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REVIEW ON ELECTRIC DISCHARGE MACHINING USING ELECTRODES MADE BY POWDER METALLURGY

Engineering

KEYWORDS: EDM; powder metallurgy; electrodes.

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ABSTRACT

Electric Discharge Machining (EDM) is a non-conventional machining processin which metal is removed using thermoelectric energy. EDM is extensively used to machine geometricallycomplex shapes, dies and molds. Electrode in EDM plays the same role as cutting tool in conventional machining processes. The parameters such as material removal rate (MRR), surface finish of the workpiece, tool wear are of great importance, in EDM machining, which depend on the tool performance and dielectric to a great extent. Different types of dielectrics have different effect on these parameters. Tool performance is highly influenced by the composition of the metals and Powder Metallurgy (PM) is a very efficient method for making tool-electrodes because through this method we can easily control the properties of the electrode by varyingthe composition and input parameters of compacting and sintering processes in PM. In this paper, the effect of performance parameters by taking various dielectrics has been reviewed. Further the effect of composite material electrode fabricated by powder metallurgy technique to machine die steels has been discussed.

INTRODUCTION

EDM process mechanism

Electric discharge machining (EDM) is one of the most important and widely used non-traditional methods of machining which has replaced the traditional machining methods such as drilling, milling etc.In EDM process, discrete electric discharges (sparks) are generated between the workpiece-electrode and the tool-electrode immersed in a dielectric medium. Sometimes it is also known as spark machining because of the sparks generated between the electrode and the workpiece. These electric discharges create plasma of electrons which strike the surface of the workpiece with great force due to which the metal vaporizes because of the thermal energy generated after the collision of the electrons with the surface. Fig 1.1 shows a schematic diagram of the basic elements of EDM.With EDM we can machine any type of material irrespective of its hardness but the material should be electro-conductive. Also in EDM, the tool does not make a direct contactwith the workpiece thus eliminating mechanical stresses, chatter and vibration problems during machining .

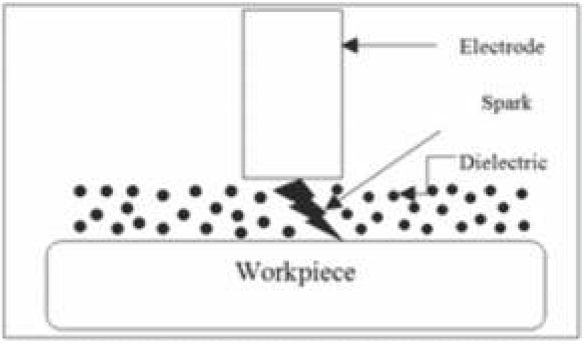

Fig 1.1 –Basic components of the EDM.

LITERATURE REVIEW

In 1943, Dr. Boris Lazarenko and Dr. Natalya Lazarenko were the two scientists, who for the first time noticed that when a high voltage electric current is passed between two electrodes separated by a short gap, then a spark is generated and this spark leads to a small amount of erosion in the electrodes. They further observed that if this phenomenon is carried out in a dielectric medium, the erosion can be controlled to a great extent. Their observation led to the invention of the electric discharge machine. The output parameters are highly influenced by the type of dielectric used in the machining. The parameters can also be altered by using different composite electrodes processed by powder metallurgy.S. Chen, B. Yan and F. Huang used Ti-6Al-4V alloy, which has high melting temperature and low thermal conductivity. In this study, the EDM characteristics of Ti–6Al–4V alloy were examined using kerosene and distilled water as the dielectric. They concluded that the material removal rate of the alloy is greater while the relative electrode wear ratio is lower using distilled water rather than kerosene. Also the size of the debris was found to be larger in case of distilled water being used as the dielectric. Recent researches have shown that it's not just the dielectric medium but the performance of the EDM depends on the type of electrodes being used. Powder metallurgy is a very good technique for making electrodes for the EDM process. In 1920's tungsten carbide was invented using powder metallurgy. Since a long time, researches have been done and PM processes have been continually evolving. Cost saving associated with the net shape processing as compared to processes like casting, metal forming etc. led to development of PM .

Dielectric medium

Dielectric medium plays a very vital role in the whole machining process. A dielectric is an electrical insulator and when a high voltage is applied, it ionizes and changes into an electrical conductor, right then the surface erosion takes place. Dielectric fluid also helps in maintaining a proper gap between the electrode and the workpiece, if the electrode comes in contact with the workpiece, sparking ceases and no machining takes place . Normally used dielectric fluids in EDM are kerosene oil or deionized water.

S. No.	Type of dielectric	Effect	Author	Year & Journal
1	Distilled water	Higher MRR and lower wear ratio	S.TariqJilani ·P.C. Pandey [5]	1984, International Journal of Machine Tool Design and Research
2	Tap water	Best machining rates, zero electrode wear possible.	• W. König, L. Jörres, [6].	1987, CIRP Annals - Manufacturing Technology
3	Powder mixed dielectric	Insulating strength of dielectric was reduced.	H.K. Kansal and coworkers, [7].	2007, Journal of Materials Processing Technology
4	Aqueous Solutions Of Organic Compound	Considerably Increases The Attainable Removal Rate As Compared To That For Pure Deionized Water, without any fire hazard.	• W. König, L. Jörres, [6].	1987, CIRP Annals - Manufacturing Technology.
5	silicon powder-mixed dielectric	reduction of the operating time, required to achieve a specific surface quality, and in the decrease of the surface roughness.	P. Pecas, E. Henriques [8]	2003, International Journal of Machine Tools and Manufacture
6	dry and near-dry EDM	high material removal rate (MRR) and fine surface finis	Jia Tao and coworkers [9]	2008, Journal of Manufacturing Science and Engineering.

Servo mechanism
As already discussed that there should be a proper gap maintained between the electrode and the workpiece to carry out the process, this gap is governed by a mechanism known as servo mechanism.

Powder metallurgy
Powder metallurgy is a process in which the powder of metals is heated below their melting point so they can attain bonding. The metals or alloys undergo following processes in powder metallurgy viz. blending, compacting, sintering and finishing. The metals which are processed by the powder metallurgy need not undergo any additional machining. In the process of PM some additives and lubricants are also added while blending the powders [10].

S. No.	composite tool-electrode prepared by PM	Effect	Author	Year and journal
1	Sialon ceramics and chromium	Surface of workpiece was coated with the electrode surface and possessed good corrosion resistence	Fukuzawa and coworkers	1995
2	Copper and tungsten	MRR more than copper electrode and tool wear is less	S.H. Lee and X.P. Li	2001
3	Cu-SiCp	Lower electrode wear ratio	Shu and Tu	2001

Need of PM processed composite electrodes
In recent years, efforts have been made to get significant results using different type of composite electrodes in EDM. The electrode is judged by the following properties viz. electrical,thermal and mechanical. Recent researches have shown that powder metallurgy (PM) is best suited for manufacturing these electrodes. The properties that are best suited for the process can be easily attained by simply changing the input parameters in the processes like compacting and sintering.P. K. Philip [14]reported that a single material property cannot be considered as the determining factor in EDM tool performance. But the combination of certain properties of electrodes, such as mechanical, electrical and thermal can give us the best tool for EDM and the powder metallurgy can aggregate these desirable properties that any other process cannot. J. Marafona and C. Wykes[15] noticed that copper increases the electrode wear rate due to its low melting point, so they evaluated a method to optimize the material removal rate (MRR) using copper-tungsten (Cu-W) electrode. Z.L. Wang and coworkers[16]developed a method of surface modification by EDM using a simple electrode and kerosene as dielectric medium. It was noticed that a hard layer of ceramic is produced over the surface of the workpiece. This layer was three times harder than the base metal. This deposition of hard layer is known as electric discharge coating (EDC). H.C. Tsai and coworkers [17] blended copper powders containing resins with chromium powders and obtained higher MRR than the copper-chromium composite electrode but the electrode wear rate (EWR) also increased. The MRR is higher when a sintering pressure of around 20-30 MPa rather than 10 MPa. H.K. Kansal and coworkers [7]carried out there research in powder mixed EDM (PMEDM). In this research they used an electrically conductive powder along with the dielectric which reduced its insulating strength. They also gave an introduction to machining mechanism, current issues and applications of the PMEDM.Parveengoyal[18]investigated that less EWR is observed in copper-manganese composite electrode when copper to manganese weight ratio is 80-20 rather than using Cu-Mn weight ratio as 70-30.
Surface modification

Surface modification is the process of electrode material deposition on the surface the work material, also known as surface alloying or electric discharge coating[19]. Tsai and coworkers [17] reportedimprovement of the surface propertiesdue to surface alloying using composite electrodes.

Applications
EDM find its application in many processes such as micromachining using EDM. As the size of the product start decreasing, its machining becomes more difficult. But with the help of EDM machining up to micro level is also possible such as drilling of micro holes known as micro electric discharge drilling[20].

Another application of EDM is machining of ceramic materials. These days ceramic materials have found there application in various industrial applications. EDM is very useful in machiningvery hard materials and geometrically complex shapes. Therefore, EDM is a potential and attractive technology for the machining of ceramics, providing that these materials have a sufficiently high electrical conductivity [21].

EDM is also employed in machining of modern composite materials and heat treated materials. EDM has replaced traditional machining processes such as the milling of heat-treated tool steels, which have hardness of 30–35 HRC [20]. These materials are very difficult to be machined with traditional machining processes so we use EDM to process these materials using electrodes manufactured by powder metallurgy.

CONCLUSION
Industrial revolution has led to the invention of very important and different types of material which cannot be machined by conventional machining methods due to their properties which are quite different from the metals or other materials used before. So to

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overcome this problem, non-conventional machining methods like EDM had to be developed and for these nontraditional methods, electrodes had to be made with some special properties like good electrical conductivity, hardness, good thermal properties, ease of manufacturing and less cost etc. After so many researches, powder metallurgy proves to be the most convenient and effective method for electrode manufacturing. Parameters like MRR, tool wear ratio, surface finish can be changed by varying the composition of the composite material processed by powder metallurgy.

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