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A REVIEW ON RESEARCH WORK IN ELECTRICAL DISCHARGE MACHINING

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ABSTRACT

Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. Despite a range of different approaches, this new research shares the same objectives of achieving more efficient metal removal coupled with a reduction in tool wear and improved surface quality. This paper reviews the research work carried out from the inception to the development of electrical discharge machining (EDM) within the past decade. It reports on the EDM research relating to improving performance measures, optimizing the process variables using ANN, fuzzy logic, etc, monitoring and control the sparking process, simplifying the electrode design and manufacture, machining of ceramics, hybrid machining and effect on surface quality . This paper also reviews the work related to emerging areas of research in electrical discharge machining (EDM) such as micro EDM, dry EDM, powder mixed EDM and parameter optimization of EDM and the recent work going on machining of composites with electrical discharge machining.

Key words: *Die Sinking EDM, Wire EDM, Hybrid EDM, Powder Mixed EDM and Micro EDM.*

1. Introduction

Electric discharge machining (EDM), sometimes colloquially also referred to as spark machining, spark eroding, burning, die sinking or wire erosion, is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks). The working principle of EDM process as shown in figure 1 is based on the thermoelectric energy. This energy is created between a work piece and an electrode submerged in a dielectric fluid with the passage of electric current. The work piece and the electrode are separated by a specific small gap called spark gap. Electrical discharge machining is a machining method primarily used for hard metals or those that would be very difficult to machine with traditional techniques. EDM typically works with materials that are electrically conductive, although methods for machining insulating ceramics with EDM have also been proposed. EDM can cut intricate contours or cavities in pre-hardened steel without the need for heat treatment to soften and re-harden them. This method can be used with any other metal or metal alloy such as titanium, hastelloy, kovar, and inconel. Anand Pandey and Shankar Singh (2010) explained about the principle of EDM, EDM equipment, EDM process parameters and various types of EDM like Die sinking EDM, Wire EDM, Hybrid EDM, etc.

Shruti Mehta, Avadhoot Rajurkar and Jignesh (2010) described about the research trends in Die sinking EDM of conductive ceramics. They explained that with the doping of ceramics with conductive elements it is possible to machine ceramics on EDM.

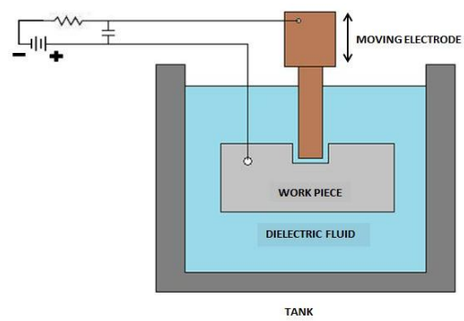

Fig. 1 Schematic Diagram of EDM Process

Gunawan S. Prihandana, Muslim Mahardika, Mohd. Hamdi and Kimiyuki Mitsui (2009) paper was about the current methods for improving Electrical discharge machining process. They have given information about the recent patents on EDM by Wei

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(2008), Varsell (2007), Chen (2007), Oldham (2007) and Curodeau (2003). K.H. Ho and S.T. Newman (2003) presented a review paper on EDM applications, major areas of EDM research. They stated that continuous work is going on optimization of process parameters of EDM process and metallurgical properties of EDM machined part. K.H. Ho and S.T. Newman, S. Rahimifard and R.D. Allen (2004) review paper is on WEDM applications, major areas of WEDM research. They found that continuous work is going on optimization of process parameters of WEDM process , monitoring and control of WEDM process, process modeling, Fuzzy control system, wire inaccuracy adaptive control system- wire breakage, wire lag and wire vibration. Norliana Mohd Abbas, Darius G. Solomon and Md. Fuad Bahari (2007) reviewed the research trends in EDM on ultrasonic vibration, dry EDM machining, EDM with powder additives(PMEDM) , EDM in water and modelling technique in predicting EDM performances like RSM model , ANN , etc. Kuldeep Ojha, R.K. Garg and K.K. Singh (2010) described the research work on EDM related to improvement of MRR along with some insight mechanism of material removal. They also proposed future scope of work in this direction.

R.K. Garg, K.K. Singh, Anish Sachdeva, Vishal S. Sharma, Kuldeep Ojha and Sharanjit Singh (2010) described the review of research work in sinking EDM and WEDM on metal matrix composite materials and future trend of research work in the same area. They found that lot of work has been done in the last twenty years in machining of metal matrix composites with EDM process. Various MMCs were machined in EDM process like Si C/ Al matrix, WC- Co, etc. Many MMC s are yet to be tested on EDM process like Al2 O3 / Al matrix, SiC/ Al- Si-Cu, etc. There is scope of research work in finding change in mechanical properties of EDM worked material.

2. Die Sinking EDM

Yih Fong and Fu Chen Chen (2003) described about the Taguchi approach for optimizing high speed EDM. They performed experiments on work piece of medium carbon steel using copper electrode. Cr powder was added into working fluid and found that the most important factors in EDM process are pulse on time, duty cycle and pulse peak current. Ahmet Hascalik and Ulas Caydas(2007) performed the experiments on EDM for machining of Titanium alloy (Ti-6Al-4V) using electrodes of graphite, copper and aluminium with kerosene as dielectric. They studied about process parameters of EDM- discharge current, pulse duration, pulse interval on work piece of Titanium alloy. They found that MRR more in case of graphite electrode but surface finish is rough. In Al electrode, MRR is least but surface finish is best because of low M.P. of Al electrode, so wear rate is highest. Mohd. Amir , Lajis and A.K.M. Narul (2009) explained about the implementation of Taguchi method on EDM process of Tungsten carbide using graphite as electrode and kerosene as dielectric. They studied about the effects of voltage, peak current, pulse duration and interval time on MRR, EWR and SR. They found that EWR decrease with peak current and interval time. But MRR increase with increase in pulse duration and slightly with increase in peak current. Surface roughness increase with voltage but decrease slightly with increase with peak current. S.H. Tomadi, Hassan and Hamedon (2009) studied about the analysis of influence of EDM parameters on surface quality , MRR,EWR of Tungsten carbide using Cu-W electrode with design of experiments. In case of Ra parameter, most influential factors were voltage and pulse off time. In case of MRR, pulse on time factor was influential. For higher values of MRR, use higher values for peak current and voltage. Sameh S Habib (2009) studied about the parameters in EDM through response surface methodology (RSM) on machining of carbon- carbon composites –Al/SiC with copper electrode and kerosene as dielectric. They found that increase in pulse on time causes an increase in MRR. It was found that MRR increases with increase in peak current for alloy values of gap voltage but MRR decreases with increase of gap voltage. Gap size values increases with pulse on time because gap size depends upon MRR but gap size increase gradually with peak current and gap voltage. Ra values increase with increases with SiC percentage because SiC particles did not melt during machining process. Ra values increases with increase of both peak current and gap voltage. Mohan Kumar Pradhan and Chandan Kumar Biswas (2009) explained the modeling of machining parameters for MRR in EDM using RSM approach. They used AISI D2 tool steel as work piece and copper as electrode in their experimental work. They studied about three parameters- pulse on time, pulse off time, and pulse current on MRR of EDM process. They found that MRR tends to increase with increase in peak current for any value of pulse on time. Max. MRR is obtained for high peak current -30A and high pulse on time-200 microseconds. With increase in Toff, MRR decreases because of undesirable heat loss which does not contribute to MRR. Jose and Catherine (2000) found a new method of optimizing MRR using EDM with copper-tungsten electrodes. They used D2 tool steel as work piece material and 75/25 tungsten- copper electrode. With Taguchi approach they found that it is possible to achieve improvement in MRR. Percentage of

carbon in black layer is very important in improvement of EDM performance. H.K. Kansal , Sehijpal and Pradeep Kumar(2006) described the optimization of EDM process when silicon is suspended into dielectric fluid of EDM. They studied about parameters- powder concentration, peal current, pulse duration, duty cycle and voltage where voltage is kept constant. They found that powder concentration has 84 % impact in these parameters whereas peak current has 8.8 % impact , pulse duration has 4.2 %, duty cycle has 2.95% impact in machining with Taguchi utility concept. H.T.Lee, T.Y. Tai (2003) found a relationship between EDM parameters and surface cracks by using a full factorial design based upon discharge current and pulse on time parameters on D2 and H13 tool steels as materials. The formation of surface cracks is explored by considering surface roughness, white layer thickness and stress induced by EDM process. When the pulse voltage is maintained at a constant value of 120 V, it is possible to avoid formation of cracks if machining is carried out with pulse current in range of 12-16 A together with pulse on duration of 6-9 micro seconds. K. Ponappa , S.Aravindan, P.V. Rao, J.Ramkumar and M. Gupta(2010) found the effects of electrical discharge machining parameters on drilled hole quality such as taper and surface finish using microwave sintered magnesium nano composites as work material. The experiments were conducted using Taguchi techniques and ANNOVA analyses were carried out to identify significant factors that affect hole accuracy and surface roughness. They found that pulse on time and servo speed is major response variables. High aspect holes (0.5 mm and 12 mm height) were drilled in composites. By optimizing process parameters, damages on mechanical surfaces such as recast layer and hair line cracks are minimized. Simul Banerjee, Debasish Mahapatro and Shishir Dubey (2009) did study of EDM process of (WC+TiC+TaC) NbC- Co cemented carbide. They considered MRR, wear ratio and surface roughness as response variables in face centered composite design model and ANNOVA analyses were carried out to identify significant factors. They found that MRR is dependent on energy input which is proportional to pulse duration. With increase in pulse duration MRR decreases because with the increase in pulse on time, dielectric does not get sufficient time to get deionized, which results in arcing and thus causes decrease in MRR. Most influencing factor over wear is current. With increase in current wear ration decreases but after some value begins to grow. Surface roughness is increases with increase in current. Narcis Pellicer, Jpaquim Ciurana and Jordi Delgado (2009) found the influence of main EDM process parameters- pulsed current, open voltage, pulse time, pulse off time and different tool geometries on EDM process of AISI H13 steel using design of experiments and ANNOVA. They found that MRR and surface roughness increases with discharge current. Tool geometry is critical choice when different features are machined. Square and rectangular electrodes present better radial and axial wear ratios, so these geometries are the best choice in flexible tool electrode shape design. Analysis of tool geometry behavior must permit storage, time and cost reduction associated to tool electrodes in workshops creating different features with simpler and more standardized geometries. S. Singh (2012) applied the designs of experiments and grey relational analysis (GRA) approach to optimise parameters for electrical discharge machining process of 6061Al/Al2O3p/20P aluminium metal matrix composites. Manish Vishwakarma, V.K.Khare, Vishal Parashar (2012) paper is to determine the optimal factors of the electro-discharge machining (EDM) process investigate feasibility of design of experiment techniques. The workpieces used were rectangular plates of AISI 4140 grade steel alloy. The results reveal that MRR is more influenced by peak current, duty factor.Finally, the parameters were optimized for maximum MRR with the desired surface roughness.

3. Wire EDM

Hari Singh and Rajesh Garg (2009) explained about the effects of process parameters –pulse on time, pulse off time, wire tension, wire feed on material removal rate (MRR). They performed experiments on work piece of hot die steel using brass wire as electrode. They found that MRR increases with increase in pulse on time and decreases with pulse off time. But MRR remains constant with the variation in wire tension and wire feed. MRR increases with increase in peak current but decrease with increase in servo voltage. So wire feed and wire tensions are neutral parameters. CVS Parmeswar and MM Sarkar(2009) described about the optimal parameters for machining brass with Wire Cut EDM. They used wires of different compositions (different percentages of copper and zinc) on work pieces of brass of different thickness .They found that cutting speed decreases as job thickness increases. Discharge current increase as material removal rate (MRR) increases for different sizes of work pieces. Roughness values decreases with increase in thickness. Wire (90 % Cu) gave best results for higher productivity. Kamal Jangra, Ajai Jain and Sandeep Grover (2010) paper is on optimization of multiple machining characteristics in wire electrical discharge machining of punching die using Grey relational analysis. They found that GRA is best technique to

optimize three machining characteristics- cutting speed, surface roughness and dimensional lag simultaneously during rough cutting in D3 tool steel. S.S.Mahapatra and Amar Patnaik (2007) found the relationship and developed mathematical models between control factors and responses like MRR, SF and kerf using linear regression analysis on D2 tool steel work piece in WEDM process. They found that factors like discharge current, pulse duration, dielectric flow rate and their interactions play a significant role in rough operations. Their study found that genetic algorithm has capability to find global optimal parameters whereas traditional optimization techniques normally stuck up at local optimal values. Fuzhu , Jun Jiang and Dingwen Yu (2007) described the influence of machining parameters(pulse duration, discharge current, polarity effect, material and dielectric) on surface roughness in finish cut of WEDM process using alloy steel as work piece material and pulse generator for power supply. They proved that surface roughness can be improved by decreasing both pulse duration and discharge current. They also found that MRR is much higher when short pulse duration with high peak values is used as comparison to when pulse duration is long. It was also observed that reversed polarity machining with appropriate pulse energy can improve machined surface roughness but some copper from the wire electrode is accreted on machined surface. Anil Kumar, Sachin Maheshwari, Chitra Sharma and Naveen Beri (2010) found additive mixed electrical discharge machining (AEDM) is a novel innovation for enhancing the capabilities of electrical discharge machining process in this direction. Despite the promising results, AEDM process is used in the industry at very slow pace. D. Satishkumar & M. Kanthababu & V. Vajjiravelu &R. Anburaj & N. Thirumalai Sundarrajan & H. Arul (2011) found in their investigation, the effect of wire electrical discharge machining (WEDM) parameters such as pulse-on time (TON), pulse-off time (TOFF), gap voltage (V) and wire feed (F) on material removal rate (MRR) and surface roughness (Ra) in metal matrix composites (MMCs)consisting of aluminium alloy (Al6063) and silicon carbide (SiCp). The Al6063 is reinforced with SiCp in the form of particles with 5%, 10% and 15% volume fractions.

4. Micro EDM

Gunawan, Mahardika and Mitsui (2009) found that micro-electro discharge machining has the ability to machine conductive material irrespective of their mechanical hardness. According to them it can also process materials such as Silicon and ferrite which have high specific resistance and have the problem of cracking when processed by ordinary EDM process. According to CIRP committee of Physical and Chemical processes, the term micromachining defines the processes that manufacturer products in the range of 1 to 999 µm. Machining of material can be done without applying pressure on the material, including high precision machining on 3-D curved surfaces, inclined surfaces, and very thin sheet materials which are difficult to drill. High aspect ratio machining can be done using the process. In an ordinary perforating process, Micro-EDM can easily perforate a hole to a depth equivalent to ten times the bore diameter. The high precision and high quality machining can be done while keeping the surface roughness between 0.1micro m to 0.8micro m based on different settings of voltage and capacitance.

Katz and Tibbles (2005) purposed a micro EDM model with numerical simulation and experimental validation. The model has predicted reasonable values for current density, crater area, power dissipation and the rate of channel growth. Machining experiments show that the micro shaft with the diameter as small as 5µm and the micro hole with minimum size of 25µm could be obtained steadily, and the maximum aspect ratios of micro shaft and micro hole are over 25 and 10 respectively. It is as an alternative method for producing photo- masks according to Yeo and Yap (2001) used in the integrated circuit(IC) industry. At last, a complicated 3D microstructure is machined by this equipment and micro-EDM technology. Given that material is removed by electro-erosion and not by mechanical contact, micro EDM can be used to machine any electrically conductive material—regardless of its hardness and strength. G.Kibria, B.R. Sarkar, B.B. Pradhan and B.Bhattacharya (2010) described the influence of various dielectrics- kerosene, deionized water , boron powder suspended kerosene in micro EDM process of titanium alloy (Ti-6Al- 4V) by considering MRR, tool wear rate, over cut, diameteral variance at entry and exit hole (DVEE) and surface integrity as performance criterion. The experimental results revealed that MRR and TWR are higher using deionized water than kerosene because of formation of oxide layer (TiO_2) when deionized water is used, which melts in lower discharge energy compared to melting of carbide (TiC) formed in case of kerosene. Ornwasa and Hans Gatzen (2010) gave a new approach using micro system technology for the fabrication of micro electro discharge machining tool electrodes using a combination of positive and negative photo resist fabricated with UV lithography as high aspect ratio micro molds was developed. Pun Pang, George and Mile Ostojic (2010) developed a method of creating metallic micro molds with features that have high aspect

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ratios. The purposed manufacturing process utilizes laser micro machining to cut negative two dimensional profiles of desired micro features and fluidic network patterns on a 100 micro meter thick brass sheet. R. Manikandan and R. Venkatesan (2012) studied the feasibility of micron size hole manufacturing using micro Electric Discharge Machining (Micro-EDM). The cutting of the Inconel 718 using Micro EDM with a brass electrode by using Taguchi methodology has been reported.

5. Hybrid EDM

B H Yan, A C Wang, C Y Huang, F Y Huang (2002) did the study of precision micro-holes in borosilicate glass using micro EDM combined with micro ultrasonic vibration machining. Because of its excellent anodic bonding property and surface integrity, borosilicate glass is usually used as the substrate for micro-electro mechanical systems (MEMS). For building the communication interface, micro-holes need to be drilled on this sub- strate. However, a micro-hole with diameter below 200 m is difficult to manufacture using traditional machining processes. To solve this problem, a machining method that combines micro electrical-discharge machining (MEDM) and micro ultrasonic vibration machining (MUSM) is proposed herein for producing precise micro-holes with high aspect ratios in borosilicate glass. In the investigations described in this paper, a circular micro-tool was produced using the MEDM process. This tool was then used to drill a hole in glass using the MUSM process. The experiments showed that using appropriate machining parameters; the diameter variations between the entrances and exits (DVEE) could reach a value of about 2 m in micro-holes with diameters of about 150 m and depths of 500 m. DVEE could be improved if an appropriate slurry concentration; ultrasonic amplitude or rotational speed was utilized. In the roundness investigations, the machining tool rotation speed had a close relationship to the degree of micro- hole roundness. Micro-holes with a roundness value of about 2 m (the max. radius minus the min. radius) could be obtained if the appropriate rotational speed was employed. B.R. Sarkar, B. Doloi and B. Bhattacharya (2006) described the development of a second order, non linear mathematical model for establishing the relationship among machining parameters- applied voltage, electrolyte concentration and inter electrode gap with the dominant process machining process criterion namely MRR, radial over cut, thickness of heat affected zone (HAZ) during the ECDM operation of silicon nitride. The model is based upon response surface methodology (RSM) with ANNOVA. From parametric analysis based upon mathematical modeling, it can be recommended that applied voltage has more significant effects on MRR, ROC and HAZ thickness during ECDM micro drilling operation as compared to other machining parameters. Amitabha Ghosh (1997) in the paper highlights the important results of investigations on electrochemical discharge machining (ECDM). This information has been effectively used to improve process capability of ECDM by substantial amount. It has been shown that ECD can be very conveniently used for micro welding operation without using any sophisticated arrangement. Biing Hwa Yan, Kun Ling Wu, Fuang Yuan Huang and Chun Chieh Hsu (2007) did the study of mirror surface machining by using a micro energy EDM and electrophoretic deposition polishing (EPD). In EDM, because of repeated heating and cooling cycle of electrolyte, heat affected zone (HAZ) is formed below recast layer. HAZ is affected by thermal conduction from surface which is melted by plasma sparks during active cycles. It is concluded that suitable working parameters for EPD process include 20 V applying voltage, 200 rpm of rotation speed and p H value of 4. Kuen Ming Shu , Hung Rung and G.C. Tu (2006) work was to develop an electrical discharge abrasive drilling (EDAD) methodology to remove the resolidified layer through the grinding induced by metal matrix composite electrode prior to the resolidification of molten material. For enhancing bonding status between matrix and reinforcement of composite electrode, electroless copper plating on reinforcement surface is adopted in this research. Copper was selected as matrix material for its high electrical conductivity and work piece was P20 tungsten carbide and HPM 5O mold steel. In this process of EDAD higher MRR and lower surface roughness can be achieved when suitable electrode rotating speed, SiCp size and working current are chosen. Experimental results showed that when using HPM 50 mold steel as work piece, EDAD machining efficiency was three to seven times that of normal EDM operations and surface finish was improved. J.Fleischer , J. Schmidt and S. Haupt (2006) did work on hybrid EDM and found that by combining laser ablation and electrical discharge machining (EDM) specific advantages of the respective technology can be utilized while drawbacks can partially be eliminated. They found that in micromachining by laser ablation (Nd- YAG laser) non conductive materials like ceramics can be machined. Amir Abdulah, Mohammad R. Shabgard(2008) described the effects of copper tool vibration with ultrasonic frequency on the EDM characteristics of cemented tungsten carbide (WC- Co). It was observed that ultrasonic vibration of tool was more effective in attaining a higher MRR approximately

four times higher than MRR of conventional EDM when working under low discharge currents and low pulse times because of gain in better flushing, ease of ionization, high rate of pressure drop at end of discharge They found that surface roughness and tool wear ratio (TWR) were increased when ultrasonic vibration was employed. It was also observed that application of ultrasonic vibration significantly reduced arcing and open circuit pulses and the stability of the process had a remarkable improvement. So these investigations of ultrasonic assisted EDM proved that it was good method of machining metallic composites.

6. Powder Mixed EDM

Farhad Kolahan and Mohammad Bironro (2008) experimental results that are related to PMEDM are used to develop the regression models based upon second order polynomial equations for different process characteristics. In this process grain size of Al powder, concentration, discharge current, pulse on time are chosen as control variables. Then a genetic algorithm has been employed to determine optimal process parameters for any desired output values of machining characteristics. Ko-Ta Chiang (2008) purposed mathematical models for modeling and analysis of effects of machining parameters on performance characteristics in EDM process of Al2 O3+ TiC mixed ceramic which are developed using RSM to explain effect of machining parameters(discharge current, pulse on time, duty factor and open circuit voltage) on performance characteristics of MRR, EWR and surface roughness. They have used centered composite design (CCD) with ANNOVA. They found that main two significant factors that affect the MRR are discharge current and duty factor. The discharge current and pulse on time have statistical significance on both value of EWR and surface roughness. Kuang Yyan Kung, Jenn Tsong Horng, Ko Ta Chiang (2009) did the study on powder mixed EDM of cobalt bonded tungsten carbide (WC- Co) using aluminum powder particle suspended in dielectric fluid. They have used RSM and centered composite design (CCD) to find the effect of machining parameters (discharge current and pulse on time) including two more parameters – grain size of Al powder particle and concentration of Al powder. MRR generally increases with increase in Al powder concentration and EWR decreases with increase in Al powder concentration. This is because an increase in Al powder concentration will help to bridge the gap between electrode and work piece, resulting in multiple discharging effects within a single input pulse and frequency of discharges increases, so MRR increase. But both MRR and EWR increase with increase in grain size and increases with increase of discharge current. Y.F.Tzeng and C.Y. Lee (2001) presented in their paper the effects of various powders- Al, Cr, Cu and silicon carbide on efficiency of EDM process with tool wear rate (TWR) and MRR as output parameters. They found that particle concentration, particle size, particle density, electrical resistivity and thermal conductivity of powders were important characteristics that significantly affected the machining performance in EDM process. Of the additives investigated, chromium powder produced the greatest MRR and lowest TWR, whereas process without foreign particles has the converse effect but there was no change observed when copper powder was added in dielectric. Particle concentration was not a dominant factor governing TWR in EDM process but pulse on time affected the TWR maximum. Aluminum powder produced largest spark gap followed by Cr, SiC powders. G.Kibria, B.R. Sarkar, B.B. Pradhan and B.Bhattacharya (2010) described the influence of various dielectrics- kerosene, deionized water , boron powder suspended kerosene in micro EDM process of titanium alloy (Ti-6Al- 4V) by considering MRR, tool wear rate, over cut ,diameteral variance at entry and exit hole (DVEE) and surface integrity as performance criterion. The experimental results revealed that MRR and TWR are higher using deionized water than kerosene because of formation of oxide layer (TiO_2) when deionized water is used, which melts in lower discharge energy compared to melting of carbide (TiC) formed in case of kerosene. Also when suspended particles, boron carbide mixed dielectric are used MRR is found to increases with deionized water but TWR decreases with kerosene dielectric. Also with SEM analysis it was found that thickness of white layer is less on machined surface when deionized water is used as compared to kerosene. So it was concluded that pure deionized water results in excellent machining efficiency in comparison to kerosene as well as B_4C mixed dielectrics. Also addition of B_4C abrasive dielectrics results in more machining time compared to pure dielectrics. Katsushi Furutani, Hiromichi Sato and Masayuki Suzuki (2009) described the influence of discharge current and pulse duration on titanium carbide (TiC) deposition process by EDM with titanium powder suspended in working oil. Titanium powder reacted with cracked carbon from oil, then depositing a TiC layer on work piece surface having hardness was 2000Hv. X-Ray spectroscopy and X- Ray diffraction analysis methods were used to titanium and carbon deposition on work piece surface. It was found that when discharge current exceeded a critical value, Ti powder could not deposit and carbon steel was removed due to melting and evaporation.

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7. Dry EDM

Irina Besliu, Hans Peter Schulze, Margareta Coteata and Dumitru Amarander (2010) described the findings on dry EDM process which is very famous in green production and purposed a device to be used for applying dry EDM drilling. It was used by NASA in 1985 where EDM drilling was conducted using argon and helium as dielectric mediums. They found that in drilling holes by dry EDM, tubular electrodes tools are used and rotation of electrode tool could contribute to diminishing of errors of circular shape in a cross section through the hole. The surface quality was good as compared to EDM process with liquid dielectric.

8. Conclusion

It is clear that Electrical Discharge Machining is widely used non conventional machining process for intricate parts and hard materials. The measurement in EDM process is very important so more focus is on surface finish. , PMEDM process provides good surface finish and better material removal rate. So lot of work is going on in this direction. The review on emerging trends of interest in EDM on Dry EDM machining, Powder Mixed EDM, Micro EDM and Optimization of process parameters of EDM is presented. For each and every method introduced and employed in EDM process, the objectives are to improve the material removal rate, surface finish and to develop new techniques for new materials.

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