ECOLOGY ASPECTS IN ORDER TO REDUCE THE MAINTENANCE RATIO IN THE EDM PROCESS

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ABSTRACT
Electrical discharge machining (EDM) is a widespread process which works very effectively in machining of difficult-to-cut materials and alloys in die and aerospace industries with high dimensional accuracies. In recent years, EDM researchers have explored a number of ways to improve the sparking efficiency including some unique experimental concepts that depart from the EDM traditional sparking phenomenon. Due to the increasing of environment and health issues of the last decades we researched these aspects in association with the University of Medicine and Pharmacy Cluj-Napoca, under the CEEPUS program. This paper reviews the new trends in EDM and the ecology benefits of using diferent kinds of dielectric in order to achieve a lower maintenance ratio.

Keywords: EDM, dielectric, ecology

1. INTRODUCTION
The manufacturing of complex surfaces by electro erosion is one of the most used methods, especially because it can generate practically surfaces as complex as it needs, and not depending on the hardness of the material. The process is used mainly in the work tools departments and for the large series of machining, also the main advantage is that the work tool is performed from materials that are easy to process and the conditions of working don't depend on the hardness of the material. The finishing of the surfaces occurs after the thermal treatment and it is a difficult and expensive process. Electric Discharge Machining becomes very efficient. Without a contact between tool and work piece, it avoids the appearance of the distortion in the work piece and of the internal stress in the superficial layer [1]. Today, by electro erosion process can be practically realised any kind of machining: drill, saw, turn, mill, ream, grind, hone, and even more. The machines were well developed and they provide a very high precision and a short time of processing making the process very easy to be integrated in the industry completing the conventional technologies. This machining method can be classified in two types: EDM (machining with massive electrode) and WEDM (machining with wire electrode).

1.1. Physical phenomena of EDM

The EDM machines can be separated in two types: universal and special machines. The physic process of material machining and the evacuation of the processed material from the spark take place in the interstice between work piece and tool. In the process of electro erosion, the electric parameters are the most important.

The warming of the surfaces of the work piece and electrode and the existence of the electric field determines the appearance of the thermoelectric and thermion emissions. It supposes most of the electrical energy to be transformed in thermal energy, developing temperatures between 4000º - 50000º C. It takes place melting, boiling off, thermal influence, structural changes of the peripheral zones of the electrodes, forming of micro fissures, forming of erosion craters [2].

Basically the phenomenon is of thermal erosion because of the very high temperature.

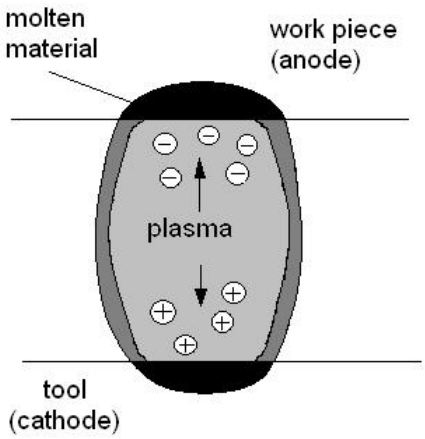

Figure 1. Electrical discharge in EDM; [3]

In EDM, conductive work piece materials are removed for the purpose of machining in a dielectric by electrical discharge. The material removal results from time wise separated, no nstationary or quasistationary discharges between electrodes, i.e., between tool and work piece.

2. ECOLOGY ASPECTS

Electro discharge machining process has also some negative points. First of all is using the hydrocarbons oils as dielectric that must be recycled after a short period of using. The major problem is that this kind of dielectric needs a maintenance schedule and it must be stored in special areas because is not environmental friendly. This procedure increase the costs of machining process. Because EDM is a thermal process the hydrocarbon oil is vaporizing and the toxic emanations affects the worker health. To avoid this problems the dielectric must be changed. During the time researchers tried a lot of combinations, but the best ecology and machining results were obtained using water as dielectric and dry EDM. Those are new ecology trends in EDM in order to increase environment quality, working place health and to reduce maintenance ratio.

2.1. EDM in water

Water as dielectric is an alternative to hydrocarbon oil. The approach is taken to promote a better health and safe environment while working with EDM. This is because hydrocarbon oil

such as kerosene will decompose and release harmful vapour (CO and CH4). Research over the last 25 years has involved the use of pure water and water with additives.

2.1.1. Pure water

The first paper about the usage of water as dielectric was published by Jeswani in 1981. He compared the performances of kerosene and distilled water over the pulse energy range 72–288 mJ. Machining in distilled water resulted in a higher MRR and a lower wear ratio than in kerosene when a high pulse energy range was used. With distilled water, the machining accuracy was poor but the surface finish was better. Tariq Jilani and Pandey investigated the performance of water as dielectric in EDM using distilled water, tap water and a mixture of 25% tap and 75% distilled water [4]. The best machining rates have been achieved with the tap water and machining in water has the possibility of achieving zero electrode wear when using copper tools with negative polarities. Konig and Siebers explained the influence of the working medium on the removal process. They indicated that working medium has a sustained influence on the removal process [5]. The erosion process in water-based media consequently possesses higher thermal stability and much higher power input can be achieved especially under critical conditions, allowing much greater increases in the removal rate. A considerable difference between conventional oilbased dielectrics and aqueous media is specific boiling energy of aqueous media is some eight times higher and boiling phenomena occur at a lower temperature level. During investigating on white surface layer, Kruth found that the use of an oil dielectric increases the carbon content in the white layer and appears as iron carbides (Fe3C) in columnar, dendritic structures while machining in water causes a decarbonization [5]. Using deionized water as dielectric the specimen after heat treatment underwent oxidation and showed no crack propagation behavior.

2.1.2. Water with additives

Koenig and Joerres reported that a highly concentrated aqueous glycerine solution has an advantage as compared to hydrocarbon dielectrics when working with long pulse durations and high pulse duty factors and discharge currents, i.e. in the roughing range with high open-circuit voltages and positive polarity tool electrode [5]. Leao and Pashby found that some researchers have studied the feasibility of adding organic compound such as ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 600, dextrose and sucrose to improve the performance of deionized water [5]. The surface of titanium has been modified after EDM using dielectric of urea solution in water. The nitrogen element decomposed from the dielectric that contained urea, migrated to the work piece forming a TiN hard layer which resulting in good wear resistance of the machined surface after EDM.

2.2. Dry machining

In dry EDM, tool electrode is formed to be thin walled pipe. High-pressure gas or air is supplied through the pipe. The role of the gas is to remove the debris from the gap and to cool the inter electrode gap. Figure 2 shows the principle of dry EDM. The technique was developed to decrease the pollution caused by the use of liquid dielectric which leads to production of vapour during machining and the cost to manage the waste.

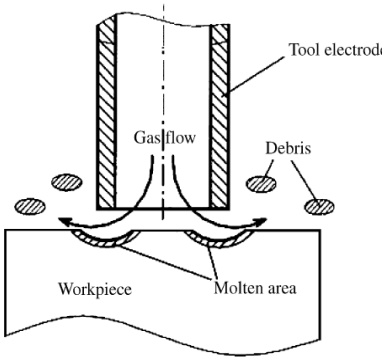

Figure 2. The principle of dry EDM

Yu investigated the capability of the technique in machining cemented carbide material and compared the machining characteristics between oil EDM milling and oil die sinking EDM [6]. He found that for machining the same shape oil die sinking EDM shows shorter machining time. But because oil die sinking requires time for producing electrodes, dry EDM should be more useful in actual production. Figure 3 and 4 shows the work removal rate and electrode wear ratio in groove machining. According to the results, work removal rate of dry EDM milling is about six times larger than that of oil EDM milling, and electrode wear ratio one-third lower.

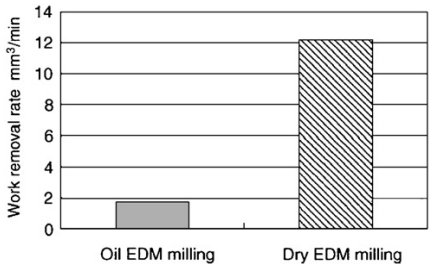

Figure 3. Work removal rate

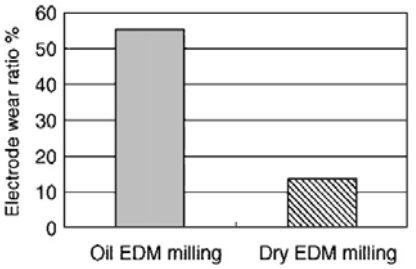

Figure 4. Electrode wear

The characteristics of dry EDM are:
(1) It is environmental friendly and reduce the technology costs.
(2) Tool electrode wear is negligible for any pulse duration.
(3) The processing reaction force is much smaller that in conventional EDM.
(4) It is possible to change supplying gas according to different applications.
(5) The residual stress is small since the melting resolidification layer is thin.
(6) Working gap is narrower than in conventional EDM.
(7) The process is possible in vacuum condition as long as there is a gas flow.
(8) The machine structure can be made compact since no working basin, fluid tank and fluid circulation system needed.

3. CONCLUSIONS

Water-based dielectric can replace hydrocarbon oils since it is environmentally safe. When comparing the performance of water-based dielectric with hydrocarbon oil it shows that surface finished in distilled water is better compared to kerosene. EDM sinking process can be made more cost effective through the use of water based media, significantly improving competitiveness with other process. The development of the dry EDM technique concerns more on to increase the MRR since the MRR is lower compared to conventional machining. This technique should be supported and more investigation should be made since it helps to save the environment. It can be seen that dry EDM has many advantages over oil EDM. Those techniques are new ecology trends in EDM in order to increase environment quality, working place health and to reduce maintenance ratio and technology costs.

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