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PECULIARITIES OF THE PROCESS OF ORBITAL LASER-ARC WELDING OF THICK-WALLED LARGE-DIAMETER PIPES

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The results of development and testing of hybrid laser-arc welding of large-diameter pipes are given. The main results of the research, in particular, on the peculiarities of weld formation in different regions of circumferential joints, mechanical properties of the welded joints, and potentialities of the available equipment for construction of main pipelines are generalized.

Keywords: *hybrid laser-arc welding, orbital welding, high-pressure pipelines, fibre-optic lasers*

One of the key components of the world energy system is a network of main pipelines. Construction of these pipelines demonstrated advantages of manual and mechanised methods of arc welding, such as manual covered-electrode arc welding, mechanised gas-shielded welding using solid or flux-cored wire, and mechanised twin-arc tandem welding. Worthy of note among the non-arc processes is flash butt welding, which has not yet found wide application for construction of modern oil and gas pipelines despite the simplicity of its principle of operation [1]. Position butt welding of pipelines is a labour-consuming process, which determines to a considerable degree the rate of laying a line as a whole. The arc welding methods employed are characterised by a relatively low speed. This limitation may be quite appreciable, for example, in construction of pipeline with a diameter of 1229 mm and wall thickness of 35 mm or more. Furthermore, the oil and gas industry is in a state of search for solutions concerning application of modern high-strength structural materials, as this would allow reducing wall thickness of pipelines in order to cut their metal intensity or increase a working pressure in the pipeline to provide a more efficient transportation of product. Instead of standard pipeline steel grades of strength classes X60 and X70 with a yield point of up to 500 MPa, according to classification of the American Petroleum Institute, steels of a higher strength class, such as X80 or X100, are introduced into practice, as a result of which the working pressure in new pipelines that are designed now can be raised from 7–10 to 15–20 MPa. Despite the fact that increase of strength characteristics of steel in terms of welding metallurgy leads to deterioration of its weldability, traditional arc welding is capable of providing the required quality of welded joints, and the use of fully automated welding processes solves the problem of its reproducibility. It is likely that the choice of these welding processes or the other for construction of advanced pipelines from high-strength steel will be based primarily on the technical-economical factors, allowing for the volumes of construction and assurance of the quality of building and assembly operations. This strategy is inseparably connected with application of the latest achievements in the field of welding technologies, among which the most attractive ones today are highly efficient combined (hybrid) welding processes based on the synergic, complex effect of the laser beam and electric arc on the weld.

The idea of using beam welding to make circumferential welds on pipelines is not new. For instance, the possibilities of using electron beam [2], gas CO_2-laser [3] and solid-state Nd:YAG-laser [4] to implement the orbital welding process have been considered in a number of publications approximately since 2000. The feasibility of applying electron beam welding for making single-pass circumferential welds was demonstrated on the 762 mm diameter pipes with a wall thickness of 19 mm. However, the use of the said welding method under field conditions is hampered by technical difficulties associated mainly with the need of creating vacuum within the welding zone and ensuring protection from X-radiation generated when electrons hit a workpiece. In the case of the laser beam, the maximal wall thickness of a pipe is limited to 10 mm, which is caused by the maximal output power of laser units employed at that time (12 kW for the CO_2-laser, and 4.4 kW for the Nd:YAG-laser).

With emergence of the high-power solid-state lasers, such as fibre-optic and disk ones, the welding industry began using up to 20 kW continuous-wave laser units featuring an excellent quality of emission and compact design. Utilisation of the said advantages of modern lasers combined with the hybrid laser-arc welding process made it possible, for the first time ever, to perform single-pass butt welding of materials with a wall thickness of up to 20 mm [5].

Potentialities of the up-to-date fibre-optic lasers for welding pipelines have been intensively studied at a number of research centres of Germany and other