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ADVANTAGES AND DISADVANTAGES OF METAL EDM

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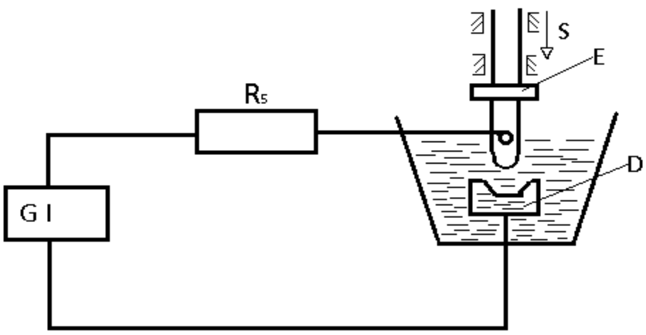
Abstract: One of the options for cleaning metals is electroerosive machining. The principle of the technology is simple. A direct current source is connected to the workpiece and the electrode, which generates short-term pulses passing through the electrodes. The electricity in the core creates an electronic arc that easily burns through the metal surface. The arc lives for a short period of time, so it does not deform the metal, does not leave marks, and maintains the integrity of the electrode.

Keywords: Pandemic, digitalization of education, innovation, highly skilled labor, economic growth

Abstract:
Keyword:
Electroerosive machining of metals is usually performed using special machines that have many advantages - high power, versatility, ease of use. But how does such metal processing take place? In what modes of operation can erosion machines operate? And what do you need to know when choosing them? These issues will be discussed in the article.
Physical and chemical foundations of electro erosion
Electrical discharge machining (EDM) is a technology that allows you to destroy the surface of metal products using electrical discharges. The phenomenon of electrical erosion is based on the destruction of electrodes under the action of an electric current passed through the electrodes. The technology was invented by Soviet engineers and scientists B. Lazarenko and N. Lazarenko in 1943.
Electroerosion technology allows you to change the size, shape of metal parts - it can be used to create holes, for grinding, for processing shaped cavities, for creating recesses, and so on. The technology is very accurate and reliable, which allows it to be used for high-precision metal processing.



Rice. 1.1 Scheme of electrical discharge machining:

GI pulse generator; R5-ballast resistance; E-electrode tool; D-processing details; S-feed of the electrode-tool.
At the physical level, the EEE looks like this:
For electrical erosion, machines are used that have approximately the same design. Their main element is the processing tool-electrode, which acts as a cutter. The second important element is the workpiece itself. The third element is a direct current source to which the electrode and the workpiece are connected.
To avoid overheating of parts, processing is carried out in a liquid medium. Dielectrics that conduct current poorly (kerosene, mineral oil) act as liquids. For convenience of work, the machine can be equipped with additional parts (rheostats, capacitors, etc.). Most modern machines are also equipped with an electronic control panel. The installation can operate in two modes - electric spark and electric pulse. In the case of the electric spark mode, the current is

supplied in such a way that the electrode acts as a minus cathode, and the part itself acts as a plus anode. During operation, the electrode generates an electric arc that ionizes the surface of the metal workpiece. The ions have a very high temperature, which leads to the melting of the metal with the formation of a small hole. In order not to melt the cathode electrode, electricity is supplied in short pulses. The duration of the electricity supply to generate 1 pulse is 0.001 seconds. During spark machining, a small amount of metal is cut off, so this technology is used for the final processing of the workpiece. In the case of an electric pulse mode of operation, the electric polarity changes. A positive current is applied to the electrode, and a negative current is applied to the workpiece. This also leads to the formation of ionized plasma, which burns through the metal with the formation of a depression. However, due to the peculiarities of the crystal lattice of metals, a more powerful flow of ions is generated, therefore, the electric pulse mode is 10–11 times more powerful than the electric spark mode. To protect the electrode from melting, the current is applied in small portions, where the duration of 1 pulse is 0.001 seconds. Due to the increased power, the electric pulse mode is used for roughing, as well as for cutting heavy-duty metal alloys.

Рис. 1.2

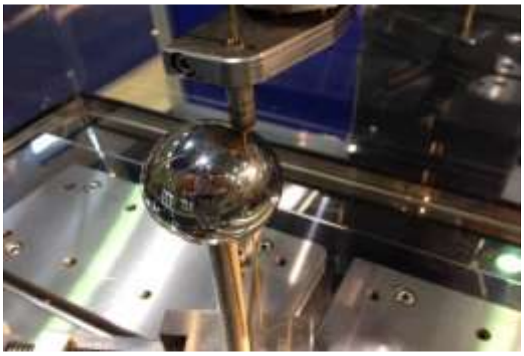


Рис. 1.3

The metal particles that are cut off by the ionic flow enter the dielectric liquid. They do not dissolve, but are in the dielectric in the form of a fine suspension. At first, the particles have a very high temperature, but upon contact with the liquid, they quickly cool down, reaching ambient temperature. After carrying out the work, it is not recommended to use the "solution" for its intended purpose, since the metal suspension can degrade the technical properties of the device being operated.

Electroerosive processing of metals

EDM is suitable for processing any metals and their alloys (cast iron, steel, brass, aluminum, and so on). The temperature of the ionized plasma is very high (more than 10 thousand degrees), which makes it possible to work with all types of metals. Plasma has a short life span, so it does not damage the metal part, and it is not too difficult to control the power of the ion beam. The technology is in demand in high-precision industries; in small-scale and home production, EDM machines are rarely used due to their high cost. In practice, EDM technology is usually used to process complex facade structures, as well as when working with heavy-duty parts for aircraft, cars, ships, and electronic devices. In the case of proper use of the equipment, microcracks and microdamage of the metal workpiece do not occur, which has a positive effect on the quality of processing. Graphite, tungsten, aluminum or brass are used to create the electrode. These materials do not break down upon contact with heated plasma and retain their shape. EDM allows you to change the shape, size, roughness of the original part.

Advantages

The technology of EEE has both advantages and disadvantages. Consider first the advantages of EEE technology:

Universality (for metals). The stream of heated plasma has a very high temperature, and it can be used to burn through any metal alloy. With the help of heated plasma, you can create a hole, cut a part, perform high-precision grinding, create a recess. This makes EDM machines versatile and easy to use.

High quality cutting. The thickness of the ionized plasma is less than 1 millimeter, so it can be used to accurately process metal parts. The heated plasma cools down quickly, so the edges of the workpiece remain smooth, strong, without melted parts. The electric arc does not evaporate the dielectric solution, so the protective liquid can be used for a long time (loss of liquid from evaporation is less than 0.1%). Ease of use. EDM machines are easy to use and do not require special care. Almost all models are equipped with an electronic panel that allows you to control the operating mode (discharge power, pulse duration, plasma delivery depth, and others). Harmful fumes and gases are not generated during operation, so the worker does not need to wear protective clothing. Several operating modes. The main modes are electrospark and electropulse. The first technique is used to cut the part, the second is used for polishing, leveling the surface. There are also auxiliary methods of processing materials - erosion-chemical technology, wire, anode-mechanical, electrocontact and others.

Flaws

Do not process dielectric materials. The electric arc, which creates a high-temperature plasma, occurs due to the contact of the electrode with the metal surface of the workpiece. If the part is made of a dielectric material (wood, concrete, plastic), then in this case the cutting arc will not occur, and the machine will be useless. High power consumption. The operation of the EDM machine requires a large amount of electricity, which increases the cost of processing. During the operation of the machine, constant parameters of the electric current (voltage, power, force) must be maintained. Therefore, many installations are equipped with protective equipment that allows you to change the parameters of the machine in the event of a power surge.

Low performance. Most models of machine tools carry out cutting at a low speed (from 0.1 to 7-8 millimeters per second, depending on the method of metal processing). Therefore, EDM machines are not suitable for factories with a high production load. High price. EEE equipment is quite expensive, which reduces its versatility and availability. Most of the machine tools are produced by foreign companies (Japan, Germany, Poland), which also negatively affects pricing. In addition, you will have to pay ancillary costs - for the purchase of a protective liquid, for the replacement of used electrodes, for the consumption of electricity and others.

Fig.1.4 Processing methods

We list the main methods of electrical discharge machining:

Creating holes. The plasma beam makes it possible to create very deep holes in the metal surface (from 20 to 40 diameters depending on the type of electrode). It is possible to increase the depth of the hole by twisting the part, moving the electrode, and using non-standard auxiliary equipment. The average drilling speed is 0.1-1 mm per second.

Cutting metal objects. Using a plasma beam, you can cut the workpiece into any number of parts. The depth of cut has practically no depth limits - the standard depth is 20-40 diameters, but it can be increased by using non-standard electrodes and rotating the workpiece. The average cutting speed is 0.1-0.5 millimeters per second.

Cutting details. With the help of EDM technology, objects of any shape can be cut. This technology is widely used to cut gemstones to create unusual jewelry. It is also used for the production of shaped cutters, dies, punches and other objects.

Grinding, alloying. EDM technology can be performed to level rough surfaces, as well as to eliminate external defects. Grinding is done by the point method using an electrode, so EDM alloying is not recommended for working with large surfaces. However, this technology can be used to work with parts of complex shape, to eliminate defects on the surface of magnetic alloys. The average grinding speed is 4-5 square millimeters per second.

The EDM technique can also be used to mark metals and create inscriptions on their surfaces. Any symbols can be used for marking - letters, numbers, special symbols. De facto, marking is the creation of non-through holes, and a code can be applied to any part of a metal part. The average performance of EEE equipment is 4-10 millimeters per second, which is a good indicator for equipment of this class.

Machine tools for electroerosion of metals

We list the main models of machine tools that are presented in Russia:

INTEGRAL 2 (AGIE). Produced by the Swiss company of the same name. Allows you to work with parts no larger than 80 x 60 x 25 centimeters. The main mode of operation is electrospark erosion in a protective medium of a dielectric liquid. It has a built-in CNC panel that allows you to control the technological features of the operation (ion flow power, processing accuracy, final roughness level).

AQ535 (SODICK). Produced by a Japanese company. Allows you to process workpieces whose dimensions are not more than 105 x 65 x 30 centimeters. EDM is performed with a cutting wire that can do all the basic operations (creating holes, marking, grinding, cutting). The model is equipped with an advanced CNC panel and has a built-in system that saves electricity, which reduces the cost of processing.

Calculation of the main time of electrical discharge machining

The main (machine) time то is one of the most important components of the piece-calculation time for processing. Knowing it is necessary when designing a new technological process and for comparing the compared options according to the cost of processing or according to another accepted criterion when choosing a technological method for manufacturing a given surface.

In the general case, the main time for electrical discharge machining is determined by dividing the allowance Vz by the volumetric productivity of the process

$т_0=V_z/П_V$ (1.4)

where VZ is the volume of the allowance removed from the workpiece, mm3.

However, the application of formula (1.6) in real conditions is difficult due to the complex dependence of the volumetric productivity of electroerosive machining on the conditions and modes of machining, the shape of the machined surface and the lack of mathematical models that establish unambiguous relationships between productivity, parameters of the manufactured part and machining conditions. In this regard, the determination of тo by theoretical calculations in the design of new technological processes or the modernization of existing ones can only be performed approximately, based on the use of the following recommendations.

If during processing the optimal ratio between the average current Iav and the processing area S is provided, then the calculation of the main time during roughing of the workpiece can be made based on the graph of the dependence of the feed rate of the electrode-tool us on the processing area (Fig. 1.5) [5]. The graph was obtained when processing steel St 45. The calculation of the main time when flashing a through hole is made using the graph according to the processing formula, min; l is the height of the stitched hole, mm; us is the feed rate of the electrode-tool, mm/min.

If the processing conditions do not match those used to obtain the graph (Fig. 1.6 in the formula

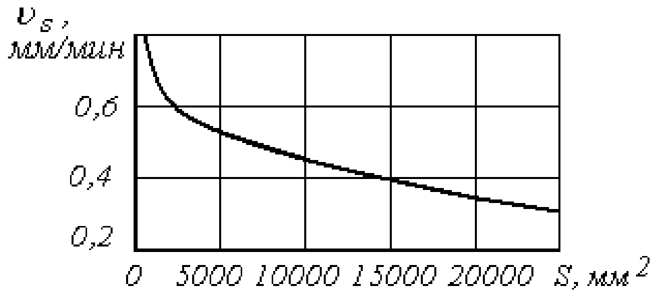
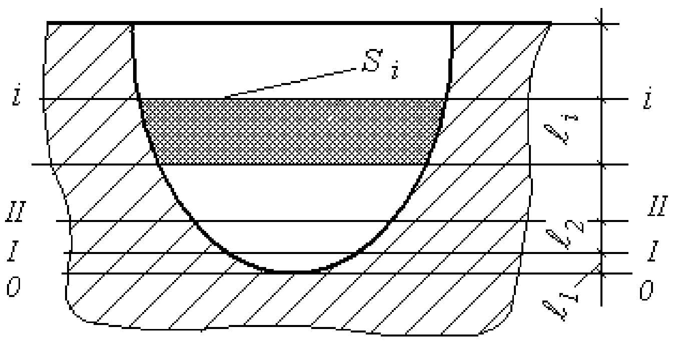


Fig. 1.6 Dependence of the speed of movement of the electrode-tool feed on the processing area

(1.4) correction factors are introduced. where тo is the main time When roughing complex shaped surfaces (see Fig. 1.5), the allowance is often removed with a change in the average value of the current strength Iav. as the tool electrode deepens into the workpiece.

Consequently, the material removal rate, and therefore the feed rate of the electrode-tool us, change during processing. The calculation of the main processing time in such cases should be carried out in stages, by determining the complexity of removing successive layers of allowance, characterized by a different working area and the processing mode used (Fig. 1.6). To do this, in the drawing, the parts are made sections perpendicular to the direction of movement of the feed and spaced from each other at distances corresponding to more or less significant changes in the areas of sections S1, S2, ..., Si, etc. Layers of material are distinguished between these sections. Further, in the calculations, it is assumed that each of the selected layers of the workpiece is removed in a constant mode, characterized by a specific optimal value of the current strength Icpi. The use of this technique for assigning the current strength makes it possible to ensure an approximate constancy of the linear material removal rate us in the direction of the feed movement Ds.

The volume of each layer and the time of its removal according to the formula тoi = li /usi are determined according to the scheme of sections of the part, the results are summed up, determining the total time of the entire roughing.



$$\tau_0 = \frac{\ell}{v_s} \quad (1.8)$$

Rice. 1. 7. Allowance layer s

$$\tau_0 = \sum_{i=0}^{n} \tau_{0i}$$

(1.10) where n is the number of sections of the part; i is the section number.

If the processing is carried out at a current strength less than the permissible value of the cross-sectional area of the surface to be treated, the feed rate is reduced as many times as the actual value of the processing area is greater than the optimal value for the accepted value of the average current strength.

When processing workpieces under conditions that differ from the modes adopted in the experimental determination of the dependences

Pv - Iav - S, Iav - f, us - S (see Fig. 1.9), the value of Iav determined by the previous methods is corrected taking into account correction factors. Further calculations are carried out on the basis of the value of Iav determined in this way.

The semi-finishing time at intermediate process steps is approximated by the total surface area to be machined. To do this, use the experimentally obtained data of Table 1.11 on the laboriousness of processing 1 cm2 of the surface when processing steel 45 with a pulse frequency fi = 400 pulses / sec.

Table 1.11
Semi-finishing time

Average current *Icp*, A	Height of irregularities *Ra*, μm	Main processing time τ_{about} the area 1 cm^2, min/cm^2
50	0,28	0,02
30	0,22	0,02
20	0,18	0,03
10	0,15	0,05
5	0,12	0,12

When finishing, the main criterion for the optimality of the process is most often taken as a given surface roughness, provided that the maximum possible productivity is ensured. In this regard, the average current strength should be reduced to the minimum possible limits. Therefore, the time for finishing is determined by the processed surface area and increases in proportion to its growth. In real production conditions, the main processing time τo is determined experimentally in the manufacture of a test part in the mode selected for the given processing conditions and equipment. When using modern CNC EDM machines, when processing workpieces on which the processing mode is set automatically and remains unknown to the technologist, the determination of the main time is possible only by an experimental method.

CONCLUSION

The technology allows cutting metals of any strength. Processing is performed by creating an ionized stream of particles that burn through the metal. Heated ions are created using an electric arc that occurs between a conductive electrode and the metal surface of the workpiece when an electric current passes between them. In order not to damage the part and not to evaporate the electrode, a protective dielectric liquid is used, and the electric current is supplied in small portions-pulses (frequency - 0.001 s).

EDM machines perform all basic operations - creating holes, cutting, marking. Electroerosive machining of metal has many advantages - high accuracy, versatility (for metals), ease of use of machine tools. However, there are also disadvantages - you can not cut plastic, concrete or wood, high electricity consumption, high cost of the machine. The use of EDM machines is recommended for the production of high-precision parts. The main machine models are AGIE INTEGRAL 2, model 4531, SODICK AQ535. Modern machines for electroerosive machining are designed to perform both mass and individual tasks of aesthetic (decoration, grinding, etc.) and practical (formation of grooves, perforation of through and blind holes, sharpening of cutting tools) nature. The cost of processing on such equipment is much lower than that of metal-cutting machine tools.

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