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PARAMETERS AFFECTING THE QUALITY OF THE ELECTRICAL DISCHARGE MACHINING PROCESS

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Abstract:
Nowadays the Electrical Discharge Machining process (EDM) is a very important manufacturing process in the metal industry. When you want to improve the quality of a metal product, you have to develop the precision. With the use of the EDM technique it is possible to cut through the most difficult and hardest metals with a very high precision rate to produce very accurate metal products.

In this paper the EDM technique in general and the different machines that are using this technique will be discussed. Some new models based on the different parts of the machine that try to improve the EDM process will also be presented. We will discuss a model based on improving the precision, a model based on saving money and finally a model based on saving time. The paper ends with an appropriate conclusion.

Key Words: EDM process, Manufacturing, Metal products

1. INTRODUCTION

Nowadays manufacturing/automatic processes are used everywhere. From the smallest to the biggest product to be fabricated, we need to use some kind of manufacturing process. Thereby, the product has to have an outstanding quality because the customer expects an even better and accurate end result.

One of the techniques that can guarantee the finest finishing quality is the EDM technique. The technique is nowadays progressively used for making moulds, high quality products and cutting through the most hard metals.

To understand the technique we need to know that EDM stands for Electro Discharge Machining. The definition of EDM manufacturing can be given as follows: the occurrence of successive, in time separate, sparks between the workpiece and an electrode in a dielectric fluid. This means that EDM is using electricity and conductive materials to cut hard metals. This paper starts with the history of this technique. We will explain the different parts of the machine with their advantages and disadvantages.

The main purpose of this paper is concerned with improving the EDM process. We try to improve the process by creating different models who adjust the parameters [1].

2. STATE OF THE ART

In the late 1770's an English scientist Joseph Priestley started to observe the EDM process. This was in fact a small study and was not really useful. EDM machining was very imprecise and littered with failures. The real EDM process as we know today was invented in 1943 by two Russian scientists Dr. B.R. Lazarenko and Dr. N.I. Lazarenko. They improved the process of applying repeated electrodes to wear away a hard surface by learning how to control the distance, intensity and frequency of the spark and apply it to machine. EDM drilling was the first developed technique. They used it to make blind holes, engravings. Nowadays EDM is more used for milling and cutting.

The First company who designed a die-sinking EDM machine was Agie in 1954.
Later in 1969 the company invented also the first numerically controlled wire-cut EDM machine [2].

Commercial machines were developed in the mid 1970s. Wire-cut EDM started to be variable technique that helped forming the metalworking industry as we see today.
In the mid 1980s, the EDM techniques were transferred to a machine tool, this made EDM more widely available and it appealed over traditional machining [3, 4].

Today this company has turned into one of the biggest producers of manufacturing machines and is called GF AgieCharmilles. The first, the most famous and also the world leader of making EDM machines is AgieCharmilles.

3. EDM MACHINE

To start we will explain the main different parts of the EDM machine. Figure 1 illustrates the main parts of the EDM machine.

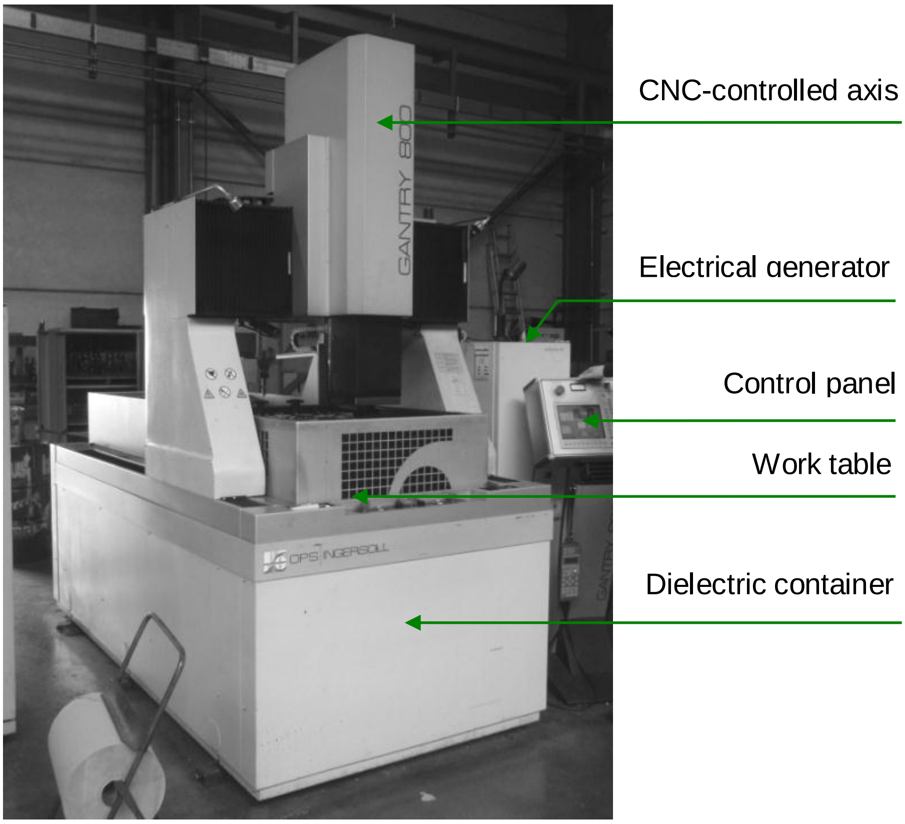

Figure 1: EDM machine.

The machine consists out of five main parts:

- CNC-controlled axis;
- electrical generator;
- control panel;
- work table;
- dielectric container with filter.

The first part is the CNC-controlled axis which is equipped with an electrode. This electrode has to be made of a conductive material such like copper, tungsten, graphite, etc. The axis is controlled by using the control panel. The next part is the dielectric container. It contains the dielectric fluid that is required to start the process. Inside the dielectric container there is also a filter that filters the dielectric liquid. This is necessary because the liquid can contain little particles from the work piece and also because it has to ensure that the fluid is still pure enough to make the electrical reaction possible [5].

The main part of the machine is the electric generator. This is the unit that generates the electric pulses. The controllability of the generator is important since the current, pulse duration and the interval between two pulses must be set accurately. Two types of generators exist: the relaxation or RC generator and pulse generator. The breakthrough of the relaxation generator depends on the size and the condition of the work crack. For the pulse generator is the breakthrough imposed by the generator itself. The last part is the worktable to fix and adjust the workpiece [6].

Like any mechanical machines and tools the EDM process has some advantages and disadvantages. One of the most important advantages of the EDM process is that it can make products with a high precise finishing, compared with other technologies and conventional tools. Therefore EDM is mostly used for very hard materials that need some complex cutting, especially for sophisticated products that must have exact dimensions. Other advantages of EDM is the use for the production of very small work pieces with great precision (micro EDM), the possibility to produce the most precise holes and shapes and very useful to process hard materials and metals.

The disadvantages of EDM is that it uses a lot of power and it has a very slow rate of material removal compared with other cutting techniques. Another disadvantage is the time needed to develop the tools of the electrode first, before you can use it on the EDM machine.

4. IMPROVING MODELS

If we want to work with EDM machines we must have in mind that this is very accurate process, so the smallest mistake we make in the beginning of the production process can expand to a great default at the end of the production process. Therefore we must be sure that the process occurs in the most optimal conditions.

To improve the precision and reliability of the EDM process we need to know which factors can be adjusted. In that case the first thing it is important to analyze the parameters which affect the final part quality in the EDM process.

The parts of the EDM machine we are able to control are:

- CNC-controlled axis;
- dielectric fluid;
- electrode;
- electrical settings.

As noticed, four different parts of the machine will influence accuracy of the EDM process. The possible models that can improve the process quality will be discussed.

4.1 Model for improving the precision

The first and maybe the most important model is the model for improving the precision of the EDM process (Figure 2). The precision and accuracy of manufacturing work pieces is nowadays very important because precision goes hand in hand with quality. Nowadays the customers always want to have the best quality.

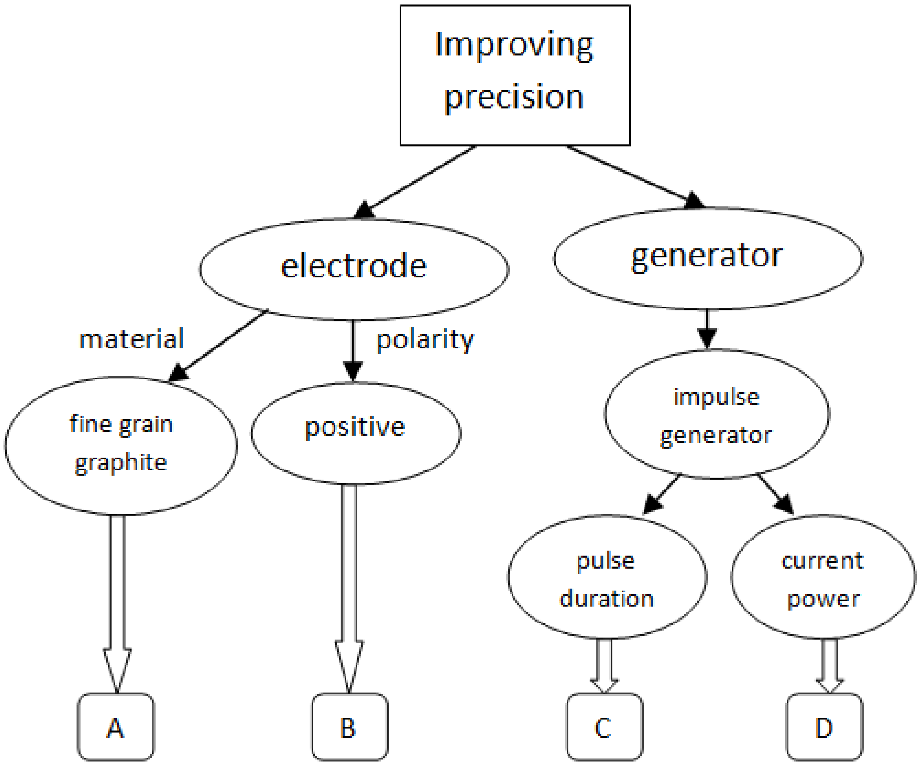

Figure 2: Improving EDM precision.

Condition A:

The precision can be improved by choosing the best electrode. This means we have to choose for the electrode that has the most superior rate of removing material. Therefore we need to choose the electrode that can resist thermal damage at high level. Because of the fine grain size of graphite it can resist higher temperatures then other electrodes and it has a higher wear resistance. So if we want to improve the process by choosing the most useful electrode we have to use fine grain graphite. On the other hand the finer the grain, the more expensive it will be.

Condition B:

Not only the material of the electrode is important, also its polarity. To have the best finishing quality it is better to set the electrode as positive to minimize wear. However there are materials like carbide, titanium, copper,… who can only be cut with a negative polarity of the electrode .

Condition C:

If you decided to work with a specific electrode and cannot change the electrode material, you can improve the precision by changing or adjusting the settings of the generator. Instead of using a relaxation generator, a pulse impulse generator can be used. It is well known that this generator can be adjusted more accurate then the relaxation generator. In this condition we have chosen to improve the precision by changing the pulse duration. Depending on which electrode we use we can adjust the generator in that way that we have a shorter pulse duration. This will result in a more accurate removal of material.

Condition D:

Another part to be adjusted, when already decided which electrode material to use, is the power of the current. It is possible to change the precision of the work piece by allowing a lower current. A high current means a high removal of material. So we remove rather big and non precise parts. Therefore a lower current will remove smaller particles with a higher precision.

As conclusion we can say if we really want to improve the precision of the process we need to use fine grain graphite as electrode material. A short pulse duration and a rather low power current together with a high frequency makes sure we have the best finishing results.

4.2 Model for saving money

Besides the precision we can also advance the process by saving money. For big enterprises it is one of the main objectives they want to improve. Because nowadays everything depends on money and gaining as many money as possible in the shortest time. That’s why I made the model with saving money as reference.

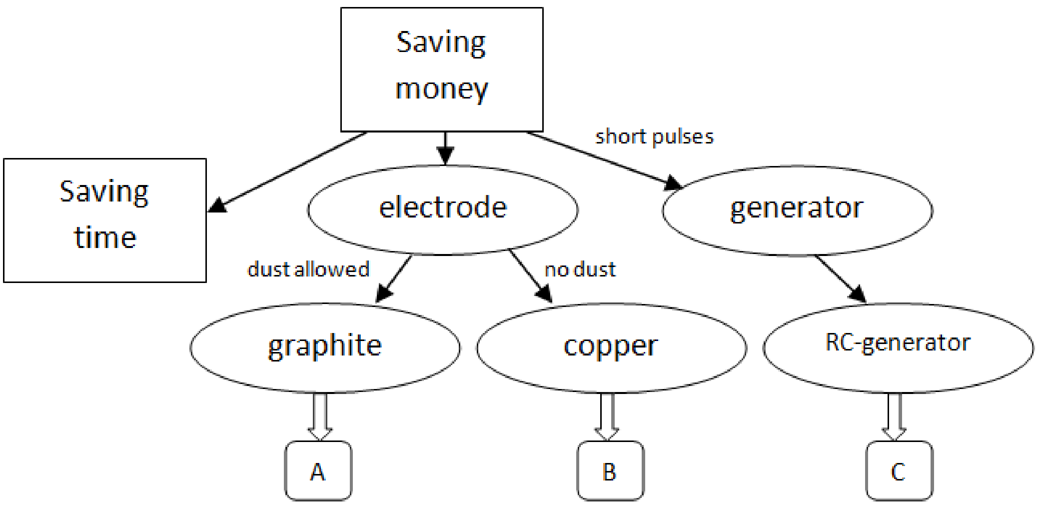

Figure 3: Model for saving money.

Condition A:

We can save money in the first place by using the most cheapest electrode. In that case we choose for the graphite electrode. It is not only the most cheapest in price, it is also the most easy adaptable electrode we have. This means that it is really easy to adjust the electrode in the correct shape and that the price for adjusting the graphite electrode is also the cheapest. The usage of graphite is only possible with work pieces where dust is allowed.

Condition B:

If there is no dust allowed for making the work piece we are forced to use copper instead of graphite. The purchase of the electrode will not only cost more, but because of a greater wear rate of the electrode we need to have more material as well. But it is still cheaper than tungsten or a tungsten-copper alloy.

Condition C:

If we want to have a well-finished product and we only need short pulses, it is cheaper to use a relaxation generator. Not just the purchasing of the machine is cheaper also the usage of power is less. A disadvantage is that we are not able to adjust the electric settings.

Another key factor to save money is saving time. But because there are a lot of factors in that case I made a new model in the next dialogue.

We can conclude that if we want to save money, we have to use graphite as electrode and use a RC-generator. But this is only possible in some occasions.

4.3 Model for saving time

Another thing that could improve the process is saving time. One of the most important things in making profit is time. The lesser time it takes to make a product, the better. So if we are able to make the same product in less time by using other techniques, we are improving the process.

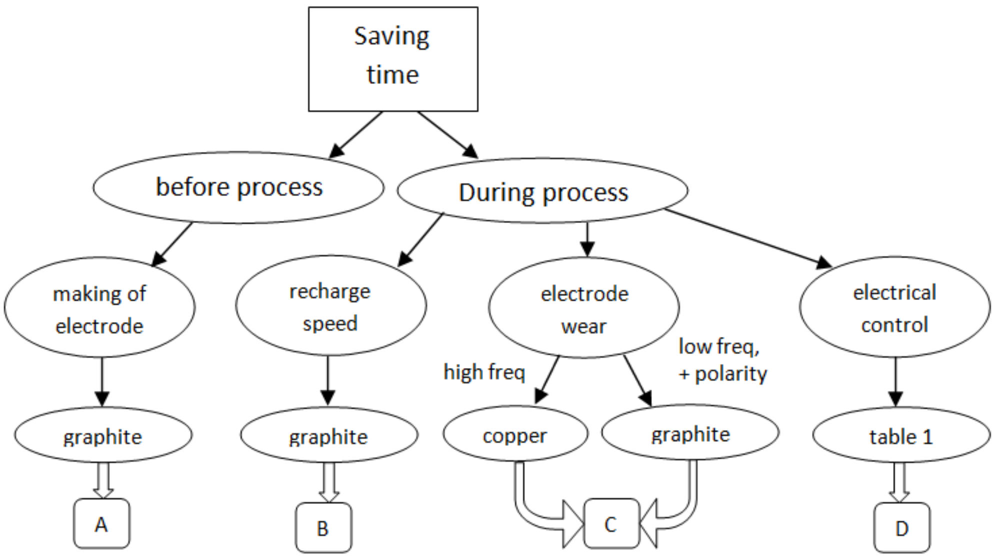

Figure 4: Model for saving time.

Condition A:

We can save time even before the real EDM process is started. The making of the electrode is an important factor in the total process. Before we can start using the EDM machine we have to create the shape of the electrode. We know that graphite has the property to be more easy adapted then other electrode materials.

Condition B:

As we know the conductivity of graphite is better than copper, this means that the recharge will go faster as well. A faster discharge of the electrode will result in a faster cutting speed, which will result in saving time

Condition C:

Another thing where we can look at to save time is the electrode wear. One of the main advantages of graphite is that it has a greater strength than copper, by which it will have a longer lifetime if we are working with a positive polarity and a low frequency. If we mainly have to work with a high frequency it is better to use tungsten. With this there will be less time to replace the electrode, creating more saving time. Off course we have to considerate the size of the power current.

Condition D:

A last thing we can do to save time is regulate the electric control. Out of schedule number two we can see an example of different electric adjustments. Out of this schedule we can conclude that the longer the on time of the electrode takes the faster the metal removal goes. The negative part is that the faster you are working the lesser precisely the final result will be. As conclusion we can say that the usage of graphite with a longer on time then off time seems to be the best solution to save time. On the other hand if we let the electrode work fast, we are losing quality of the work piece and the electrode will wear faster. So we can conclude if we want to save time in the EDM process we have to use graphite as electrode. The biggest disadvantage of using graphite is the forming of dust.

Table I: effect of electrical control adjustments EDM operations.

On time (μs)	Off time (μs)	Frequency (kHz)	Peak current (A)	Metal removal rate (in^3/hr)	Electrode wear (%)	Surface finish (μ in R_a)
40	60	10	50	0,8	2,5	400
20	30	20	50	0,7	6,3	300
40	10	20	50	1,2	1,4	430
40	60	10	25	0,28	2,5	350

Note: 1 $inch^3$ = 16,39cm^3

5. CONCLUSION

The EDM process is nowadays a very commonly used process and the usage of this technique will only increase more and more in the future.

We started the paper with explaining the main parts of the machines which are using the EDM technology. After this we tried to improve the EDM process by writing down which different factors we can adjust. We made models for improving the quality, saving time and money.

Although we have to say that the results would have been more reliable if we had the chance to work on an EDM machine. Sadly enough we did not had this opportunity. Therefore someone can even more improve these models by testing this actors on a real EDM machine. As conclusion we can say that there are some models we can follow to improve the process. I also have to mention that these models are primarily meant for the die sink EDM process as for the wire-sink EDM process there are fewer factors we can adjust.

REFERENCES

[1] De Henau, A. (2007-2008) Production technologies. Course University College Ghent, Faculty of Applied Engineering Sciences.

[2] Machinery´s Handbook (2004) 27th edition. P.1351 - 1355

[3] Electrical Discharge Machining, from http://www.edmmachining.com, accessed on 24-04-2010

[4] AgieCharmilles. EDM machine maker, from http://www.gfac.com/, accessed on 25-04-2010

[5] Ficko, M.; Balic, J.; Brezocnik, M. & Pahole, I. (2010). Solving of floor layout problem in flexible manufacturing system by genetic algorithms, International Journal of Advanced Intelligence Paradigms, Vol. 2, No. 4, 354-364

[6] Cus, F. & Balic, J. (2010). Combined system for off-line optimization and adaptive cutting force control, Journal of Machine Engineering, Vol. 10, No. 2, 25-35