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Advanced laser welding technologies for offshore rig structures

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Competitive capability in shipbuilding depends greatly on technological effectiveness and quality of products. In general, qualitative changes in the sector are mostly related to introduction of advanced technologies with simultaneous increasing of automation level at shipbuilding enterprises.

One of the methods of improving production quality in shipbuilding is implementation of processing technologies, based on high-concentrated energy sources, including here laser and plasma technologies.

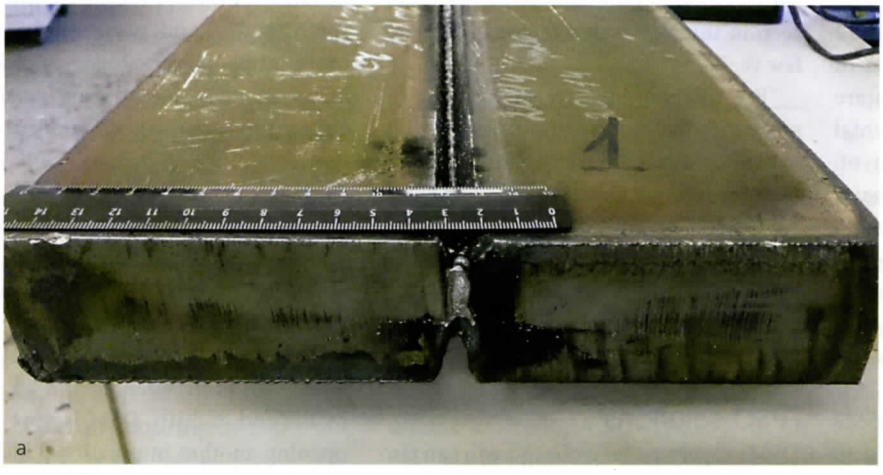
JSC Shipbuilding and Shiprepair Technology Center is a leading design and technological center in Russia, having developed and supplied advanced technologies for construction, operation and repair of marine equipment for more than 75 years. In particular, JSC SSTC is developing laser and plasma technologies for the shipbuilding sector.

The main advantages of laser and plasma technologies, compared to conventional arc processes, are high processing speed, good quality of weld seam, minimal thermal effective area, low consumption of filler materials and practical absence of welding deformations.

Deformations are reduced due to low rate of energy input, in comparison with conventional arc welding. Our experts have conducted a number of research works in the field of laser and hybrid laser-arc welding, developed technologies and designed equipment for application in shipbuilding production. For example, standard macro sections, obtained after laser and hybrid laser-arc welding of 11 mm thick steel at a speed of 2.2 m/min. Laser emission power was 10.2 kW for laser welding and 10.5 kW for laser-arc process. Arc parameters were: I = 243 A, U = 25.3 V, welding wire diameter – 1.2 mm.

Computer support was provided with the help of program LaserCAD, which allows calculation of geometric parameters of future joint, select optimal mode of processing, select equipment in accordance with estimated parameters, and select filler material in accordance with estimated joint properties. The analysis allows users to make a conclusion, that laser and laser-arc welding can ensure penetration to more than 10 mm at welding speed of around 2 m/min. However, main criteria for selection of welding technology and processing modes are ensuring the required mechanical and visco-plastic properties of welded metal, ensuring necessary weld depth and possibility of work with a gap between welded edges.

Laser welding is used normally for welding of aluminum and titanium alloys, stainless and high-alloy steel. However, comparison of estimated thermal cycles shows that laser-arc hybrid welding privides better conditions for weld shaping, control of heat input and metal alloying.



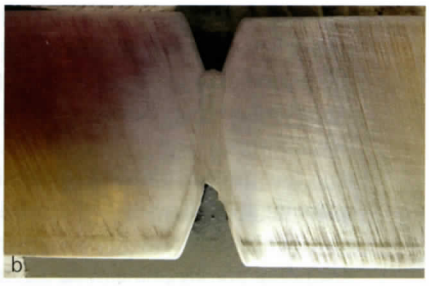


Fig. 1 – Overall view of a specimen (a) and macro section of weld seam (b). Pl = 15 kW, U = 40 V, I = 370 A, vw = 1,0 m/min, vgr. = 18 m/min.

JSC SSTC has developed practical technology for manufacturing flat hull panels with use of laser cutting and hybrid laser-arc welding. The Russian Maritime Register of Shipping approved the standard procedure of hybrid laser-arc welding of plates and framing for ship hull structures with integrated grooving by laser cutting.

JSC SSTC, in cooperation with IMG, Germany, constructed a pilot automated line for assembly and welding of flat panels. The line allows to manufacture flat sections up to 12x12 m in size from plates of 4 to 20 mm in thickness. Some technological solutions in this line are implemented for the first time in world shipbuilding practice. A true innovation is, for example, combination of grooving operation by laser cutting and with hybrid laser-arc welding of plates at one position. Also, a multi-post operation of one laser source is implemented by means of using fiber laser LS-16-P4 (16 kw) with four-channel optical switch, allowing to transfer laser beam to operation positions through optical fiber.

Testing of butt and T-welds, made by hybrid laser-arc welding, demonstrated stable values of visco-plastic properties both in the weld seam and in adjoining zone, with meeting, or even exceeding the rated parametres. Hardness parameters do not exceed 300 (HV5) and are within the permissible limits. Laser-arc welding ensures considerable compressing of arc beam, high stability of welding pool and much better effectiveness, comparing to conventional arc welding, as well as smoother thermal cycle and less strict requirements to gaps and assembly accuracy, comparing to pure laser welding.

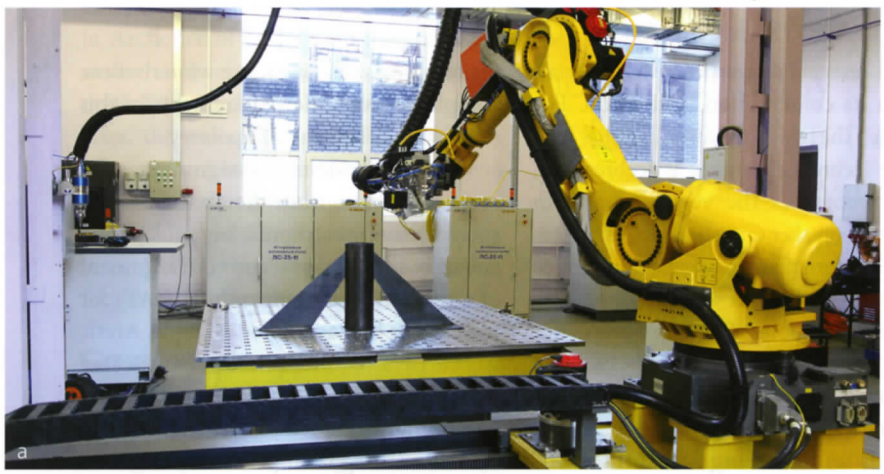
Main advantages of laser techniques in panel manufacturing, comparing to conventional methods, are:

- High effectiveness of the process (1.5 – 3.0 times more effective);
- Low material and energy consumption (by 20.0-40.0%);
- Minimum residual welding stresses and deformations in the structures.

Laser technologies allow to manufacture flat panels without defects, with the required quality and necessary geometric parameters, comparing to panels, made with use of conventional welding.

In the course of experiments, vertical joint was welded from high-strength shipbuilding steel 48 mm thick, with X-type grooving. The butt was welded with hybrid laser-arc welding. Overall view of specimen after welding and macro section of weld seam are presented in Fig. 2.

For manufacturing welded structures with complex shapes, JSC SSTC has designed a robotized complex for laser cutting and welding in various positions (see Fig. 2). This system allows to reduce over-all cost of hull manufacturing by up to 30%, increase labor productivity in min. 1.1 times with simultaneous reduction of welding deformations at least in 1.4 times, comparing to conventional welding methods.



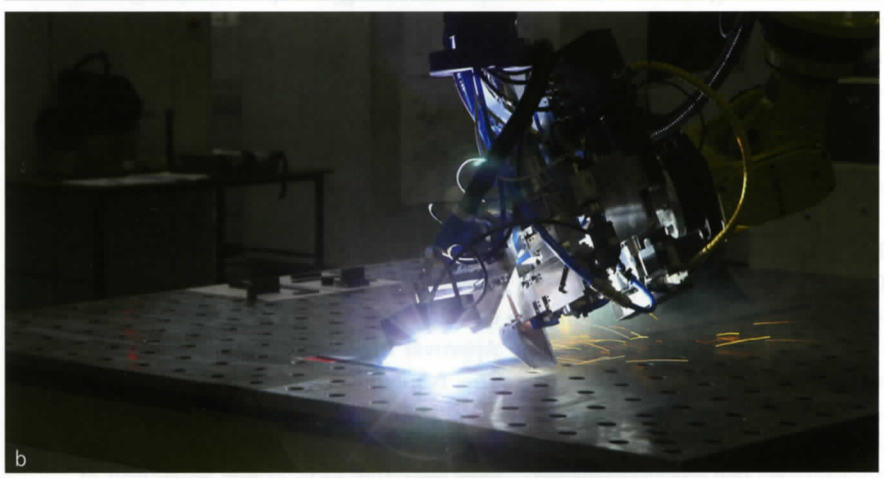


Fig. 2 Robotized complex for laser welding and cutting in various positions: overall view (a), laser-arc welding process (b)

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