ELECTRICAL DISCHARGE MACHINING OF THE CURVILINEAR AXIS HOLES

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Abstract: Curvilinear axis holes can be obtained both by classical and nontraditional machining methods. In the case of electrical discharge machines, a specialized work device could be used to ensure a circular motion of the electrode tool, so that finally a circular axis hole is obtained. Some considerations concerning the requirements specific to such a device are presented in the paper. Among several mechanisms able to change the rectilinear work motion of the machine tool work head into a circular one, the crank – connecting rod mechanism was preferred.

Keywords: electrical discharge machining, curvilinear axis hole, device

1. INTRODUCTION

Within the machine building, there are situations when curvilinear axis holes must be obtained. Generally, these holes could be classified by taking into consideration their cross sections and axis shapes, respectively. If the cross section is analyzed, one can notice that there are holes with circular cross sections and with different other profiles of the cross sections (circular, rectangular, square, ellipse etc.). If the shape of the hole axis is examined, essentially two types of holes could be met: holes with rectilinear axis and holes with curvilinear axis; a hole could present a curvilinear axis in plane or in space. If the holes with rectilinear axis and circular cross section or other cross sections could be relatively easy obtained by the so-called classical machining methods (drilling, broaching etc.), the holes with curvilinear axis could be difficulty achieved by the classical machining methods [4]. In such a case, a flexible shaft could be rotated, to ensure the feed of the cutting tool along a small zone of the hole to be obtained; the tool motion must be adequately guided along the axis of the curvilinear hole.

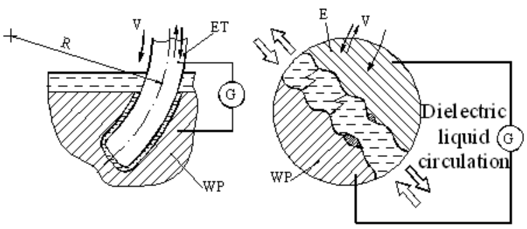
To improve the possibilities to obtain holes with curvilinear axis, various non-traditional machining methods were investigated. For example, such holes should be obtained by electrical discharge machining, by electrochemical machining and by ultrasonic machining.

The modern ram electrical discharge machines are endowed with numerical control subsystems; in such a case, holes with curvilinear axis could be relatively easy obtained if there is a controlled circular motion. In the case of the older ram electrical discharge machines, there is only a rectilinear work motion of the machine work head; to obtain holes with circular axis, a specialized device is necessary, to change the rectilinear motion into a circular motion. Obviously, if a more complex curvilinear axis hole is necessary, it is possible to use both the rectilinear work motion of the machine work head and a supplementary circular motion obtained by means of a specialized device.

The specialty literature highlighted some technological solutions to obtain holes wit curvilinear axis by electrochemical machining and respectively by electrical discharge machining [2, 3, 5].

In Romania, some ways to obtain holes with curvilinear axis were investigated by M. Miulescu, within her doctoral research [3]. She investigated more detailed a device based on a crank – connecting rod mechanism, to obtain with curvilinear axis holes by electrical discharge machining.

T. Ishida described [2] a more complex device, able to ensure the conditions of machining holes with curvilinear axis and of large diameters by electrical discharge machining. Cables acted adequately facilitate ensure the motion of the electrode tool along the axis of the hole to be obtained by machining.



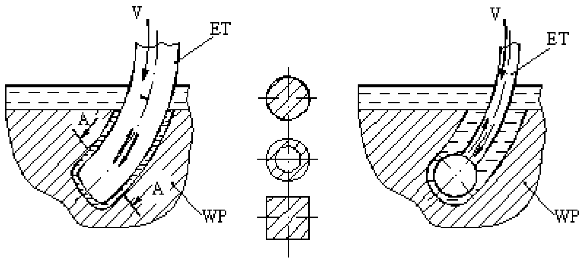
a b

Fig.1. Electrical discharge machining of curvilinear axis hole (a – work principle; b – detail from the work zone)

The electrical discharge machining of the electroconductive materials is based on the development of electrical discharges between the closest asperities existing on the surfaces of the electrode tool and the workpiece (fig. 1). Because the electrical discharge machining is characterized by a low material removal rate and a relatively high cost, it is applied either to obtain complex surfaces in electroconductive materials or to achieve surfaces in workpieces made of materials having a low machinability by the so-called classical machining methods. Nowadays, the electrical discharge machining allows to obtains surfaces in pieces used in aeronautics, textile industry, car manufacturing industry, manufacturing stamps etc.; holes with curvilinear axis achieved sometimes by electrical discharge machining could be met, for example, in the case of the turbo blades etc.

2. REQUIREMENTS FOR A DEVICE FOR ELECTRICAL DISCHARGE MACHINING OF THE HOLES WITH CIRCULAR AXIS

As above mentioned, the material removal from the workpiece during the electrical discharge machining is essentially the result of the electrical discharges developed between the closest asperities existing on the electrode tool *ET* and workpiece *WP* surfaces . Due to the high temperatures generated by the electrical discharges, small parts of the asperities volumes are melted and vaporized and the circulation of the dielectric liquid contributes to the removing from the work gap of the particles detached from the workpiece. But the electrical discharges act also on the electrode tool material, determining a certain material removal from the electrode *ET*; thus, a wear phenomenon develops. In accordance with the so-called Palatnik criterion [1], the material of the electrode tool should be characterized by high values of the heat capacity, of the density, of the thermal conductivity and of the melting temperature.



a b c

Fig.2. Shape of the electrode tool active part; a – ring shape; b – cross sections through the electrode tool; c – spherical shape

A curvilinear hole could be obtained by moving a profile corresponding to the hole cross section (fig. 2, *b*) along the curvilinear axis. In the case of the circular cross section, an electrode tool having a partial ring shape could be used. If the wear phenomenon is very low, a spherical shape of electrode tool active part could be used (fig. 2, *c*), but practically there are not materials which could not be affected by the thermal effects of the electrical discharges.

It is known that the electrical discharge machining process needs the circulation of the dielectric liquid in the space between the electrode tool and the workpiece (work gap) to remove the particles of material detached from the electrode tool and the workpiece by the electrical discharges.

Generally, the ensuring of the dielectric liquid circulation is not a simple problem. Frequently, the electrical discharge machining develops by immersing the electrode tool and the workpiece in the dielectric liquid; periodical alternative motion of the electrode tool ensures conditions for the dielectric liquid access in the work gap.

Other requirement specific to the curvilinear axis holes refers to the clamping of the electrode tool; the device used to obtain circular axis hole should ensure the possibility to fix electrodes with curvilinear shape axis and eventually having various radii.

3. POSSIBILITIES TO OBTAIN A WORK MOTION ALONG A CURVILINEAR AXIS

In order to ensure the electrode tool motion along a curvilinear trajectory, a specialized device could be necessary. To transform this rectilinear motion of the machine work head into a circular motion *v*, various mechanisms could be used (screw-nut, crank – connecting rod, gear rack, oscillating crank lever etc.

A more detailed analysis could show which from the various mechanisms could be more convenient.

Thus, initially, a mechanism wheel – rack was proposed to change the rectilinear motion of the machine work head into a circular motion of the electrode tool. The rack could be fixed on the machine work head and the wheel could be placed on the same shaft which supports also the electrode tool. The shaft has to be supported by a bearing found on the machine tool work table. As above mentioned, the electrode tool must have a periodical alternative motion with a small amplitude, to facilitate the access and the removal of the dielectric liquid from the work gap; one can consider that the high clearances specific to the wheel rack mechanisms could generate difficulties in the adequate functioning of the device for obtaining the motion of the electrode tool along the circular axis.

For this reason, a second solution, based on a crank – connecting rod was takenk into consideration (fig. 3). The crank could be articulated to the machine work head, while the connecting rod could be fixed on the shaft whose rotation ensures the rotation motion of the electrode tool. As in the case of the wheel – rack mechanism, the bearings of the shaft could be placed in a support clamped the machine tool table. A supplementary device should be used to position and to fix the workpiece.

Even it is very familiar, the screw-nut mechanism was not considered, due to its high clearances, which could determine a lent change of the directions at the ends of the rectilinear motions.

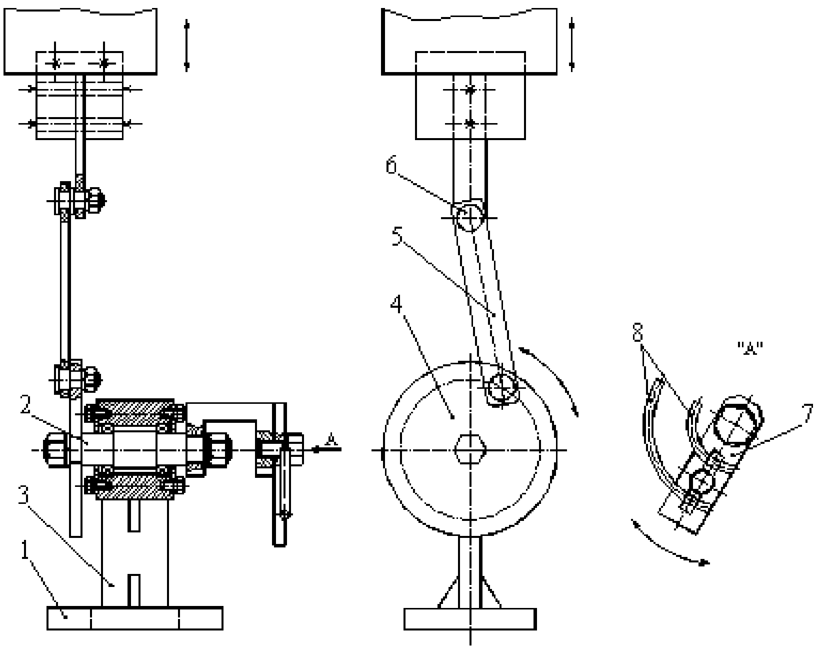


Fig.3. Solution to obtain circular axis holes by electrical discharge machining

4. GENERAL SOLUTION OF DEVICE FOR OBTAINING CIRCULAR AXIS HOLES BY ELECTRICAL DISCHARGE MACHINING

The above mentioned considerations were used to design a device which could be used to obtain circular axis holes on an electrical discharge machining existing in the laboratory for non conventional technologies from the “Gheorghe Asachi” Technical University of Iaşi, Romania. Taking into consideration the frequency of the rectilinear - alternative motions of the work head, the solution based on the mechanism crank – connecting rod was preferred.

The device includes a base plate *1* which could be placed on the machine table; a shaft *2* can be rotated in bearings existing in a piece *3* fixed on the base plate. The shaft *2* is acted by the mechanism crank *4* – connecting rod *5*; the last part (connecting rod *5*) is articulated at the other end to a shaft *6*, which could be rotated in a bearing clamped on the work head of the ram electrical discharge machine.

The shaft *2* is endowed at the other hand with a plate *7* destined to be used for clamping the circular electrode tool *8*. One has to mention that the electrode tool *8* could have a circular shape in accordance with the radius *R* of the curvature corresponding to the hole to be obtained. In the same time, the electrode tool holder should ensure possibilities to clamp electrode tools having different curvature radii

5. CONCLUSIONS

In the industrial practice, there are situations when curvilinear axis holes has to be machined. Such holes could be obtained by using both classical machining methods and non-conventional machining methods. The researches developed in this direction up to now have highlighted the possibilities to use devices adapted on ram electrical discharge machines, so that circular axis holes could be obtained. Since the work head of the majority of the machine tools can achieve only a rectilinear motion, various mechanisms able to transform the rectilinear motion in a circular motion were analyzed. In the laboratory of non conventional technologies from the “Gheorghe Asachi” Technical University of Iaşi – Romania, a solution including a mechanism crank – connecting rod was preferred. In the future, there is the intention to build and experiment such a device to obtain circular axis holes.

REFERENCES

[1] ARTAMONOV, B.A. et al. Dimensional electrical machining of metals. Handbook (in Russian). Moskva: Vysshaia shkola, 1978

[2] ISHIDA, T., MIYAKE, Y., KOJI TERAMOTO, K., TAKEUCHI, Y. Development of an electrode motion control device for curved hole electrical discharge machining. International Journal of automation technology, Vol. 2, No. 6, 2008, pp. 447-455

[3] MIULESCU, M. Studies and researches concerning the machining by electrical discharge machining. Doctoral thesis (in Romanian). “Lucian Blaga” University of Sibiu, 2009

[4] SAUER, L. Tools for machining the holes (in Romanian). Bucureşti: Editura Technică, 1966

[5] TOHRU, I. Creation of long curved hole by means of electrical discharge machining using an in-pipe movable mechanism. Journal of Materials Processing Technology, Vol. 149, No. 1-3, 2004, pp. 157-1