

DEVICE FOR THREADING BY ELECTRTICAL DISCHARGE

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ABSTRACT: There are situations when for distinct reasons, a process of threading by electrical discharge machining has to be applied. In order to materialize an electrical discharge threading process, an analysis of the information available in the specialty literature and in industrial practice was developed. The analysis revealed the possibility to design a device for electrical discharge threading adapted on a ram electrical discharge machine. On this base, a device including a ball screw and a gear mechanism was designed. The device transforms the rectilinear work motion of the machine tool head into a rotation motion and a rectilinear feed of the tool electrode.
KEYWORDS: electrical discharge threading, ram electrical discharge machine, device, electrical discharge machining process, machining scheme

1. INTRODUCTION

The nonconventional machining technologies could be considered as technologies in which the material removal from workpiece is based on phenomena distinct in comparison with the phenomena specific to the so-called *classical machining technologies*; in the case of the nonconventional machining technologies, the removal of material from workpiece develops as a consequence of a supplementary energy transfer or this energy transfer contributes to a better development of a process specific to a classical machining process. One must mention that in the case of the classical machining process, one supposes that the material plastic deformation is the main phenomenon able to generate the material removal from workpiece.

Generally speaking, the nonconventional machining technologies are applied when there is not a possibility to use a classical machining process or the use of such a process is appreciated as being of low efficiency. Such situations are specific to the very hard material (when the classical cutting tools are affected by significant wears or really the classical cutting tools could not be used) or when the surface to be machined is very complex (when the classical cutting tools cold not access or they could not be used in order to obtain surfaces in accordance with the quality request).

If the main phenomena found at the base of nonconventional machining technologies are taken into consideration, the following groups of nonconventional machining methods could be highlighted:

a) Machining methods which use electrical discharges;

b) Electrochemical machining methods;

c) Chemical machining methods;

d) Ultrasonic machining methods;

e) Machining methods which use plasma beam, ion beam, laser beam, electron beam;

f) Hybrid machining methods, when a combination of a nonconventional machining process and another classical or nonconventional machining process is applied.

The machining methods included *in the group of electrical discharge machining methods* are based on the material removal from workpiece as a result of electrical discharges developed between the closest asperities placed on the active surfaces of tool electrode and workpiece, when a dielectric liquid is circulated in the work gap existing between workpiece and tool electrode [2, 4, 13]. Essentially, the electrical discharge machining methods could use the so-called massive tool electrode (this is the case of *ram electrical discharge machining*) or the wire tool electrode (whose use led to the development of *wire electrical discharge machining methods*).

In the case of ram electrical discharge machining processes, the surface to be obtained is gradually generated as a consequence of some relative motions developed between tool electrode and workpiece. In a certain extent, some elements specific to the active surfaces of tool electrode could be copied into machined surface.

A way of obtaining threaded surfaces is really based on a process of ram electrical discharge machining. One accepts that a threaded surface could be gradually generated by the motion of a certain flat profile (triangular, shape or arc of circle, rectangular, trapezoidal etc.) along a spiral trajectory found on a revolution surface.

There are various ways of classifying the threaded surfaces; if the shape of the flat profile moved along the spiral trajectory is taken into consideration, one can identify metric threads, Whitworth threads, threads generated by means of an arc of circle, trapeze, saw tooth etc.

As main machining techniques able to be used in order to obtain threaded surfaces, one can mention the threading by plastic deformation, by classical cutting methods (turning, milling, grinding) and by using nonconventional machining methods. One of these nonconventional machining methods is just the electrical discharge machining method.

In accordance with the above mentioned arguments, the electrical discharge threading could be applied when the workpiece material is characterized by a high hardness and when the classical machining methods could not be used in order to obtain threaded surfaces.

As less convenient aspects specific to the electrical discharge threading, one can mention the necessity to use devices adapted on the ram or wire electrical discharge machines; generally, the electrical discharge machines are expensive and the devices for threading are not offered with the machining equipment and this means that the device must be designed and materialized.

One must mention that actually there are computer numerical controlled electrical discharge machines which could be used when a threaded surface has to be obtained by electrical discharge machining, but such a machining equipment is much more expensive than the electrical discharge machine which has not subsystems for computer numerical control.

Over the years, the researchers were preoccupied to find efficient solutions of devices adapted on the ram electrical discharge machines and able to ensure the obtaining of threaded surfaces [6].

Thus, Coldwell et al. showed that the tapping is a difficult machining process. They developed an experimental research concerning the drilling and taping of test pieces made of AISI D2 and H13 steels, inclusively by considering a water-based electrical discharge machining instead of using conventional soluble oil cutting fluid, in order to develop a hybrid machining process on one machine tool [3].

Uliuliuc et al. developed an analysis of possibilities of obtaining cylindrical threaded surfaces in workpieces made of hard materials [15]. They proposed a device able to generate a rotation motion of the electrode tool in correlation to the usual work motion achieved by the machine tool head. Essentially, when the work head moves vertically, a gear rolls on a rack placed on the machine tool table, the rotation motion of the gear being transmitted to the tool electrode holder.

Practical details concerning the tapping methods by electrical discharge machining were offered by Kern [10]. He showed that a device for EDM tapping could be attached to the ram electrical discharge machine. An undersized threaded tool electrode is used in order to obtain threaded holes. Kern mentioned that there are four methods able to be used in order to obtain threaded surfaces: hand servo lead nut tapping, machine servo lead nut tapping, CNC Z-A axis helical interpolation tapping and orbit tapping. A problem that must be solved is the calculation of the overcut allowance.

Possibilities of electrical discharge threading are mentioned in the case of CNC electrical discharge machines [1, 8, 12, 14].

Problems of design and achieving tool electrodes for tapping were investigated [5, 7, 11]. Taking into consideration the high resistance of carbon to material removal by electrical discharges, the idea of using graphite tool electrode for tapping was taken into consideration [9].

Within this paper a solution for a device adapted on a ram electrical discharge machine and able to facilitate obtaining threading surfaces is presented.

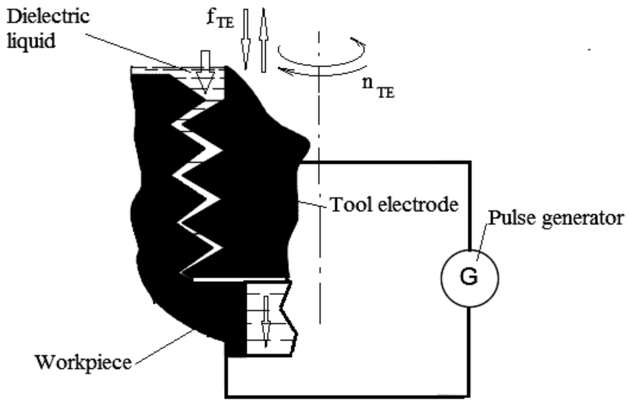

Figure 1. Machining scheme valid in the case of electrical discharge threading

2. CONDITIONS FOR OBTAINING THREADING SURFACES BY ELECTRICAL DISCHARGE MACHINING

The process developed during the electrical discharge machining supposes the material removal from workpiece as a result of initiating and developing electrical discharges between the closest asperities existing on the active surface of tool electrode and on the surface to be machined of the workpiece.

A general machining scheme valid in the case of the electrical discharge threading has to include (fig. 1) a linear rectilinear motion f_{TE} by which the distance between the workpiece and tool electrode diminishes up to the moment when electrical discharges appear. In order to ensure the conditions for generation the threaded surface, a rotation motion n_{TE} is also necessary; among the speeds of the rotation and rectilinear motions, a certain correlation must exist, so that a rotation is possible when the distance achieved by rectilinear motion corresponds to the pitch *p*, which is an essential characteristic of the threaded surface.

Within a ram electrical discharge machine, a rectilinear motion is achieved by the machine tool work head; in such a situation, the rotation motion could be achieved also by the tool electrode (clamped on the machine tool work head) or by the workpiece) clamped in a vice placed on the machine tool table). Other machining schemes corresponding to the electrical discharge threading on a ram electrical discharge machine could involve the materialization of the both motions by the workpiece, which could be placed, at its turn, on the machine tool work head or on the machine tool table.

If the electrical discharge machining process is analysed in detail (fig. 2), one can notice that initially, between the closest asperities, an electric field is generated. When the distance between asperities is lower than a certain value *s*, the electrical resistance of the dielectric liquid found in the work gap could be pierced and an electrical discharge develops. In the zones where the plasma column corresponding to the electrical discharge takes contact with the tool electrode material and workpiece material, a high quantity of heat appears. Such a phenomenon determines the increase of temperature up to values when the electroconductive

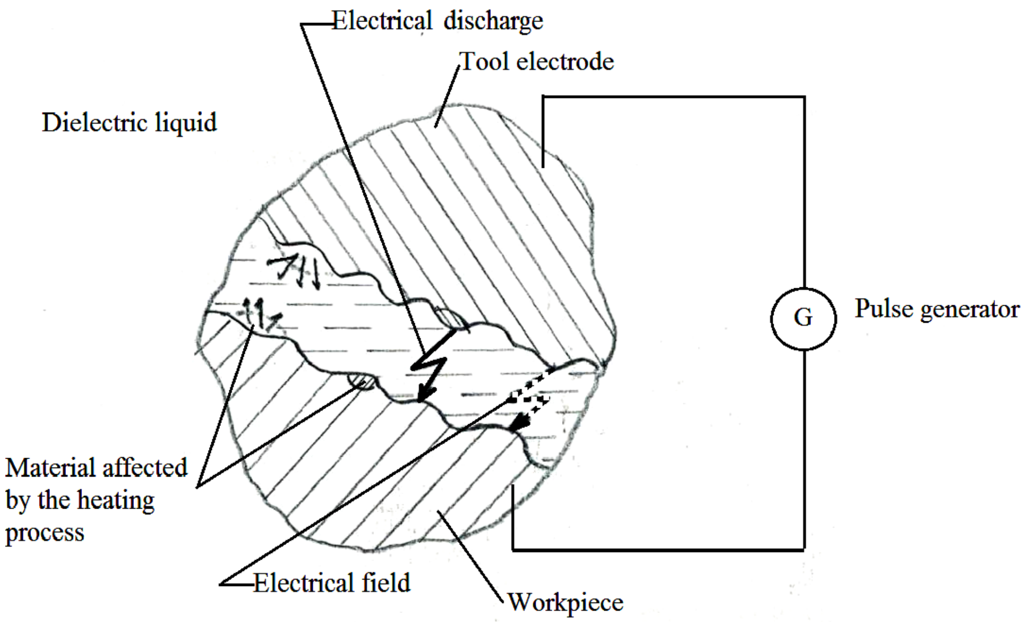

Figure 2. Phenomena in the work gap at electrical discharge threading

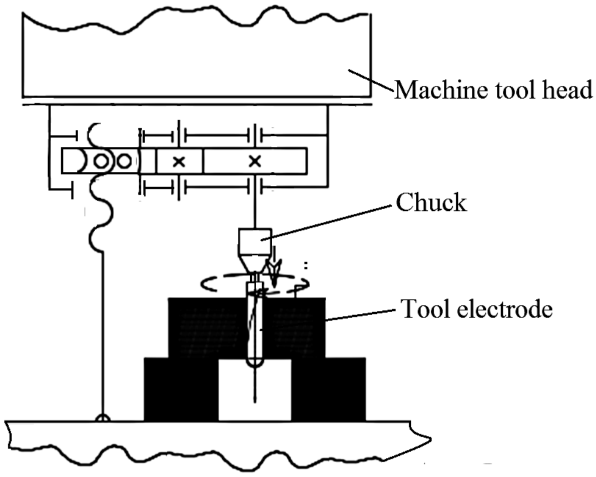

Figure 3. Principle scheme of the device for electrical discharge threading

metallic materials are melted and even vaporized. The rapid evolution of the melting and vaporizing could generate an explosive effect, which could throw small quantities of electrodes material in the dielectric liquid. Usually, the tool electrode material is selected so that the thermal phenomena developed in the electrodes surface layers determine a higher removal from workpiece material and one more reduced from the tool electrode. In this way, one could obtain a higher productivity of the machining process and, on the other hand, a tool electrode diminished wear.

One considers that in order to generate the electrical discharges, the distance s between the closest asperities existing on the surfaces of tool electrode and workpiece must be in accordance with the equation:

$$s \leq \frac{U}{E}, \qquad (1)$$

where U is the voltage applied to the two electrodes and E is the electric rigidity of the medium found in the work gap.

As above mentioned, distinct machining schemes could be applied in order to materialize an electrical discharge threading process on a ram electrical discharge machine. A simplified machining scheme was considered that presented in figure 1.

3. PROPOSED SOLUTION FOR ELECTRICAL DISCHARGE THREADING OF EXTERNAL SURFACES

The problem of identifying and applying an electrical discharge threading process appeared in a big industrial enterprise from Iaşi (Romania), when a threaded hole had to be made in a workpiece made of hard material.

The analysis of distinct solutions that could be applied in order to solve this problem highlighted the possibility to materialize an electrical discharge threading process on a ram electrical discharge machine.

One noticed that there was a ram electrical discharge machine on which a device able to generate an electrical discharge threading process could be adapted.

Taking into consideration the characteristics of this ram electrical discharge machining, the scheme presented in figure 3 was elaborated.

As one can see, a rigid threaded rod was put in connection with the machine tool table. When the machine tool head achieves the vertical work motion to the workpiece, a ball nut included in the device and moved along the threaded zone of the rigid threaded rod is obliged to achieve a rotation motion, together with the gear to which the nut is attached. The rotation motion of the gear, is subsequently transmitted to a shaft, by means of a group of changeable gears.

On the shaft corresponding to the last gear, a chuck is mounted; this chuck holds the threading tool. In the case of such a machining scheme, the threading tool, as tool electrode, achieves both the rotation motion and the feed motion found in correlation with the rotation motion, so that finally, a thread with the desired pitch can be obtained.

The proposed solution was designed and materialized, so that the practical problem was solved.

4. CONCLUSIONS

When the workpiece material is characterized by a high hardness or the surface to be obtained is too complex to be machined by classical machining methods, the so-called nonconventional machining technologies could be applied. In this way, the problem of obtaining threaded surfaces in workpieces made of electroconductive hard materials was formulated. Taking into consideration the characteristics of electrical discharge machining process and of the available ram electrical discharge machine, a principle solution based on the use of gears was identified. The machining scheme supposes the contact of a rod attached to device for electrical discharge threading with the machine tool table, as a consequence of the vertical work motion achieved by the machine tool work head. Due to a threaded zone of this rod, a nut has the possibility to be rotated in a mechanism existing in the device placed on the machine tool work head. The rotation of the nut is transmitted by means of gears to a tool electrode whose constructive solution is similar to those corresponding to a classical threading tap, but presenting some differences, in order to be adapted to the electrical discharge machining process. In this way, the tool electrode achieves a rotation motion in correlation with the work motion achieved by the machine tool work head and a thread could be gradually generated in the hole existing in the workpiece placed on the machine tool table. In the future, there is the intention to improve the constructive solution of the device, by identifying a possibility to compensate the influence of the clearance existing between the components of transmitting the rotation motion.

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