THE EVALUATION OF MICROSTRUCTURE OF CARBON STEEL SURFACE LAYER AFTER DIFFUSION CHROMIZING AND LASER HEAT TREATMENT

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1. Introduction

Damage and wear of machine components is a significant problem in many industries. Various technologies for producing surface layer in order to improve the surface properties are developed [1-4]. There is a growing demand for technology that improve the performance of machine and equipment parts to lower manufacturing costs. The attributes of chromized layers produced by powder methods are enhanced through the selection of optimal mixture components, carbon concentrations in steel and process parameters. The advantage of this process is the ability uphill diffusion of carbon, that activity is lowered in the presence of chromium atoms and carbon was migrated from the steel core to the diffusion layer. Modification of surface layers formation with the help of laser techniques has been dealt with in many scientific centers. The use of laser for surface heat treatment can be also applied on various metal alloys (mainly iron alloys), even with diffusion layers [5-8].

This paper is devoted to the evaluation of microstructure of C45 steel surface layer after diffusion chromizing and laser heat treatment. The influence of laser parameters on the microstructure of the modified layer were analyzed.

2. Investigated materials and methods

Samples of C45 steel were chromized by the powder-pack method and were placed in the powder mix in special boxes made of X6CrNiTi18-10 steel. To prevent sample oxidation, the boxes were covered with lids and sealed with vitreous enamel. The applied powder mixture to produce the chromized layer contained: Cr_2O_3 with an addition of Al, Al_2O_3 and an activator NH_4Cl. The process was carried out in a Labotherm LH15/14 furnace at 1050°C for 8 hours. Chromizing process was followed by laser heat treatment in two variants of laser beam parameters. Dual diode TRUDISK 1000 laser device has been used. Laser beam power density variant no 1: 678 E [W/mm^2] , variant no 2: 185 E [W/mm^2]. The structure of the analyzed layer was evaluated by an optical and scanning microscopes. The phase composition of a chromized layer and laser heat treatment was evaluated using a Panalytical Empyrean equipment with the CuKα radiation. The chemical composition of the diffusion layer and remelted zones was assessed by optical emission spectrometry. Vickers hardness tests were preformed on transverse microsections. The depth, width, hardness of remelted zone from the solid state case modified by laser heating were carried.

3. Results and discussion

Chromized layer on samples of C45 steel were clearly separated from the ferrite-perlite steel substrate with an estimated thickness of 30 μm. After laser heat treatment of the diffusion layer remelted zone was appeared. Chromized diffusion layer following after laser heat treatment on samples of C45 steel were characterized by higher surface roughness than chromized steel. The surface of C45 steel samples following diffusion chromizing viewed under the SEM is shown in Figure 1 and following diffusion chromizing after laser heat treatment is shown in Figure 2.

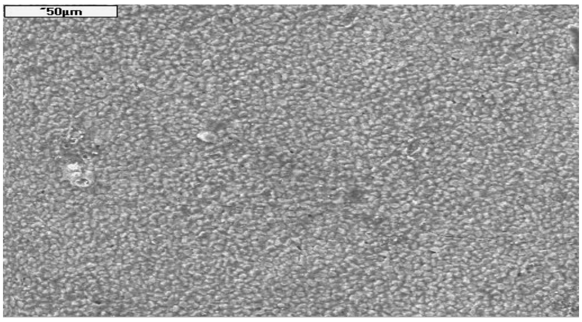

Fig.1. An example of the surface of C45 steel following diffusion chromizing, SEM

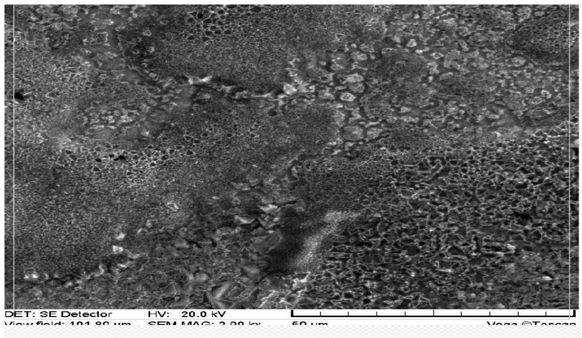

Fig.2. An example of the surface of C45 steel following diffusion chromizing and laser heat treatment, variant no 1, SEM

Microscopy observation revealed that, the microstructure of laser remelted zone was fine and homogenous in both treatment variants. Although, the size of the laser modified zone depended on laser beam parameters. It was also observed that chromium contracted in the layer after diffusing chromizing was dissolved in whole remelted zone as a result of laser heat treatment. Achieved zones were characterized by higher hardness than the core material of C45 steel. It is worthy emphasizing, that the presence of the hardened zone form the solid state under the remelted zone should additionally strengthen the whole surface layer. X-ray diffraction of chromized layer revealed the presence of: $(Cr, Fe)_{23}C_6$, Fe_2AlCr and $Cr_2(N,C)$ but chromized and laser heat treated layer: $(Cr, Fe)_{23}C_6$, Cr_2O_3, Fe_3O_4 in case of the first variant LHT and $(Cr, Fe)_{23}C_6$, $(Cr, Fe)_7C_3$ $Fe_{0,942}O$, Fe_2C, Cr_2O_3 in the second one. It could be the result of different conditions of microstructure creation resulted of different laser beam parameters in case of those two variants. It seems, that lower value of laser beam power density allowed to create additional type carbide $(Cr, Fe)_7C_3$.

4. Conclusions

The investigation have been carried out to analyze in details the diffusion chromizing process and laser heat treatment of C45 steel. Performed research showed, that it is possible to change the microstructure effectively of diffusion layer using the laser heating.The considered problem modification of microstructure after diffusion chromizing and laser heat treatment can be applied to gain some specific microstructure with grain refinement. The density of the laser beam exerts a significant influence on the structure of the chromium layer after laser heat treatment. The structure of the chromized layer after laser thermal treatment depended on the parameters laser beam power density applied.The presented research on modification of a chromized layer of medium carbon steel by laser heat treatment could find practical applications.

6. References

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