IMPROVEMENT OF THE QUALITY OF WELDED ASSEMBLY FOR BRANCHPIPE CUTTING INTO THE WALL OF OIL STORAGE TANK

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Performance of the assembly for cutting branchpipes for process pipelines and hatches in lower rings of the wall of high-capacity oil storage tanks is considered. It is shown that one-sided grooving of holes for the branchpipes followed by circumferential welding on the inside of tank wall, specified by industry standards, cannot guarantee the required complete penetration. It is suggested that the two-sided non-symmetrical edge preparation should be made, providing substantial improvement of welding conditions and quality of the circumferential welds.

Keywords: *arc welding, oil storage tanks, wall, branchpipe cutting-in assembly, one-sided welding, complete penetration*

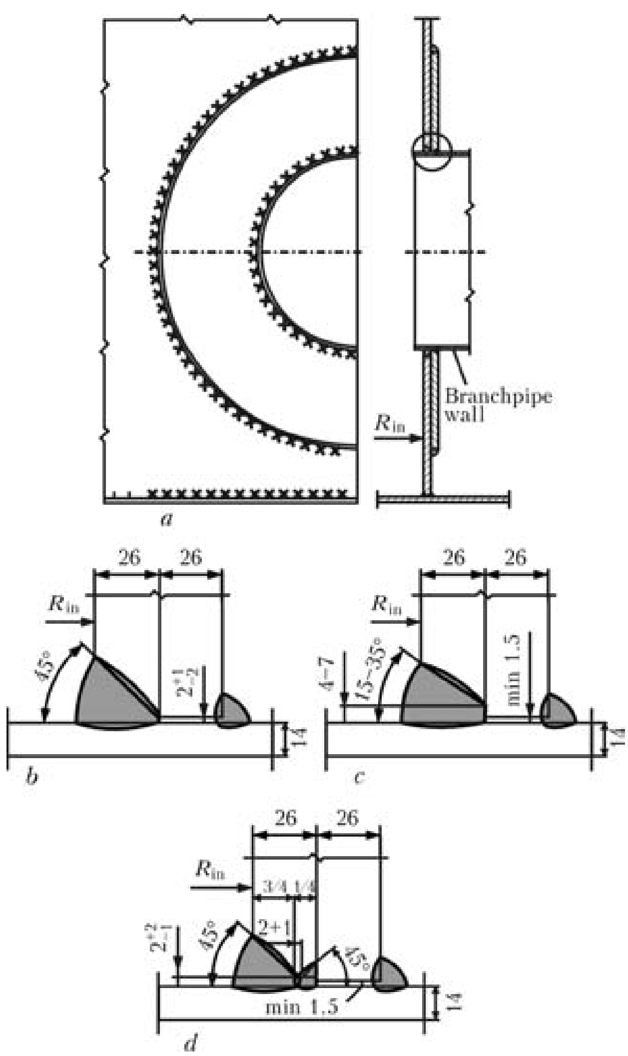

Figure 1. Design solutions of the assembly (*a*, *encircled*) of the joint of the wall of 50,000 m^3 tank RVS PK with the shell in keeping with PB 03-605–03 norms (*b*), standard API 650 (*c*) and PWI solution (*d*): R_{in} — wall inner radius

In keeping with technological requirements, cutting-in of various branchpipes for process piping and hatches is performed in the lower ring of the wall of vertical cylindrical tanks for oil storage. Cutting-in sites are located in the wall region, which is subjected to the impact of circumferential and bending stresses of edge effect caused by rigid connection of the wall to the bottom. In order to ensure the required serviceability of branchpipe cutting-in locations, the current technological norms envisage reinforcement by special coverplates, while complete penetration of the wall to branchpipe joint (Figure 1, *a*) should be in ensured [1, item 3.10.1.6] and [2, item 3.7.2.1].

Holes under the branchpipes are cut out manually by oxygen cutting in site. Gap between the wall and branchpipe, in keeping with the technological norms [1], should be equal to 0–3 mm. At tank wall thickness of 20 mm and more and one-sided welding of position butt joint with the above gap, it is difficult to cut-out and soundly grind the root of such a weld with the abrasive wheel, because of branchpipe wall and groove curvature. Depth of cutting out the weld root from the reverse side reaches 4–6 mm (Figure 1, *b*). In the absence of an efficient method of control and methods to repair the available defects, the quality of weld formation depends on welder qualification.

Experience of operation of tanks with the design of branchpipe cutting-in assemblies, recommended in [1], is indicative of the fact that cutting-in locations are zones of increased stress concentration, and they can be the sites of crack initiation and propagation. Figure 2 shows cracks propagation in the circumferential weld, made on the fastening of reinforcing coverplate to 16 mm wall of the oval hatch on an oil tank RVS PK of 20,000 m^3 capacity from 09G2S-12 steel. Crack initiation and propagation are largely promoted by the presence of a coverplate on the vertical axis of in-site butt weld. Figure 3 shows another case of failure of a circumferential weld, made at welding-in of Dn 300 branchpipe into 26 mm wall of RVS PK tank of 50,000 m^3 capacity from S390 type steel. A

Figure 2. Crack propagation in the circumferential weld made on reinforcing coverplate of the oval hatch in the oil tank of 20,000 m^3 capacity from 09G2S-12 steel with 16 mm wall thickness

Figure 3. Cracks in the circumferential weld at welding-in of Dn 300 branchpipe in the first ring of the wall of 50,000 m^3 oil tank RVS PK from S390 steel with 26 mm wall thickness

water leak through the control hole in the coverplate developed at hydraulic testing. After complete draining of the water, dye penetrant flaw detection in the circumferential weld inside the tank was performed, revealing the presence of through-thickness circumferential and transverse cracks predominantly in the weld lower part (see Figure 3). Alongside the deficiencies of the welding technology, there also exist a number of other negative factors that lead to crack initiation and propagation. These are the difficulties of achieving complete penetration of the wall across its thickness, particularly in the weld root.

To improve the conditions of producing the weld of required quality in keeping with the current norms [2], a somewhat different groove geometry in the wall hole is recommended (see Figure 1, *c*), when the gap between the tank walls and branchpipe should be increased to 4–7 mm. In order to reduce the volume of deposited metal, groove angle is selected equal to 15–35°. However, welding brachpipes into the wall of RVS PK tank of 50,000 m^3 capacity showed that increasing the gap at reduction of groove angle does not solve the problem of sound penetration of circumferential weld root. At the gap of 5–7 mm the volume of deposited metal in the weld root increases significantly, and the end face of weld root has 3–8 mm recession on the outside, that does not allow performing its sound grinding and subsequent back-up welding. On the other hand, in all the illustrations to the norms [1, 2] there are no direct recommendations on the need for grinding and back-up welding of weld root with subsequent cutting off of reinforcement flush with the wall to ensure a tight fit of the reinforcing coverplate.

Analysis of engineering solutions, proposed in the current norms, for ensuring complete penetration of the wall of RVS PK tank of 50,000 m^3 capacity at its joining to the wall of welded-in branchpipes, showed that at more than 20 mm thickness of the lower ring standard solutions do not guarantee producing a circumferential weld of the required quality. It is proposed to move over to a two-sided welding of the circumferential weld with two-sided edge preparation of the hole in the wall. In the solution presented in Figure 1, *d*, preservation of groove angle of $\alpha = 45°$ provides the conditions sufficient for sound welding of the weld root and filling the weld groove, while wall grooving from the outside gives good access for root cleaning and performing its sound back-up welding. Root weld reinforcement can be removed with an abrasive wheel or by making a chamfer on the coverplate.

Technology of welding branchpipes into the lower rings of tank walls also has certain peculiarities. The main of them consists in that the circumferential weld is made under the conditions of a rigid contour, when there is no compliance of welded elements and the transverse shrinkage deformations of the weld should be compensated by ductile properties of the metal of the wall and the weld proper. In order to compensate the above deformations, the current norms make special additional requirements to the tank wall metal: required ratio of yield point to tensile strength is equal to $\sigma_y/\sigma_t \le 0.75$ [2], value of reduction in area is $\psi_z \ge$ ≥ 25 % [3], and the circumferential weld proper should be subjected to heat treatment (tempering). When the tank is made of high-strength steels (S390 type, etc.) it is recommended to apply preheating and postweld local heating of its wall sections, adjacent to the circumferential weld, that improves the conditions for realization of high ductile properties of the base metal and weld metal. Used welding consumable should provide a sufficient ductility of the weld metal and, particularly, the root passes.

1. *PB 03-605–03*: Rules of construction of vertical cylindrical steel tanks for storage of oil and oil products. Moscow.
2. *API 650*: Welded steel tanks for storage of oil products. American National Standards Institute FNSI/STD 650. Introd. May 1993.
3. *GOST 28870–90*: Steel. Methods of tensile tests of plate iron in thickness direction. Introd. 01.01.92.