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SATURATION OF STEEL WITH CARBON BY THE ACTION OF IMPACT WAVES

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When metal surfaces are acted upon by impact waves there is a considerable strengthening effect. Under certain conditions dynamic plastic deformation is accompanied by heating; in particular with impact speeds of 4000 m/sec iron recrystallizes [1, 2]. When iron was heated by laser light with a pulse duration of 10^{-3} sec it could become saturated with carbon to a depth several orders of magnitude greater than the possible depth of penetration of carbon by solid-state diffusion [3]. Anomalously large zones of carbon saturation were observed at the boundaries of graphite and ferrite grains in cast-iron that was exposed to light pulses.

It was of interest to study the possibility of saturating iron with carbon by the application of impact waves. The iron-carbon pair was selected for preliminary study because carbonization has been thoroughly studied under a variety of conditions [4] but not including those of dynamic loading.

The studies were made on annealed low carbon steel St. 20 with ferritic-pearlitic structure.

The tests were made with the procedure for hardening steel plates described in [6]. A plate of low-carbon steel, mounted on a heavy steel base, was covered with a uniform layer of graphite powder. The graphite was driven into the low-carbon steel by impulse loading. This loading was produced by using explosives to throw a thin plate of the same steel onto the test-piece at a speed of 1975 m/sec. Sheet plastic explosive was used with a detonation velocity of 7500 m/sec and density of 1.65 g/cm^3; it was detonated with a capsule detonator. The impact pressure was 425 kbars. In order to carbonize a thin plate from both sides the experimental procedure was somewhat altered. A sheet of low-carbon steel with a layer of graphite powder was placed between the bedplate and the explosive thrown sheet. This impact scheme gave a travelling impact wave. After the treatment specimens were cut from the plate in a direction perpendicular to the front of the impact wave, and were studied by metallographic and x-ray structural analysis; the microhardnesses of the structural components were also measured.

X-ray studies of the phase composition of the specimen surfaces showed that in the initial state, (within the sensitivity of the analysis) the material consists only of ferrite with a volume centered cubic structure (α phase). After treatment with explosives and smoothing the surface by grinding, x-ray investigation revealed only very weak lines of the α phase, and the principal phase component was cementite. The relative intensity of the cementite line was compared with that observed on reference specimens of iron-carbon alloys of various compositions. The relative intensity corresponded approximately to that obtained on transeutectic white cast irons (about 4.5% C). The sudden change in the phase composition of the steel during carbonization by an impact wave can be seen by comparing the intensity curves on the x-ray graphs shown in Fig. 1.

Prolonged etching (0.5 h) in 4% alcoholic solution of nitric acid revealed the structure of the carbonized white layer (Fig. 2) which was acicular, similar to that near a cooled melt, which was observed when white cast iron was irradiated with laser light impulses. The structure of the white layer indicates a high carbon content.