COMPARATIVE STUDY ON THE EFFICIENCY OF THE SURFACE HEAT TREATMENT WITH CONCENTRATED ENERGY SOURCES

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Abstract: *The concentrated energy sources taken into study were that of the laser and the electron beam, which was applied to surfaces with substrates of improved steel. The layers thus obtained were subject to tests of hardness, microstructure, wear resistance. As a result of experimental attempts and final tests, it has been found that for the small parts it is also possible to consider these processes to replace the deposition of harder layers, more expensive. Superficial hardening with laser and electron beam can be technically and economically efficient with appreciable practical results and high productivity. Using laser in this purpose has proven to be more efficient than the electron beam. And in the case of superficial hardening with concentrated energy sources, alloyed steels give superior results to carbon.*

Keywords: *superficial hardening, laser, electron beam*

1. INTRODUCTION

1.1.Laser surface treatment

The laser generator produces a laser beam that focuses on heating surfaces [2]. Depending on the physical properties of the surfaces to be treated and the characteristics of the laser beam, it is possible to achieve the surface treatment in two ways [3,6]:

- by solid phase transformations;
- by liquid phase transformations (vitrification) when the power densities are greater than 12…13 Kw / cm^2 .

For both cases it is not necessary to use external cooling, the heat dissipating quickly in the mass of the piece and respectively in the surrounding environment [4,7]. The laser heating cycle has a sharp form, with a sharp slope for both heating and cooling [8].

1.2. Electron beam surface treatment

The electron as the elementary particle is also characterized by the fact that it holds the mass. If it prints a speed, it also shows energy. If an electron beam is oriented towards a metal surface, the kinetic energy turns into thermal energy, heating the material to be processed [1].

The electron beam produced by a specific installation (the main subassembly being the electron gun) is focused on the piece to be treated . Both the piece and the electron beam space transit are situated in a vacuum space.

And when using the electron beam, the hardening of the surface can be done with and without the melting of the target as follows:

- With power densities of 10^3 .. 10^4 w / cm^2 and action duration of 1 ... 3 seconds, the heating of the material takes place in the solid state domain [5];

-With power densities of 10^6 .. 10^7 w / cm^2 and action duration of 10^{-2} ... 10^{-1} seconds, after the electron beam heat treatment, the metal is melting, followed by a extremely rapid cooling along with durification.

2. EXPERIMENTAL ATTEMPTS

Experimental attempts were aimed at determining the comparative of superficial treatments efficiency using two concentrated energy sources (heating with laser and electron beam). The tests were performed on two types of improvement steels, the chemical composition of which is shown in Table 1.

Table1. Chemical composition

No.	Mark of steel	Chemical composition in %							
		C	Cr	Ni	Mo	Si	Mn	S	P
1	OLC45	0,467	0,165	0,141	0,035	0,240	0,650	0,019	0,017
2	41Cr4	0,444	1,00	0,029	0,022	0,207	0,740	0,011	0,077

The specimens necessary for carrying out volumical and superficial thermal treatments, specimens corresponding to the hardness tests, microhardness, metallographic structures, wear resistance, were made from these steels. Initially, the samples were subjected to the thermal improvement treatment, as shown in Table 2.

Table 2. Volumical heat treatment

No.	Mark of steel	Nitrural hardness	Hardening			Annealing		
			Temperature [^{0}C]	Cooling medium	Hardness [HRC]	Temperature [°C]	Time [h]	Hardness [HRC]
1	OLC45	23,5	850	water	60,5	550	1	33,8
2	41Cr4	24,2	850	oil	54,5	550	1	37,5

Concentrated energy sources were used to superficially heat treatment of samples which were thermally treated as above. The following are the tehnological processes for durification of the external layers by the above mentioned processes.

2.1. Superficial laser hardening

A CO2 laser pulse generator was used. A working regime has been chosen, so that only transformations in a solid state occur in the superficial layer. Table 3 shows the working conditions for the superficial hardening of samples from the two steels.

Table 3. The working parameteres at superficial hardening with laser

Alloyd steels	P [w]	v [mm/s]	d_{spot} [mm]	D_{beam} [mm]	Number of passage	Medium microhardness
OLC45	700	7,5	3,5	30	5	484
41Cr4						535

Superficial hardening with laser was effectuated with no cooling liquid, only with radiation and conduction.

Aspects of microstructures of superficial layers hardened with laser are shown in figures 1 and 2.

FIG.1. OLC 45 steel improved and superficial hardened (laser CO2) superficial layer +ZIT; Nital Atack 200:1

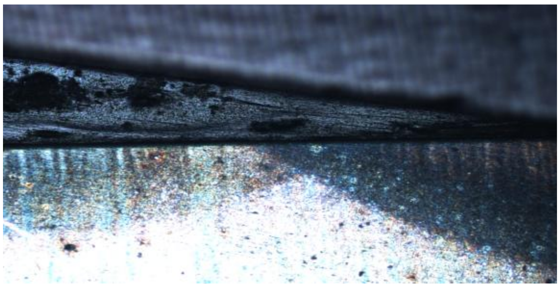

FIG.2. 41Cr4 steel improved and superficial hardened (laser CO2) superficial layer; Nital Atack 200:1

The microstructures above were chosen due to notice the influence of a passage on superficial processing.The strips were made with the distance between the spots (Fig. 1) and the partially overlapping spots (fig. 2).

2.3.Superficial hardening with electron beam

Experimental attempts have been made to work by scraping surfaces The working parameteres at superficial hardening with electron beam are shown in table 4.

Table 4. The working parameteres at superficial hardening with electron beam

U	I	v	l	Layer hardness	
				OLC45	41Cr4
60	18	140	150	675	711

Aspects of microstructures of superficial layers hardened with electron beam are shown in figures 1 and 2.

FIG.3. OLC45 improved steel and superficial hardened with elecron beam. Nital Atack 200:1

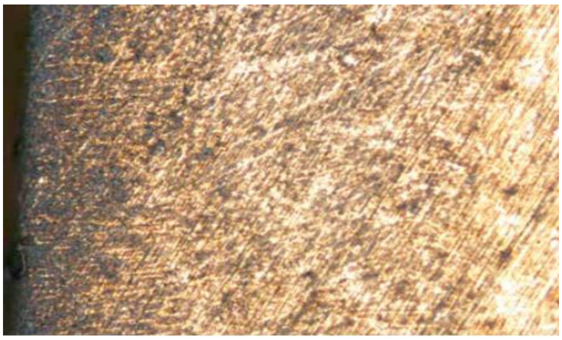

FIG. 4. 41Cr4 improved steel and superficial hardened with elecron beam. Nital Atack 200:1

The results of wear experimental attempts for samples superficial hardening

For each sample, weighing with the analytical balance was performed successively 5 to 6 times at equal time intervals (5 min); In this way, weight loss was determined after each wear cycle.

These operations were performed for each brand of steel, respectively for each heat treatment state:

- after improvement (hardening and high annealing) CR;
- after improvement followed by superficial laser hardening (CR+L);
- after improvement followed by superficial electron beam hardening (CR+FE);

The reasults of wear measurements are given in tables and diagrams below.

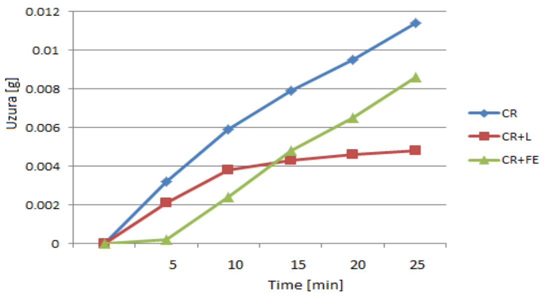

FIG. 5. The wear evolution of OLC45 steel samples treated in different mode

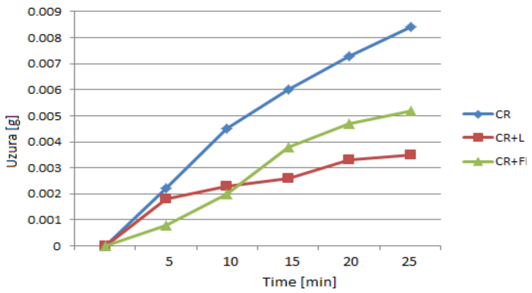

FIG. 6. The evolution of wear at 41Cr4 steel samples treated in different mode

It can be noticed that the size of wear has recorded differences, not only in different treatments but also from one material to another. From the above we can state the following:

- compared to improved condition, by applying superficial heat treatment, wear behavior significantly improves by 50% and even more;

- superficial laser thermal treatment is generally more efficient than with electron stream treatment;

- to some samples the wear was lower at the CR + FE samples, compared to CR + L samples, but only at the beginning of the wear process. Perhaps superficial hardening with electron beam also produced an outer film (very thin) by transformation from the liquid state. After the wiping of this film, the wear process has been enhanced.

- 41Cr4 Alloy improvement steel, gave superior results to OLC45 carbon improvement steel. The formation of chromium carbides as well as the martensite alloyed with this element contributed to the improvement of the wear resistance.

3. CONCLUSIONS

In addition to the usual surface treatments, it can also take into consideration the unconventional ones, namely the concentrated laser energy sources and electron stream. These processes have areas of application on small active surfaces, such as parts in the electrotechnical field and fine mechanics (cricket wheels, cams, sticks, small gears, etc.). At some points, the unconventional processes studied in this paper may become effective due to the extremely short process time and the fact that it does not require liquid medium for cooling . In improved condition, as well as through superficial hardening, whatever the process used, alloyed steels to the same carbon content, give better results.

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