"Structure and characteristics of thin sheet laser welded joints of nitrogen content austenitic and martensitic steels".

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Abstract - There were tested thin sheet joint welds of nitrogen content, austenitic and martensitic steels with 0.5 and 0.13% nitrogen (N) respectively, which have been obtained by laser welding.

Keywords - laser welding, microstructure, joint weld, austenitic steel, martensitic steel, microhardness

Nitrogen alloyed steels are a combination of high strength, corrosion and wear resistance, good ductility and high toughness. An essential aspect of production (WCn) of hot-rolled thin sheet (3 mm thick) nitrogen content, strength, corrosion and wear resistance, good ductility and nitrogen (N) respectively, which have been obtained by laser welding.

This article investigates laser performed welded connection (WCn) of hot-rolled thin sheet (3 mm thick) nitrogen content steels: austenitic steel 05X22Al15H8M2Φ with 0.5% N (according to DIN-system transcription X3 CrMnNiMoVN 22-15-8-2.), and martensitic steel 05X16H5AБ with 0.13% N (in DIN-system – X5 CrNiN 16-5). Grade chemical composition of steels is shown in Table 1. Open butt joint with a gap < 25 μm was welded by fiber laser (designed by IPG IRE-Polus), without welding filler. Welding conditions: power P = 1 ... 6 kW; welding speed V = 1 ... 7 m / min, focus depth is +3 ... -3 mm from the surface. From WCn metallographic samples were prepared. The following investigations were carried out: micrographic investigation (on with X-ray microanalysis optical and scanning electron microscopy with electron microprobe analysis - EMPA), Vickers microhardness tests (under a load of 100 g, 40 measurements) of parent metal (PM) and joint weld (JW) metal; ferrite content check.

Austenitic steel test results (1).

JW thickness ranged from 350 to 1200 μm. Between PM and JW there is a clearly defined boundary of fusion line (FL). Microcracks on FL are absent. Heat affected zone (HAZ) of JW in PM is absent. All the JW, regardless of welding conditions, have fine dendritic structure, in which dendrites, sized 5 to 150 μm, branch from the weld center in the direction toward PM, so that there is a pronounced axial symmetry of JW. On the polished surface of investigated JW are observed lengthy strips of dendritic microstructure elements, buried to 0.2-0.4 μm with respect to other surface of JW. According to EMPA: the average chemical composition of such elements is the same that chemical composition of other areas of metal in JW; the JW-metal contains smaller concentration of Mn regarding PM (in average - 14.2% against 15.3% in PM). Ferrite is absent in the phase composition of JW metal. Microhardness of JW does not depend on welding condition. For the tested JW of austenitic steel specimens average microhardness HW was: for PM - 302, for JW metal - 296. This data is demonstrating an equal strength level of PM and JW of austenitic steels.

Martensitic steel test results (2).

JW thickness is 350 to 1550 μm. JW characteristic properties: diffuse FL, absence of clearly visible boundary between JW and PM and pronounced dendritic structure of JW. HAZ of JW in PM is absent. Grain size: in PM - 3-10 μm; martensite in JW is in a form of large plates (lamels), sized about ~50 μm. In JW metal there are a great number of submicron inclusions, disposed on the edges of plates of martensitic grains and straight edges of martensite packages. Probably, these are nitride particles. Axial symmetry of JW is shown in significantly lesser extent than in JW of austenitic steels. With larger thickness of JW its axial structure, with crystallites elongated in the direction of heat sink (toward PM), is more pronounced. Pores and cracks, caused by welding, were not detected. Microhardness of JW does not depend on welding conditions. For JW of martensitic steel under examination average microhardness HW was: for PM - 329, for JW metal - 412. According to EMPA chemical compositions of JW metal and PM are identical and correspond to steel grade composition.

Conclusion.

The tests have proved high usability of laser welding by ytterbium fiber laser (designed by IPG IRE-Polus) for the purpose of obtaining quality joint welds of plate (3 mm thick) austenitic steels (1) with 0.5% N and martensitic steels (2) with 0.13% N.

TABLE 1. GRADE CHEMICAL COMPOSITION OF STEEL 05X22Al15H8M2Φ (1) AND STEEL 05X16H5AБ (2).

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<tr>
<th>Steel</th>
<th>Weight content of elements, % (ferrum – base material)</th>
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<td>C</td>
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<tr>
<td>1</td>
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JW thicknes