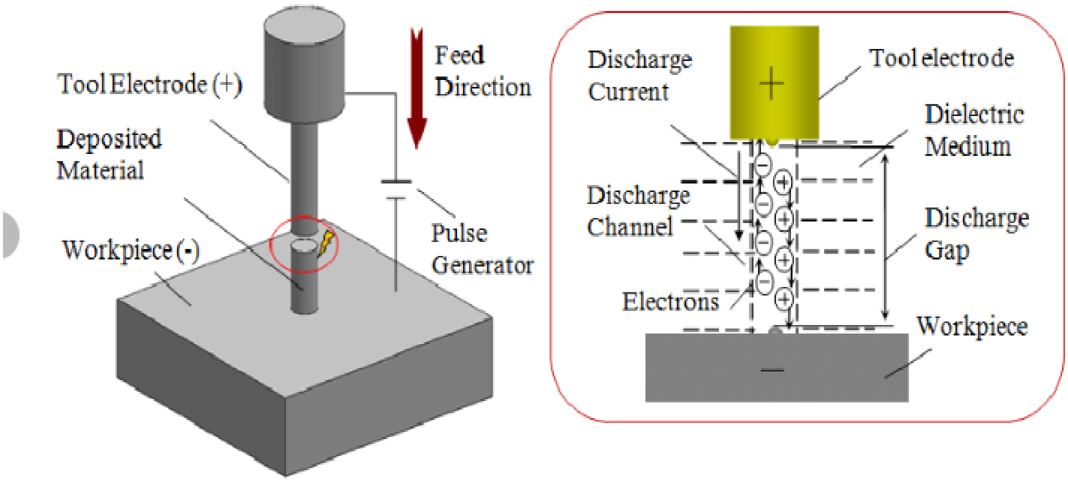

Figure 1.Principle of Micro EDM

3. Types of EDM process

3.1 Die sinking EDM

Die sinking EDM (also known as Ram, sinker, traditional, volume, or cavity-type EDM) is the best Electro Discharge Machining for creating parts with complex cavities. It is also the method chosen for solving the sharp internal corner issue when CNC machining. This method utilizes graphite or copper electrodes, a dielectric fluid, and an electric spark induced between the electrode and the workpiece. In the first step of this process, an electrode is produced in the reverse shape of the required cavity. This forms the die. A voltage is then induced between the die and the electrically conductive workpiece while submerged in a dielectric fluid like oil. The die is slowly lowered towards the workpiece until 'electric breakdown' occurs and a spark jumps the 'spark gap'. This vaporizes and melts material from the workpiece while dielectric fluid subsequently carries any ejected particles away. A small amount of the electrode is also often eroded during this process. As the series of high-frequency sparks repeatedly removes a small amount of material from the workpiece, the desired shape will begin to take place and be precisely cut out. This die-sinking EDM process can be depicted in the image below: Every aspect of this process, between the servers, power supply, and position of the electrodes, is completely controlled through precision machining.

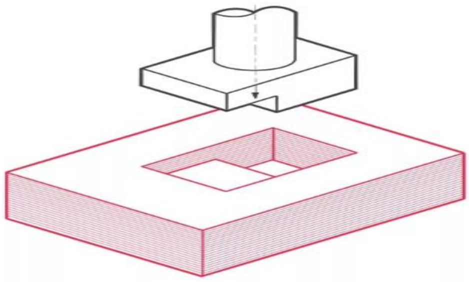

Figure 2.Die sinking EDM

3.2Wire EDM

Wire EDM, otherwise known as wire erosion, is commonly used to produce extrusion dies. It cuts using the same mechanism as die-sinking. However, the die is replaced with a very fine electrically charged wire which will work as the electrode. This machining method is comparable to a cheese cutter, making a two-dimensional cut in a three-dimensional part. The wire is usually very thin, with a diameter of around 0.05mm to 0.35mm. A fresh wire is automatically spooled throughout the machining process to avoid using burnt wire and to ensure precise cutting. The below image illustrates the way wire is utilized in wire EDM: This process will produce incredibly precise cuts. However, if you are looking to cut sharp inside corners, it's important to note that wire EDM alone won't be able to give you true square corners. The wire and spark gap will create a tiny radius of about 0.13mm to 0.15mm, but this can be smaller or larger depending on the diameter of the wire. If that is not sufficient for your project, a small dog bone corner can be applied to create perfectly square internal corners. Read our guide on how to machine square corners for more information on the best ways to machine sharp internal corners. Sometimes it is necessary to start a cut from the center of a part rather than from one of the edges. For example, machining a complex shape in the center of an extrusion die. If that's the case, hole drilling EDM can make a small hole for the wire to be threaded through for wire EDM machining.

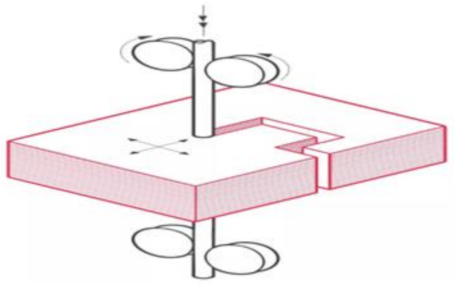

Figure 3.Wire EDM

3.3Hole drilling EDM

As the name implies, Hole drilling EDM is used to machine holes. However, this technique can accurately machine extremely small and deep holes that don't require debarring compared to traditional whole drilling methods. This method also uses the same fundamental principles as die-sinking EDM. However, the cut is made with a pulsing cylindrical electrode with dielectric fluid fed into the cutting area while moving deeper into the workpiece. This method has been key to the advancement of high-temperature turbine blades, as it allows for very intricate cooling channels to be manufactured inside the turbine blades.

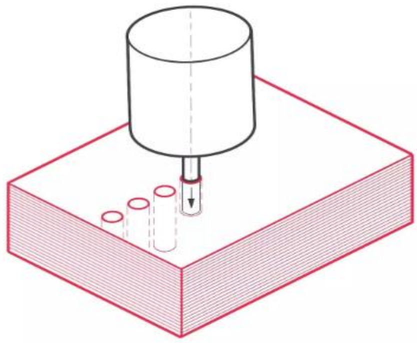

Figure 4.Hole drilling EDM

4. Different Aspects of Micro EDM technology

4.1Micro-EDM as a coating process

Electrical discharge coating is generally used to enhance the wear and corrosion resistance of the cutting tools, electrodes and molds. The process of coating is based on the material transfer phenomenon from the tool electrode to the workpiece electrode, i.e., reverse polarity. Janmanee and Muttamara [9] used the titanium coating layer to study the surface modification of the tungsten carbide surface. The experimental work was carried out in dielectric oil with tungsten carbide material, while titanium particles were used as powder. A comparative study was carried out on machining characteristics by Chiou et al. [10] using a coated electrode in micro-EDM milling process. In this investigation, they used three different types of electrodes, i.e., WC, WC coated Ag, and WC coated Cu. Minimum surface roughness was obtained with the WC-coated Ag electrode, while maximum MRR was obtained with WC-coated Cu. Hence, this shows the significance of the electrode coating in terms of thermal and electrical properties.

4.2 Micro-EDM coloring

Tsai et al. [11] used the micro-EDM process for the generation of the colorful thin-film oxide layer on titanium sheet. In this process, they used copper as an anode while titanium sheet as a cathode under the dielectric medium of tap water. They varied the voltage from 10 to 240 V and noticed the variation in colors with voltage. The increase in pulse duration causes non-uniformity in color distribution. Minami et al. [12] used the EDM process as a coloring method on the titanium alloy sheet. Ohmori et al. [13] had tested the color finishing process condition and mechanism on the same material, i.e., titanium alloy sheet in 2004 via electrical grinding process.

4.3 Micro-EDM in spherical probe fabrication

A new approach of micro-EDM combining WEDG with OPED (one pulse electro-discharge) system had been implemented by Sheu [14]. They used tungsten and tungsten carbide for the fabrication of micro spherical probes. First, thin cylindrical and square rods were fabricated by microWEDG. It was further connected with the OPED system. Single discharge electric pulses were implemented near the tip of the fabricated rod. Gap distance control played a significant role in obtaining the desired dimension of the microprobes.

5. Conclusion

In this paper principle of micro EDM, types of micro EDM and different aspects of micro EDM technology discussed. This paper is essential for the development in the research to fabricate the micro EDM with micro actuator tool feed mechanism machine.

REFERENCES

[1] Jahan MP, Wong YS, Rahman M(2010)acomparativeexperimental investigation of deep-hole micro-EDM drilling capability for cemented carbide (WC-Co) against austenitic stainless steel (SUS 304). Int J Adv. Manuf Technol 46:1145–1160.

[2]Uhlmann E, Rosiwal S, Bayerlein K, Röhner M (2010) Influence of grain size on the wear behavior of CVD diamond coatings in microEDM. Int J Adv Manuf Technol 47:919–922.

[3]Qin Y, Brockett A, Ma Y, Razali A, Zhao J, Harrison C, Pan W, Dai X, Loziak D (2010) Micro-manufacturing: research, technology outcomes and development issues. Int J Adv Manuf Technol 47:821– 837.

[4]Huang SH, Huang FY, Yan BH (2005) Fracture strength analysis of micro WC-shaft manufactured by micro-electro-discharge machining. Int J Adv Manuf Technol 26:68–77.

[5] NEXUS Market Analysis for MEMS and Microsystems III, 2005-2009, NEXUS Newsletter 01/2006.

[6] E. Uhlmann, S. Piltz, U. Doll, Machining of micro/miniature dies and moulds by electrical discharge machining—Recent development, J. of Materials Processing Technology, 167 (2005)488- 493.

[7] S.H. Huang, F.Y. Huang, B.H. Yan, Fracture strength analysis of micro WC-shaft manufactured by micro-electro-discharge machining, Int. J. of Advanced Manufacture Technology, 26 (2005) 68- 77.

[8] J. Valentin6i6, M. Junkar, On-line selection of rough machining parameters. J. mater, process. Technology, 149 (2004) 256-262.

[9] Janmanee P, Muttamara A (2012) Surface modification of tungsten carbide by electrical discharge coating (EDC) using a titanium powder suspension. Appl Surf Sci 258:7255–7265.

[10] Chiou AH, Tsao CC, Hsu CY (2015) A study of the machining characteristics of micro EDM milling and its improvement by electrode coating. Int J Adv Manuf Technol 78:1857–1864. Https: //doi.org/10.1007/s0017 0-014-6778-3.

[11] Tsai YY, Song PL, Fang JSC (2013) Colorful oxide film formation on titanium by using EDM process. Int J Precis Eng Manuf 14:1933–1937. Https: //doi.org/10.1007/s1254 1-013-0262-0.

[12] Minami H, Masui K, Tsukahara H, Hagino H (1998) Coloring method of titanium alloy using EDM process. VDI Berichte. Https: //doi.org/10.2493/jjspe .64.1723.

[13] Ohmori H, Katahira K, Mizutani M, Komotori J (2004) Investigation on color-finishing process conditions for titanium alloy applying a new electrical grinding process. CIRP Ann Manuf Technol 53:455–458.Https: //doi.org/10.1016/S0007 -8506(07)60738 -0.

[14] Sheu DY (2004) Multi-spherical probe machining by EDM: combining WEDG technology with one-pulse electro-discharge. J Mater Process Technol. https: //doi.org/10.1016/j.jmatprotec .2004.02.023.