CHARACTERISTICS OF THE DRY ELECTRICAL DISCHARGE MACHINING

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ABSTRACT: The electrical discharge machining - EDM is one of the most applied non-conventional machining methods, based on the thermal effect of the electrical discharges. Sustainable development within the industrial researches covers also the EDM field. One of the main research directions regarding EDM is the replacement of the dielectric working liquid with dry or semi-dry dielectric fluids that are characterized by a lower negative impact over the environment. The paper highlights the main aspects regarding the dry EDM, based on the specialty literature study.

KEYWORDS: Electrical discharge machining, Dry machining, Characteristics

1. INTRODUCTION

In the last years, the electrical discharge machining (EDM) becomes more and more popular. There are researchers that classify these methods as being the fourth most used machining method after milling, turning and grinding [6]. The reasons for these claims relay on the advantages of EDM described by high material removal rates (MRR), low costs and high machining efficiency in shaping complex profiles.

The EDM method uses electricity to remove the metallic material by means of spark erosion and it is generally carried out using dielectric liquids. The reasons of using dielectric liquids are to cool and evacuate the debris existing in the gap between tool electrode and workpiece and to ensure the generation of the pulse discharges between the two conducted surfaces of the electrode tool and the workpiece.

Today's widespread concern for the environment and human health was also reflected in the studies regarding the "non-conventional" machining processes. The environmental problems related to the EDM methods refer to the mineral oils that are typically used as dielectric medium. These oils generate toxic fumes and can produce fire hazards. That's why the recent researches in the EDM field [1, 2, 3, 4, 5, 6, 8, 9, 10] focus in developing environment friendly EDM techniques that use high pressure gases instead of the conventional dielectric liquids. Dry EDM is considerated to be a completely "green" machining process, characterized by less environment impact, no fire hazards and reduced health problems.

The first scientific paper referring to the dry electrical discharge machining method was a succinct NASA technological report dating from the year 1985 that deal with the drilling using argon and helium gas as dielectric medium [4, 5].

Over the next years, the researchers investigated the possibilities to use different types of gases as dielectric fluids and tried to determinate the influences that these dielectric mediums can have on the entire EDM processes.

The researches conducted by Kunieda et al. [5] showed that the material removing rate can be improved by using the oxygen as dielectric fluid in EDM. Their study not only demonstrated that EDM in gaseous medium is possible, but also brought out some of the advantages of the process. They demonstrated that the high velocity gas flow through tool electrode reduces debris reattachment after a spark, thus considered to be effective in flushing.

The feasibility of 3-D surface machining by dry EDM investigation was explored by Zhnabo et al. [10]. They reported that compared to the wet EDM, the dry EDM method can reach smaller tool electrode wear ratio and improved profile accuracy. Their experiments were conducted using the oxygen as dielectric medium and rotating pipe electrodes. The researchers also concluded that there are optimum combinations of cut depths and gas pressures that can assure maximum material removal rate with minimum tool electrode wear ratio.

There were some researchers which investigated also the rough - cutting with dry wire electrical machining (dry-WEDM). The research group led by Furudate et al [2] reported that the dry methods are more efficient in terms of corrosion and process accuracy than the conventional ones. However, they identified as primary disadvantage of dry wire EDM the lower material removal rate.

The experiments conducted by L.Q. Li, W.S. Zhao et al. [4] demonstrated that the direct polarity is more efficient in dry EDM, because of the lower tool electrode wear ratio.

The tool electrode has an important roll in ionization, absorbing less energy than the anode represented by the workpiece.

In gas mediums, the discharge passage extends more rapidly compared to the so called conventional wet method, protecting the tool electrode by the debris adheres on the tool.

In the United States of America, an important research center in the EDM area is located at the Michigan University. In the latest years, the Mechanical Engineering Department of this university showed a great interest for dry EDM, developing/evaluating different kinds of techniques for the method [1,6]. The results of their investigations reveled that by using oxygen and copper pipe electrodes, the material removal rate increases to 36 mm^3/min, compared to 20 mm^3/min obtained in the wet EDM method [6]. They also studies the possibilities of using the dry EDM as finishing process and concluded that by using nitrogen mist and graphite electrodes, the surface roughness can by improved from R_a=4 μm to almost 0,7 μm [3].

2. SYSTEMIC ANALYSIS OF THE DRY EDM PROCESS

For a better understanding of the method, a systemic analysis of dry EDM was developed, pointing out some of the primary input factors and also the main output ones.

As it can be seen in the figure 1, some of the input factors taken into account are the following: the electrical mechanical and thermal proprieties of the dielectric fluid, the main electrical parameters, some properties of the workpiece material and the tool electrode and the machining parameters. When referring to the output parameters, the main factors are: the integrity of the finish surfaces, the roughness, the accuracy, the tool electrode wear ratio, material removal rate and the level of pollution generated by the process. Some of the perturbing factors of the system are the atmosphere temperature and the extern vibrations. Many researchers had demonstrated that by using compressed air flow the surface quality can be improved.

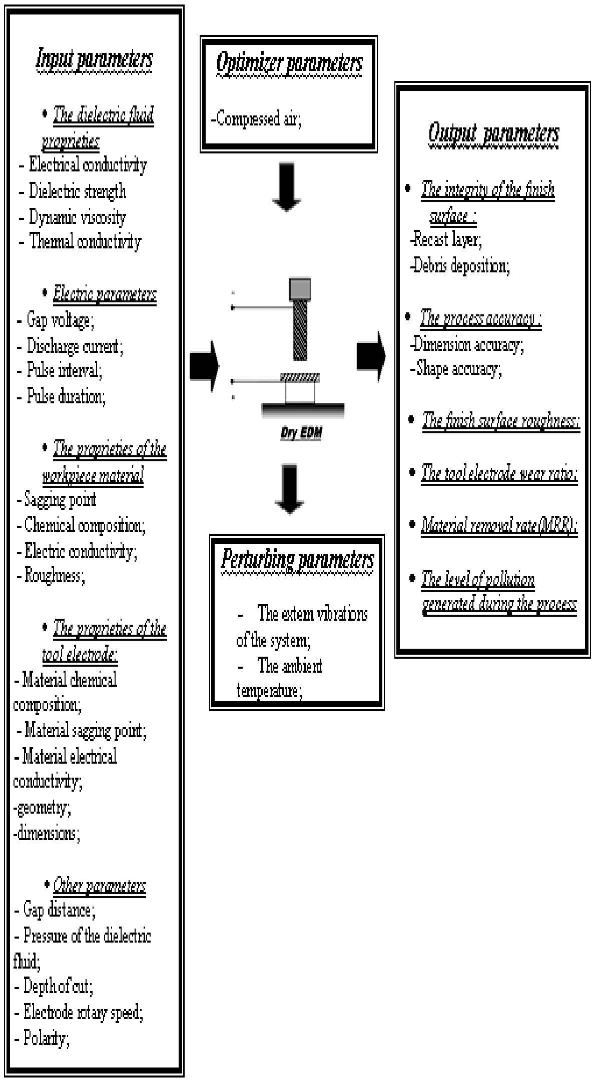

Fig. 1. The systemic analysis of the Dry EDM process

3. EXPERIMENTAL SETUP

The study investigates the characteristics of a certain dry electrical discharge machining method.

The experiments were carried out on a 3D CNC machine from the non-conventional technologies laboratory of the Gheorghe

Asachi Technical University of Iasi. The discharge circuit of a spark marking equipment was used and its schematic is presented in figure 2.

The work material used in the research was a steel type AISI 1045 (OLC45) and the electrode tool was made of wolfram. The experiments were done in three different mediums, respectively with compressed air blowing, with dielectric liquid and in normal atmosphere. For each condition, three experiments with a working duration of 30 seconds, 1 minute and, respectively, 2 minutes were made.

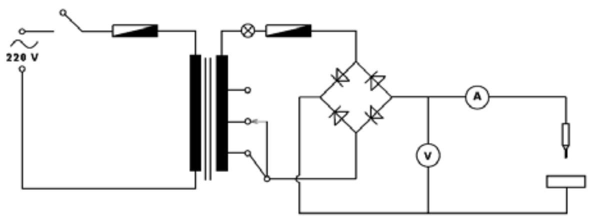

Fig. 2 Discharge electrical circuit of the EDM marking equipment

Figure 3 illustrates the experiment setup in which the EDM processes were conducted. For all the experiments, the gap voltage used was of 15 V. The supplied compressed air pressure used was 1,5 bar.

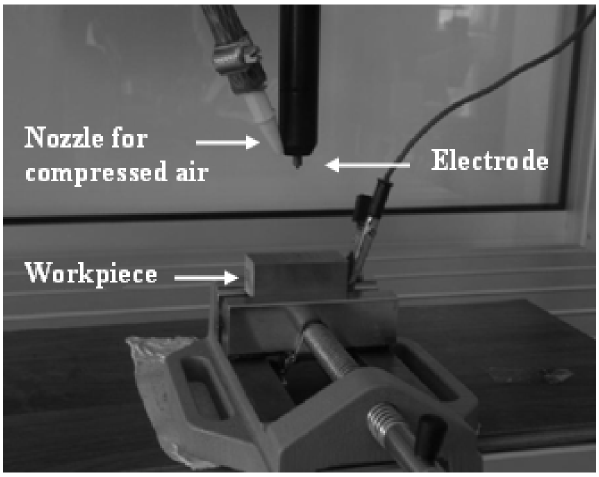

Fig. 3 Experimental setup

To establish the influence that each type of medium used in the research has on the quality of the worked surface, the authors proposed a comparison between the machining results, using as index the hole depth and the shape of the machined surface. The hole quality was inspected using an optical microscope at 60X magnification.

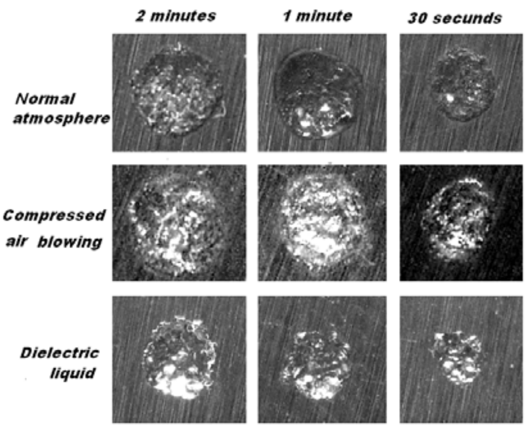

Fig. 4 Optical micrographs on holes drilled in time of (a) 2 minutes (b)1 minutes (c)30 secunds

Figure 4 shows the optical micrographs of the top side views of the holes obtained by EDM.

The shape quality is considered to be better for the holes drilled under normal atmosphere conditions, although they present severe debris deposition problems, compared with the ones conducted under the other two mediums.

By using compressed air as dielectric fluid, the debris deposition problems can be efficiently eliminated.

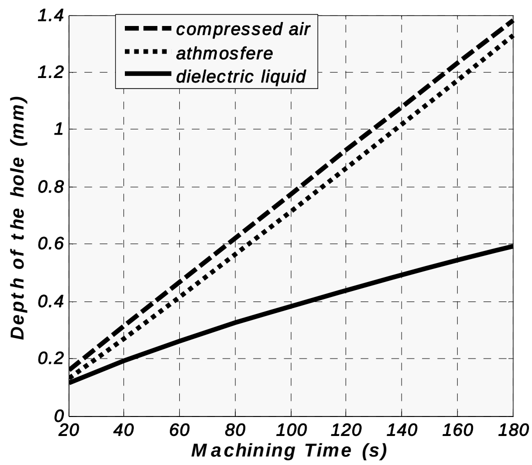

Fig. 5 Relation between machining time and depth of the hole

The depths of the holes were also measured for a better material removal rate comparison of the methods. As one can see in figure 5, the dry EDM drilling has a consistently higher material removal rate (MRR).

The maximum MRR is obtained for the drilling process conducted under compressed air blowing conditions.

4. CONCLUSIONS

In comparison to the conventional method, the dry EDM process is characterized by the improvement of some of the output parameters, as the material removal rate, shape accuracy and the integrity of the finish surfaces. That's why the researches in this field are entirely justified. The results presented in this paper suggest the need to investigate new methods for the dry EDM processes, so that the industrial applications can be realized.

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