

CONTACT BREAKING ELECTRICAL EROSION – MODERN TECHNOLOGY OF METAL FORMING

Bucur Viorel [1], Ţîţu Mihail Aurel [2] and Făgărăşan Vasile [3]
[1] "Lucian Blaga" University of Sibiu, bucur_ani@yahoo.com
[2] "Lucian Blaga" University of Sibiu, titu.mihail@gmail.com
[3] "Lucian Blaga" University of Sibiu, vasile.fagarasan@ulbsibiu.ro

ABSTRACT: This paper is a preamble to a series of another paper “Unconventional metal forming process and methods”, as a result to the research activity of several academic staff and experts in the field. The authors would like to present synthetically certain theoretical and practical aspects which emphasize the evolution, processes, mechanisms and fields where these technologies are applied or could be applied with positive outcomes. The wide bibliography from foreign literature is the confirmation of the opportunity of approaching this field of a genuine use for the top breaches of industry from all around the world, and implicitly from our country.
KEY WORDS: contact breaking electrical erosion, nonconventional technologies, experimental research, physical mechanism of contact breaking electrical erosion.

1 INTRODUCTION

Today a series of top branches of industry (mechanical engineering, fine mechanics, aviation, ship building etc) claim the application of certain “unconventional” processes, including certain processing technologies satisfying the more increased demands requested by [10]:

- Process of multiple categories of materiel with special physical, chemical and mechanical characteristics;
- Necessity of processing the surfaces of certain materials with these characteristics.

Metal forming technologies, using unconventional processes are widely employed in the important branches of the industry (metallurgy, mechanical engineering, aeronautics, etc.) proving to be completely useful, from the point of view of costs and productivity.

Contact breaking electrical erosion is one of the modern methods that can be applied especially in the manufacturing industry, metallurgy, but also in other branches.

Countries with a wide experience and expertise in the field (U.K., U.S.A., Germany, Russia) and others, use more and more the unconventional processing having positive outcomes.

The literature in this field states the main types of erosion that are of high interest in terms of technology, according to figure 1 [11].

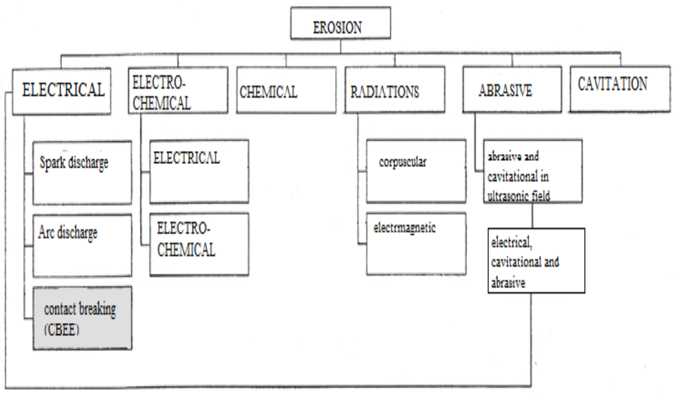

Figure 1. Main types of erosion of technological interest

2 EROSION AS A TECHNOLOGICAL METHOD

Erosion machining is a “technological method of dimensional engineering”, based on the complex erosive discontinuous and located effects of certain electrical discharge in impulse, started repeatedly between two electrodes, the first one being the erosive agent, and the second one “the erosion object”.

Observation:

In the special literature the two electrodes are well known as T.O. (transfer object or electrode) and P.O. (processed object or part).

As a technological method of processing the metallic materials, the erosion is a part of the processing methods based on the substance breaking [5].

The main types of Contact breaking electrical erosion (CBEE), interesting from the point of technology used as a final process, are defined according to the transfer object (TO):

- with steel disk;
- with steel strip.

3 CBEE BACKGROUND AND EMPLOYMENT

This process was first mentioned in the Russian technical literature (in the ’50), then being applied on an industrial level after 1957, especially for reconditioning certain parts made in manganese steel (with a high level of hardening), used in the mining or ship building industry (tracks, rotary wings, propellers etc).

Concerning its applicability field and from the point of technology of working with CBEE, the following processes worth mentioned [1]:

- Cutting off steel and bar strips with a high level of carbon (hard to be processed);
- Removing the defects on the surfaces of certain parts specific to the metallurgy;
- Sharpening certain splinting tools;
- Smoothing or ratifying certain surfaces of certain parts with a high level of hardening, etc.

In table 1 several applications of CBEE process are mentioned.

Table 1. Applications of CBEE process

No.	Process name	Shape of transfer object	Material quality
1	Burring – cleaning	Circular disk	OLC – 45 alloy steel
2	Punching	Cylinder	OLC – 45 alloy steel
3	Surface brushing	Radial brushes	OLC – 45 stainless steel
4	Cutting-off	Circular disk	Stainless steel or thermal resistant steel
		steel strip	

4 PHYSICAL MECHANISM OF CBEE MACHINING

Physical conditions necessary for dimensional process using CBEE

In order to achieve optimal results and a relevant efficiency, the main key conditions necessary to ensure the stability of the CBEE process are:

- direct introduction of electrical energy in the contact area of TO and P.O., using the specific electrical conductor materiel; Example: If steel strip is used as T.O. then the contacts are of graphite carbons;
- ensuring the optimal conditions necessary to start discharging;
- ensuring the optimal values of working space between T.O. and P.O.;
- ensuring a polarity that should lead to prevail the smallest amount of material as possible of the T.O. (being as resistant as can be to erosion);
- ensuring an optimal working space by continuously changing the positions of T.O. against P.O. that should allow an efficient evacuation of erosive products resulted.

It is important to bear in mind the fact that “the energy is transferred P.O. discontinuously as electrical impulse beams developed mechanically, within the workspace defined between T.O. – steel strip and P.O - part.

Primer process and phenomena regarding CBEE

The literature in the field mentions the fact that: “the primer CBEE processes are developed and formed in the basic workspace (at the point levels between T.O. and P.O.) between the two surfaces in interaction and the working environment [2].

Thus, between T.O and P.O. great current densities are developed creating heat with the help of Joule – Lenz effect, and reaching the melting point between the bridges (contacts) created between T.O. and P.O., according to Figure 2 [2].

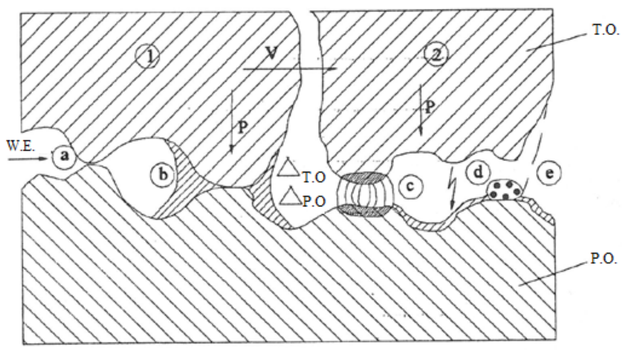

Figure 2. The structure of an elementary working space

The bridges break down, being determined by the mechanical action exercised between T.O. and P.O., contact pressure, and the existing relative speed, thus creating the conditions to develop the electro – erosion process, by triggering the non-stationary arc discharge.

The space between T.O. and P.O. is defined as being a gap characterised by 5 areas that can be highlighted in figure 2, as it follows:

- short-cut area (δsc);
- non-stationary arc discharge (δa);
- dielectric area (δdi);
- area of electrical impulse discharge (ϟ);

- area of erosive products.

Observation: During the real process of erosion development two distinctive pairs are formed $\Delta_{T.O}$ - $\Delta_{P.O}$, representing the point contacts of the micro-irregularities between the two interacting objects (regarding the transfer and parts). Thus, every distinctive pair, $\Delta_{T.O} = \Delta_{P.O}$, shall follow successively the 5 area mentioned above.

The main primer erosive processes mentioned in the literature in the field are:

- Applying the supply voltage to T.O. – P.O. contact surface

The micro-irregularities of the T.O. and P.O. surfaces lead to surface contacts, a, under the contact pressure, cp, thus leading to a high growth of current density and to the release of a large quantity of heat – Q, due to the Joules-Lenz effect.

$$Q = I^2 x R x t \text{ [J]} \quad (1)$$

This quantity of heat Q will be localised in the contact surfaces mass $\Delta_{T.O}$, $\Delta_{P.O.}$, fact that will determine the surfaces to heat until they reach the melting point.

At the same time, the existence of cooling environment can cause an oxide layer to appear, b, as an effect of the interaction between the heated metal (until it reached the melting point) and the elements of dissociation from the cooling environment used.

- Non-stationary electrical arc discharge

At the level of contact bridges breaking, c, the development of non-stationary electrical arc discharge leads to the appearance of thermal phenomena, by rising the temperature, fact that will lead to the melt (and even evaporation) of larger or smaller micro-volumes of materials from $\Delta_{T.O}$ and $\Delta_{P.O.}$

By continuing the process with the 5 specific stages (a÷e), this will lead to material sampling, creation of new contact bridges, as well as to developing new chemical processes of element dissociation from the cooling environment. It takes place the removal of erosive products, d, where the relative movement between the steel part and steel strip or steel disk has an important role.

5 CBEE PRINCIPLE WITH T.O. - STEEL STRIP

5.1 The basic scheme of CBEE principle, with T.O. – steel strip

Figure 3 shows that the two objects (T.O. and P.O.) are in contact through micro-irregularities of surfaces, being connected to a power unit (PU) of (continuous or alternative) current, the inherent process being wet (or aired) in order to locate the effect energy (to cool the T.O. and P.O.) and as well as for activating the eroded particles evacuation in the working environment (W_E) [2], [13].

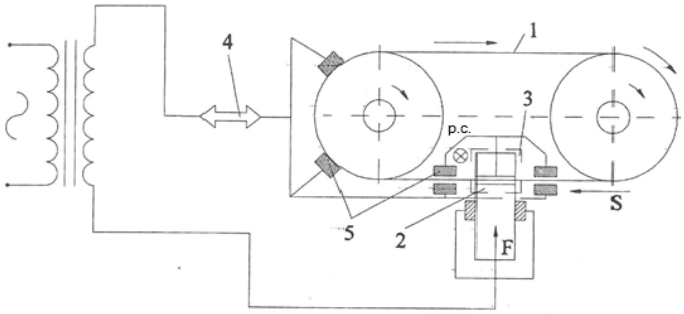

Figure 3. The basic scheme of CBEE principle, with T.O. – steel strip

1 - steel strip (T.O.);

2 - processed object (P.O.);

3 - working or cooling environment (W.E);

4 - power unit

5 - ac/dc receivers

F - pressure force;

cp. – contact pressure;

S - T.O. forward motion

The impulse development is mechanical, using T.O. – steel strip that executes translation motions against the P.O. and moves tangentially on its surface.

Applying the press force F., the contact pressure is ensured and the feed motion S can be executed both by T.O. and P.O.

Evacuating the erosion products from the working space and re-establishing the disruptive conditions assure the microscopic continuity/flow of working process between the part (P.O.) and steel strip (O.T).

5.2 Fields where CBEE can be applied (with T.O. - steel strip or steel disk)

Here under are some technological operations within the industrial branches specific to mechanical engineering or metallurgy, where the BCEE process can be employed:

- cutting certain markers or semi/products of hard steel;
- cropping certain casted components;
- processing certain surfaces (plane, cylindrical, frontal etc);
- smoothing or ratifying certain processed surfaces.

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