

but drop steeply in the transition region to the values of the initial state of the deposited metal — Fig. 3. It shows the size of the transition zone is not more than 0.5 mm, so the boundary between the quenched and initial structures (Fig. 4) can be described as abrupt.

A narrow (about 2 mm) tempering zone is present in the quenched zone of the first pass of the plasma jet, where the second pass overlaps the first (Fig. 2B), and the temperature of reheating in this region is higher than A_{c3} (marked 4 in Fig. 2). The microstructure of the different regions of the HAZ of the 5 Cr-0.5 Mo-0.15 V (0.20 C) deposited metal is shown in Fig. 5.

The initial structure of the 5 Cr-0.5 Mo-0.15 V (0.20 C) deposited metal consists of highly tempered lath martensite. At larger magnification it is possible to see the remaining stretched crystals, containing polygonal-shaped subgrains — Fig. 6A. Their dimensions do not exceed the thickness of the initial martensite crystals. Such a structure is formed in the process of surfacing of subsequent layers during the rapid cooling in the temperature range of the phase transformation. This results from rapid heat removal in the base metal, following heating to the temperature of significant tempering, when the next layers of metal are deposited (Ref. 6). Lower carbon content in martensite (Table 2), when compared to the steel composition, testifies significant tempering takes place. At the same time, alloying with chromium, molybdenum, vanadium and silicon, accompanied by a lower rate of separation and growth of secondary carbides, protects some supersaturation of the α -solid solution (Ref. 11) because of a decrease in the rate of carbon diffusion and an increase in the strength of chemical bonds in the crystal lattice of the α -solid solution. The carbon content in the initial martensite remains high.

The initial structure of the deposited metal is characterized by the presence of a large quantity of carbides. The carbide phase is represented by cementite Fe_3C and complex carbides $Me_2_3C_6$. The hardness of the deposited metal is HV 390–410 (Table 2) and, according to modern classification, it can be classified as a martensite-carbide steel.

Following surface heating with a highly concentrated plasma jet, natural cooling at a speed of the order of $10^{5^{\circ}C/s}$ leads to the formation of a hardened zone with a fine-grained martensite structure. The morphology of martensite at plasma quenching does not change. Mostly lath martensite is formed; however, it is significantly fine-grained — Fig. 6B. The average lath thickness, as visible in a thin-foil plane, is about $0.1 \mu m$; the size of

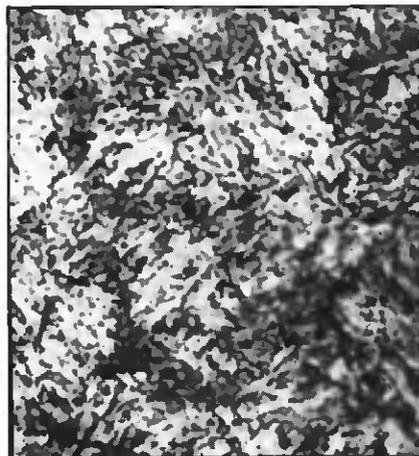


Fig. 4 — Microstructure of the 5 Cr-0.5 Mo-0.15 V (0.20 C) deposited metal at the boundary of the quenched and initial structure (400X).

sheaves (packets) being up to $2 \mu m$. Within the limits of one sheaf (packet), some adjoining subgrains are disoriented at angles of 2 to 3 deg, separated at the plane $\{110\}_{\alpha} \parallel \{111\}_{\gamma}$ by small-angle dislocation subboundaries (mostly twisted). Such a group can be presented as a monocrystal with a layered dislocation structure, without full relaxation, because of high dislocation density inside each subgrain (Ref. 11). In addition to lath martensite, about 15% of the plate martensite is also detected in the structure of the hardened zone.

The constitution of the carbide phase after plasma hardening is changed fundamentally by the dissolution of cementite and of a large part (more than a half) of the special carbides. Additionally, the martensite matrix is saturated with carbon and alloying elements, all of which lead to an increase in parameters ρ , $\alpha c/\alpha$ and $\Delta\alpha/\alpha$. The martensite structure in the plasma quenching zone is also significantly changed by the splitting of mosaic hlocks and an increase in dislocation density to more than an order — Fig. 6C.

Such martensite may not be characterized on the radiographs as a structure of tetragonal crystal lattice featured in divided doublets. This is explained by the formation of an inhomogeneous tetragonal structure resulting from the partial decomposition (self-tempering) of martensite. Within the martensite laths, thin plate-like carbide particles (tertiary carbides) oriented in several directions, are precipitated — Fig. 6D. The submicroscopic dimensions of these carbides (several orders less than those of martensite laths), the remaining high carbon content in α -solid solution and the remaining parameters α , c/α and $\Delta\alpha/\alpha$ testify self-tem-

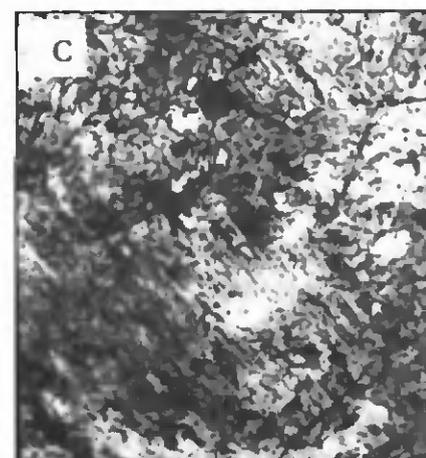
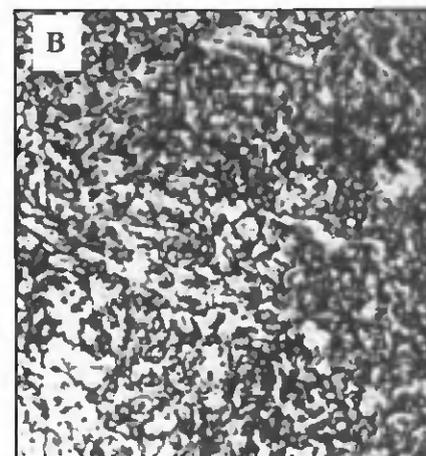
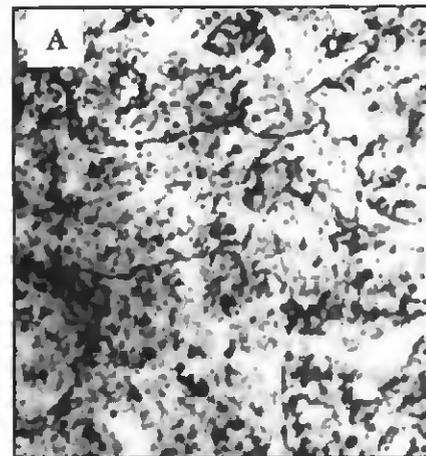


Fig. 5 — Optical micrographs of the 5 Cr-0.5 Mo-0.15 V (0.20 C) deposited metal at the HAZ regions. A — At the quenched zone (marked 1 in Fig. 1); B — at the tempered zone with HAZ overlapping (marked 4 in Fig. 1); C — at the initial structure (marked 3 in Fig. 1) (550X).

pering of finely dispersed martensite in the plasma quenched zone is stopped at the initial stage. Martensite of this zone in its parameters is practically the same as the original martensite. Similar results had been received for laser surface hardening

