International Scientific-Technical and Production Journal

The Paton WELDING JOURNAL

February 2011 # 2

English translation of the monthly «Avtomaticheskaya Svarka» (Automatic Welding) journal published in Russian since 1948

Founders: *E.O. Paton Electric Welding Institute of the NAS of Ukraine*
International Association «Welding»

Publisher: *International Association «Welding»*

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State Registration Certificate
KV 4790 of 09.01.2001

Subscriptions:
$324, 12 issues per year,
postage and packaging included.
Back issues available.

CONTENTS

ASSESSMENT OF DEFORMABILITY OF PIPE STEEL JOINTS MADE BY AUTOMATIC CONTINUOUS FLASH-BUTT WELDING

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Peculiarities of formation of high quality flash-butt welded joints on pipes are analyzed. Factors affecting the results of impact tests of standard specimens are considered. Toughness properties of metal in the welding zone have been studied by using different impact test methods. It is shown that metal of as-welded joint made at optimum parameters has sufficiently high resistance to impact loads. Conditions for performing flash-butt welding and inspection of the joints providing high operating reliability of pipelines have been determined.

Keywords: *flash-butt welding, pipelines, joint quality, impact testing methods, joint zone, impact toughness, operating reliability*

One of the important tasks in construction of pipeline systems is ensuring their operating reliability. It is solved by specifying a number of technical and technological requirements pertaining both to welding performance, and to the properties of site (circumferential) butt joints. Mechanical properties of the latter are represented by values of strength and ductility, and they should meet the requirements of standards [1, 2]. In addition, in order to prevent fractures in butt joint operation because of the most characteristic defects, inherent to the applied welding process, also specified are the requirements to the value of joint metal impact toughness representing the energy consumed in fracture of a standard sample.

Over the recent decades the method of impact testing of samples with a sharp mechanical notch (*KCV*) of depth $h = 2$ mm with radius $r = 0.25$ mm at the bottom, has become the dominant method that was due to a high probability of formation of sharp stress raisers in welds, including crack-like ones. Nowadays such a testing procedure and established values of impact toughness are extended to all the welded joints, irrespective of the process of their welding. In keeping with the requirements of [1], average value of impact toughness of metal of welded joints on pipes of strength class X52–X70 at −20 °C testing temperature should be not less than 34.4, and minimum value should be 29.4 J/cm^2. These *KCV* values were determined allowing for the inevitable and admissible defects for joints made by electric arc welding processes. These defects include external crack-like defects (one- and two-sided lacks-of-penetration — lacks-of-fusion) of up to 1 mm depth and up to 30 mm length, weld root concavity (shrinkage of down to 2 mm depth and length of up to 1/6 of welded butt joint perimeter), as well as internal lacks-of-penetration both between the layers and around the contour of the edges. In addition, in electric arc welding there is a high probability of appearance of various kinds of cracks, which are not allowed in welded joints. Their detection, however, by industrial NDT methods presents certain difficulties in a number of cases.

Transfer of the testing procedure and the above standard *KCV* requirements to welded joints made by other welding methods, is not always justified by far. In the case of absence of the above defects in the weld, ensuring *KCV* values on the level of 34.4 J/cm^2 for all the zones of the joints should be recognized as unpractical as such requirements make pipeline construction more complicated and lead to excessive consumption of material means. API-1104 standard is advanced in this respect [2]. It does not specify the impact toughness values; they are indicated by the customer in the form of special requirements that are defined allowing for specific conditions of pipeline construction and operation. Such an approach is directed to simultaneous solution of the two main tasks: lowering of failure probability of the pipelines in operation with the most probable defects in circumferential butt joints, characteristic for the applied welding process, and minimization of construction costs.

Many years of experience of operation of various diameter welded pipelines, including high-capacity gas- and oil pipelines of 1420 mm diameter, shows the high reliability of circumferential welds, made by automatic flash-butt welding. Mechanical properties of these joints meet all the requirements of the standards, in keeping with which large-scale construction of the main and industrial pipelines is performed, except for individual cases when special requirements are made to the value of impact toughness (mainly in welding large diameter pipelines operating at below zero temperatures).

Compared to electric arc fusion welding, flash-butt welding has principal differences in joint formation,

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