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# STUDY OF MICROSTRUCTURE AND MICROHARDNESS OF THE OVERLAPPING ZONE IN LASER TRANSFORMATION HARDENING OF AISI 1045 AND AISI D2 STEELS

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The new technologies of surface treatment of the metal products are developed and used in modern mechanical engineering to enhance both the operational properties of the surface layer and process performance. In contrast to traditional processing methods, laser surface transformation hardening allows selectively heat the most responsible areas on the product surface with high heating/cooling rates and a short term of action, providing a disperse martensitic structure with residual stresses on the surface [1,2].

It is known that there is a need to apply the laser transformation hardening with overlapping of laser tracks for surface hardening of large-sized products due to the impossibility to treat the whole surface with a scanning laser beam. The problems of microhardness reduction in the areas of overlapping laser tracks after laser surface hardening of carbon and tool steels with scanning optics are given in works [3-5].

Thereby, the study of the effects of overlapping ratio on the microstructure and microhardness distribution in the areas of overlapping laser tracks at multi-pass laser transformation hardening of carbon and tool steels using a fiber laser and a 2D scanner become especially relevant.

The plane specimens of the AISI 1045 carbon steel and AISI D2 tool steel were used (Fig. 1) for experimental studies, which were previously subjected to annealing.

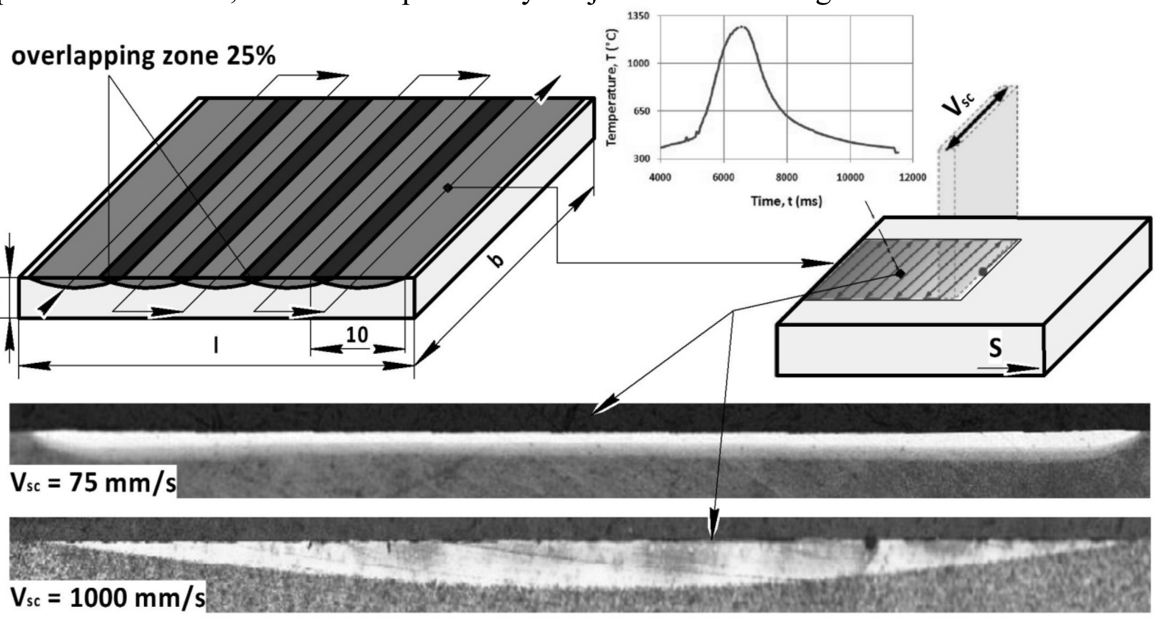
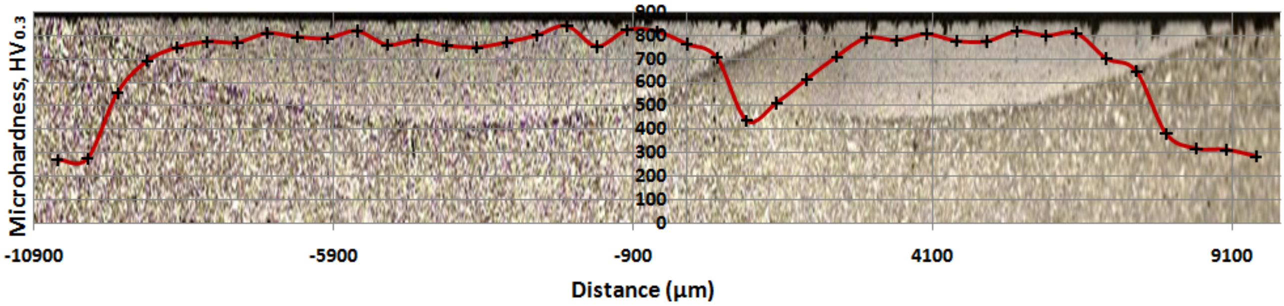



**Fig. 1. Scheme of laser surface transformation hardening with overlapping laser tracks of 25%: *h*×*l*×*b* is the height, length, and width of the specimen, respectively; *S* is the feed rate of the specimen; $V_{sc}$ is the speed of scanning a laser beam**

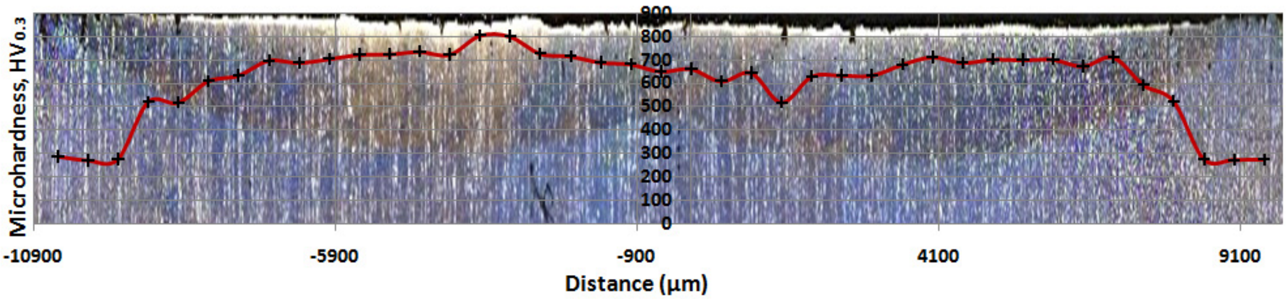
The laser heat treatment of specimens was carried out by a Rofin Sinar FL010 continuous laser fiber with a radiation wavelength of 1.06 μm [2,5]. The laser hardening process was performed at a laser power of 690 W and a specimen feed rate of 90 mm/min. Herewith, the diameter of the laser beam was 1.2 mm, and the overlapping ratio of the laser beam was 10%, 25%, and 40%, respectively. The laser beam was scanned by a Scanlab Hurryscan25 2D scanner at the high scanning speeds (1000 mm/s) to obtain the maximum hardening depth in the center of the laser track 10 mm in width (Fig. 1) [2].

The surface temperature magnitudes were recorded in real time by means of an optical pyrometer for each process condition in order to estimate the effect of the treatment regimes on the variation of the surface temperature.

The results indicated that the measured surface temperature was approximately 1230 °C at a laser power of 690 W regardless of the overlapping ratio. It has been found that there is an over-tempered structure with a lower microhardness near the overlapping area in the first laser track due to the thermal effect of the second laser pass in all cases (Fig. 2). Herewith, the microhardness is reduced to about 400 HV (AISI 1045 steel) and 500 HV (AISI D2 steel) in the tempered zone due to the formation of not only tempered martensite, but also tempered sorbite.




a)




b)

**Fig. 2. Microhardness distribution in the specimen cross-section at a depth of 150 μm below the surface along the two laser tracks at overlapping ratio of 25%: a) AISI 1045 carbon steel; b) AISI D2 tool steel**

It is established that in order to obtain at least 350 μm of the overlapping depth of laser tracks, must be used a repeated action by a scanning laser beam with an overlapping ratio of 25...30% regardless of the type of studied steel. Moreover, it should be noted that should be used an intensive plastic deformation using both dynamic and static processing methods to obtain a uniform structure and microhardness distribution in multi-pass laser transformation hardening.

**References:**

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