Middle-East Journal of Scientific Research 19 (8): 1096-1098, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.19.8.21041

Wire Electrical Discharge Machining of Items After Plasmatic Surface Hardening

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Abstract: Within the framework of this work the study of a hardened surface layer of an item after wire electrical discharge machining was performed. Experimental studies were carried out on steel specimens of 40H13 mark. During the study metallographic and durometric analysis of a treated surface was performed. The changes of a structure formed on hardened surfaces after electrical discharge machining were identified during the work. Results of micro-hardness of a surface layer after electrical discharge machining were presented.

Key words: Plasma hardening · Electrical discharge machining · Structure · Hardness · Surface layer

INTRODUCTION

The priority aim of modern engineering is constant improvement of quality and reliability parameters of manufactured products. Occurred competition forces companies to create high-tech products, superior to existing analogues by their specifications [1].

As was noted in work [2], requirements to a surface layer differ from the requirements to an item as a whole. An item surface hardening, increased hardness and wear resistance can be obtained not only by means of welding and thermo-chemical treatment, but also by surface heat treatment.

Surface hardening processes require a usage of concentrated source of heating with heat flow density on the material surface of 10^3 – 10^6 W/cm^2. Electronic and laser beams, as well as plasma arc have such characteristics. However, the usage of laser and electronic beams is constrained by high costs and low mobility of equipment, as well as by low-productivity of the process itself. Therefore, the usage of plasma arcs (due to such advantages as high heating efficiency, the ability to control the rate of input energy of a compressed arc) is justified both economically and in terms of technologies [3].

Further processing of hardened surface layer is an actual task for engineering. When treating a hardened surface, first of all it is necessary to provide a minimum temperature heating of an item being treated. Excessive heating can reduce the obtained physical and mechanical characteristics of a hardened surface layer, which is not acceptable.

One of the most common methods of hardened surfaces treatments is wire electrical discharge machining (WEDM).

Processes accompanying the WEDM are determined by the physics of the interaction of a material with concentrated energy flow initiated by a spark or pulsed arc discharge. The discharge is regulated by voltages applied to the electrodes, by the time of an impulse formation, by the condition of working fluid and by the size of an inter-electrode gap.

An integral link of these processes is the formation of secondary structures on working surfaces of treated items and electrode tools. It is due to the fact that a surface layer of treated workpiece material is subjected to intensive thermal impacts [4].

In works [4-10] it was established that after WEDM the properties of a surface layer had been changed. At the moment the influence of WEDM on changes of a surface layer of items after plasma surface hardening is not fully defined yet.

The aim of the work is to study the changes of the structure of a surface layer of a hardened item after wire electrical discharge machining.

MATERIALS AND METHODS

Workpieces of martensitic steel of 40Cr13 grade with and without reinforced surface layer were used as

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Table 1: Mode of EDM machining (T_{on} - time of pulses turning on, T_{off} - time of pulses turning off, I - average current, U – average voltage, W - wire feeding)

T_{on} (micro-second)	T_{off} (micro-second)	I (A)	U (V)	W (m/min)
60	21	1.5	50	3

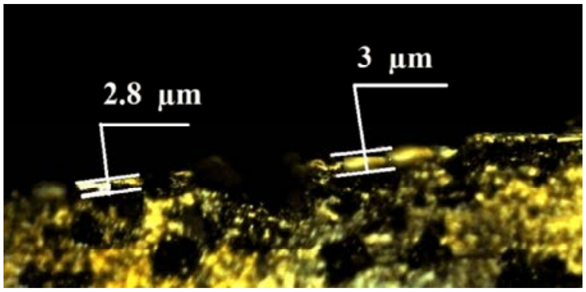

Fig. 1: Structure of a surface layer after WEDM (x 500)

experimental samples. The hardness of a hardened layer is 49 - 54 HRC, the depth of a hardened layer is 4 mm, the hardness at a depth of 4 mm is not less than 42 HRC, while maintaining the original properties in the core of an item. The hardness of steel in its initial state is 15 - 20 HRC [2].

Experiments were carried out on EcoCut wire EDM machine. A brass wire of BercoCut grade of diameter of 0.25 mm was used as a tool electrode.

Clean distilled water was used as working fluid (WF).

The processing mode is presented in Table 1.

The surface layer formed by an electrical discharge machining process was studied by metallographic analysis. Metallographic analysis was performed using Olympus GX 51 light microscope (500-time magnification).

Durometric analysis was performed using DuraScan 70 micro-hardness meter by the method of reconstructed footprint (by pressing a tetrahedral diamond pyramid with a square base at a load of 25 g with increments of 35 microns).

Main Part: During the pilot study straight cuts for modes shown in Table 1 were performed on samples. During the cutting equally stable sparks were observed on both samples. Cutting rate for both samples was 1.1 mm/min.

Metallographic analysis showed that a white layer is observed on surfaces of treated workpieces (Fig. 1). According to [4] the white layer is alloys of an item material components and a material of a tool electrode, as well as materials of working fluid, carbides and oxides formed on the machined surface of a workpiece. It was established [4-7] that the presence of the white layer is not desirable on a workpiece surface, as it may reduce the performance of an item.

Metallographic study revealed that the size of the white layer formed on the surfaces of both workpieces does not exceed 3 microns. The analysis of machined surfaces showed that the white layer does not uniformly cover the treated surfaces and has an uneven, discontinuous structure. A white layer is not observed on the most area of the surfaces being treated. It was established that for the tested workpieces the white layer depth and the nature of its distribution on treated surfaces are the same.

When conducting the durometric analysis of treated workpieces surfaces, the method of a reconstructed print was used. An indention from the edge of a sample exceeded the depth of the white layer and was 30 microns.

According to the results of the experiment, the changes of micro-hardness of samples surface treated by WEDM were not identified. Thus we can assume that the area of heat influence at wire electrical discharge machining of 40Cr13 steel workpieces is absent and the heating does not exceed the level of the mean tempering (450°C).

CONCLUSION

The analysis of experimental data shows that the process of electrical discharge machining of 40Cr13 steel does not depend on the hardness of a surface layer of a processed material.

According to metallographic analysis the depth of a white layer does not depend on the hardness of a processed workpiece and does not exceed 3 microns. Within the framework of this work it was established that the resulting structural changes of a surface layer after WEDM are insignificant and do not affect the performance of the items being treated.

Findings: During the study it was established that wire cutting out electro-discharge machining, within an investigated range of cutting modes, does not affect the structural changes of a surface layer of workpieces. This treatment can be applied to workpieces of 40Cr13 steel with a hardened surface layer.

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