Design of mobile hybrid laser-arc welding system on the base of 20 kW fiber laser

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Hybrid laser arc welding is one of the most prospective technologies for joining of gas and oil pipes, bridge sections and building constructions. The main advantage of hybrid welding is a possibility to weld by one path materials with thickness up to 15 mm and more, including new high strength steels. Hybrid processes allow increase productivity and tolerance, provide weldability in comparison with laser ones and increase productivity and quality of weld, decrease distortion in comparison with arc welding. In spite of all advantages, the usage of this technology in the case of real production is restricted by high complicity of the process [1] and appearance of porosity, cracks, spiking and hamping in the weld seam, especially in welding of alloyed steels. Important problem for widening of usage of hybrid technology is absence of mobile welding systems, which can be used for welding of non-turnable pipes joints, off-shore constructions, bridge sections and so on.

Development of technological machines for hybrid welding in ILWT is based on block-module approach [2], which allow provide several inheritance in design, compatibility and strongly decrease of development time. In accordance with this approach each installation consist of: laser source, arc source, laser-arc module (welding tool), control system, cooling system, gas distribution system, welding parts manipulator, seam tracking system and process monitoring system. Joining of subsystem is providing by common interfaces for control, mechanic connecting, gases and water. On the base of this approach a number of machines has been developed for industry, some examples are descried below.

System based on soft direction belt, on which a motion unit with hybrid module, seam tracking, filler wire feeding are installed. Other subsystems are in stationary unit. Machine use 20 kW fiber laser with two direction switch, that allow weld two joints in one time. Also a new arc invertor source VD-508 of ETS is used in this machine. It is necessary to mention, that design of all subsystems, which are have to be useful in hybrid process, have a number of peculiarities. For example, seam tracking sensors have to work under conditions of high power lightning by reflected laser radiation and high power arc in real time mode, that require spectral and temporal selection of signal and special algorithms of data processing. The monitoring system, which provide on-line control of process quality, have to be able select appearance of such defects of weld seam, as spiking, hamping and porosity.

The control system of the laser-arc complex is realized as a hardware-software complex. This is a distributed computing operating system, which manages all components of the welding complex and consists of the welding joint monitoring subsystem, the welds monitoring subsystem and automatic control system.

The control system carries out: reading of a joint profile of welded parts, control of the joint geometrical characteristics, tracking coordinates of the joint at welding speed up to 3 m/min, positioning of the welding head above the welded joint; control of the laser radiation source, control of the arc source, control of protective gases feed, control of the welding process parameters and their documenting, measurement of the welding head parameters and protection against invalid modes, on-line quality control of the welds by using the process-monitoring.

The laser-arc module is intended for work in technological complexes for hybrid laser-arc welding of high thickness metals with possible gap between welding parts up to 2 mm, so that MAG torch is installed before the laser beam. It consists of: manipulator, laser welding head, arc welding torch, sensor of the seam tracking system, sensor of the process monitoring system. Gas protection of the weld is also provided. Control and stabilization of position of the hybrid laser-arc module relative to the joint is fulfilled by linear drives system, installed on moving platform. It operates the executing devices of the manipulator, such as keep of position of the focus point of the laser head relative to welded surfaces (“vertical moving”), keep of positions of the focus point of the laser head relative to the joint (“cross moving”).

Accuracy of keep of the focus point position of the laser head in relative to welded surfaces in the vertical direction is 0.2 mm. Accuracy of keep of the focus point position of the laser head in relative to the joint in the cross-section direction is 0.5 mm

During technologic experiments the plane and circular samples with thickness of 8, 16, 24 mm from pipe steels 10G2FBU were melted and welded in butt joint. Welding was carried out along non-turnable joint of large diameter pipes. Argon, welding dioxide of carbon and their mixes were used to protect welding bath and seam metal. A coaxial protective gas jet nozzle and non-coaxial protection of the welding bath were used additionally. Quality of all welded seams was estimated visually on their appearance, on the base of metallographic researches of cross-sections, with x-rays investigation and with standard mechanical tests. The penetration depth and other seam geometry parameters were determined as well as defects presence and material properties in weld seam and HAZ.

Hybrid scheme allow too increase a process tolerance. As it was proved experimentally, technology can provide

appropriate weld formation even in the case of more than 3 mm of vertical displacement of pipe joint edges. Optimization of arc torch position relative laser beam, optimization of composition of arc gas mixture together with usage of special filler wire with nanopowder admixtures, which was developed for this process, allow to avoid appearance of such defects, as porosity, hot cracks and hamping, and provide value of impact energy on temperature -40 C in the bounds of 140 – 200 J for pipe steel X80. Equipment and technology of hybrid welding has been successfully tested for the welding of non-turnable joints of pipes for oil and gas.

[1] G. Turichin, I. Tzibulsky, E. Valdaytseva, A. Lopota, Hybrid laser arc welding of metals of large thickness, Welding and Control (RUS), 2009, № 3. p. 16-23

[2] Turichin G., Valdaytseva E., Tzibulsky I., Lopota A., Velichko O., Simulation and technology of hybrid welding of thick steel parts with high power fiber laser, Physics Procedia, Proceedings of the 6th International WLT Conference on Lasers in Manufacturing, LiM, Munich, 2011. p. 646-655.