

Corrosion Protection of the Zone of Thermal Action (Zone of Butt of Tubes While Welding) from the Inside When Laying Multifunctional Pipeline Systems

V. A. Glouschenkov, V. F. Karpukhin

Samara State Aerospace University, Russia

Abstract

The work is aimed at handling a main problem of corrosion protection of the pipeline's interior section adjacent to a weld butt. It is proposed to execute fastening of elements of the protective system of pipes by application of the pulse-magnetic technology which has essential technical and economical advantages over other methods. Protection of end sections of pipes is performed by pulse-magnetic pressing-in of a bush made from stainless steel or by pulse-magnetic welding of rings from a protective material. Commercial tests of the pipelines produced by the technology being proposed supported good prospects of this technology use.

Keywords

Corrosion, Welding, Assembly

1 Introduction

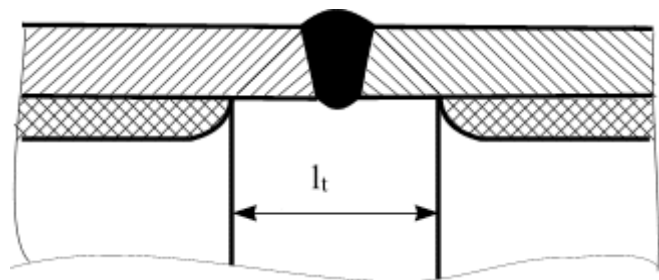
Experience of operating of pipelines shows that most of the accidents with pipelines are associated with the corrosion breakdown of tubes. So, while assembling and operating pipelines much attention is given to the corrosion protection of them.

Corrosion protection of pipelines from inside is performed in two directions. The first direction concerns the use of pipelines with a protective coating from the high corrosion-resistant materials. The second – use of cathodic protection wherein as a result of electrochemical processes, the protective material, preventing corrosion of the pipeline's material, dissolves in the course of operating of the pipelines.

In practice, both directions are widely used. Paint, varnish, polymeric, enamel and other coatings are used as protective ones.

At the present time while laying steel multifunctional pipeline systems only tubes with an inner anticorrosive coating are used. But during butt electric- arc welding of pipes, heat of the end sections of the pipes greatly exceeds their heat resistance. Therefore the subsequent protection of the pipes' sections adjacent to the weld butt is a complicated problem.

A draft of a zone of a pipeline's weld butt is shown in Fig.1. A weld butt is placed at a distance of 10-15 m from a free face, therefore applying a protective coating in this zone after welding is rather difficult to perform.



l_t – zone of thermal action

Figure 1: A draft of a zone of a pipeline's weld butt

One of the presently most abundant methods of protection of the zone of thermal action is the method of setting of TUBOSCOPE sealing bushes (US). But this technology has disadvantages: the process is conducted in-the-field, requires high accuracy of diameters to be butt-joined, it is rather labor-intensive because of use of hand work when applying a hermetic and setting a bush.

2 Research Results

The following methods of protection of the zone of thermal action with use of pulse-magnetic technologies were developed [1]:

- Welding of rings from aluminum alloys on pipes (cathodic protection);
- Pressing of thin-walled bushes from stainless steel in the zones adjacent to faces of pipes.

View of the zone of a weld butt with fastening of elements by the processes of pulse-magnetic technology is shown in Fig.2.

The advantages of pulse-magnetic loading are super-little machine time, high velocities of deformation, low power consumption, ecological safety of the processes. The processes of pulse-magnetic fastening the elements of corrosion protection of pipes are performed in stationary, working conditions with the rather simple technological attachments. They don't require close fitting the parts being joined. Therewith the technologies of applying the inner protective coating on pipes and of butt -welding pipes are essentially unchanged.

Figure 3 presents the process of fastening the protective rings in pipes with a help of pulse-magnetic welding [2].

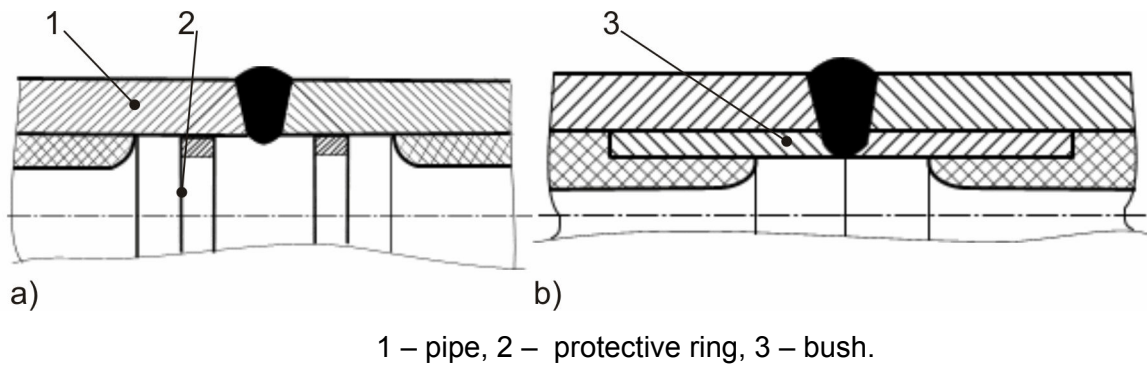


Figure 2: Zone of a pipeline's weld butt with corrosion protection by protectors (a) and with bushes from stainless steel (b).

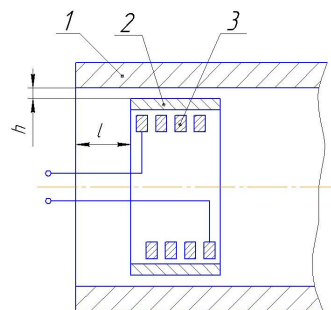


Figure 3: Scheme of process of welding protective rings with a pipe

Minimum values of a distance from the pipe face to the protective ring face l are selected such that during welding a butt of pipes, the temperature of the zone of joining of the protective ring with the pipe exceeds 350°C . The reliable joining of the parts being welded is formed by a high-speed collision of the protective ring 2 with the pipe inner surface 1. The protective ring is accelerated in the gap "h" to the speed, required for formation of joining of the materials being welded, under the action of radial electrodynamic forces appearing when an intense pulse current flows along the inductor 3.

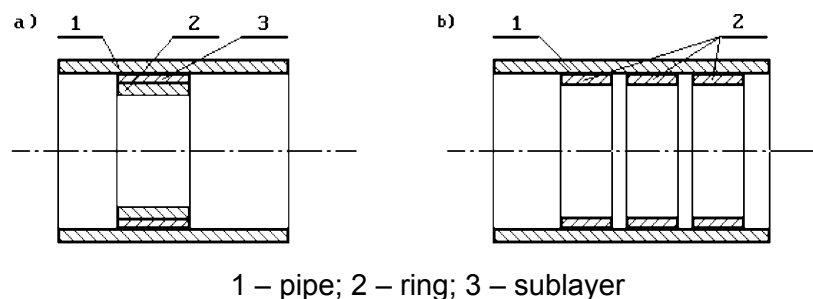


Figure 4: Protection of end sections of pipes with one protective ring (a) and with several rings (b)

Aluminum alloys alloyed with magnesium are used as protective materials. Joining such materials with steels by methods of welding under conditions of high-speed collision is impracticable [3]. Therefore the pipe's inner surface is clad with technically pure

aluminum by the method of pulse-magnetic welding and then the ring from a protective material is welded with the cladded surface of the pipe. View of such joint is shown in Figure 3a.

It is rationally to use pulse-magnetic welding for formation of welded joints of length no more than 20...25 mm [4] with ring's thickness of 2...3 mm. So length of the protective ring may not exceed 20...30 mm. To increase protector's mass several protective rings should be welded successively in a row [2] as it is shown in Fig. 4b.

In deciding on the technological parameters of the process of pulse-magnetic welding a protective ring with a pipe, it should be taken into account that pipes have a wide zone of tolerance on sizes. As a result a value of the initial gap between the surfaces being welded may differs essentially from the nominal value. To compensate for possible departures of the initial gap's value (at small values of the gap) it is necessary to increase considerably the energy of discharge as compared with the rated level. This greatly enhances the load on the inductor and reduces its life time. Moreover as the value of the initial gap increases the magnetic field pressure level, required for acceleration of the protective ring to the velocity providing formation of a welded joint, decreases. Therefore parameters of the process of pulse-magnetic welding must be selected in relation to the condition of collision of the parts being welded during the second quarter of the period of oscillations of the discharging current. Recommended value of epy initial gap is defined by the following expression:

$$h_{\min} > \frac{V_{\min}}{12f}, \quad (1)$$

Where V_{\min} is the minimum collision velocity providing formation of a welded joint, f is the operating frequency of the discharging current.

The maximum value of the initial gap is limited by two conditions. In the first place, a value of plastic deformation of the ring may not exceed a limiting value δ_p for the protective material. This condition is described by the expression:

$$h_{\max} < \delta_p R, \quad (2)$$

where R – the initial radius of the protective ring.

In the second place, the value of forces applied to the inductor's inner surface as a result of action of the "coil effect" may not exceed forces of interaction between the inductor and a billet. This condition is described to sufficient accuracy by the expression [5]:

$$h_{\max} = \sqrt{R_c + R_i} - (R_c + \delta_i), \quad (3)$$

where R_c and R_i are the inductor's outer and inner diameters, respectively and δ_i is a value of the insulating gap between the inductor and billet.

It is of prime importance to take into account conditions (2) and (3) when developing the technology of welding of protectors with pipes in diameters up to 130 mm.

Use of sufficiently large gaps makes it possible to perform welding of protective rings of one standard size with pipes of a variety of standard sizes different in wall thickness. For welding protectors with pipes of the same outer diameter with the wall thickness from 4 mm to 10 mm it will suffice to have two standard sizes of protective rings and, accordingly, two inductors.

The amplitude value of pulse-magnetic field pressure P , needed for acceleration of a protective ring of thickness “ s ” at the close of the first half-period of the discharging current to the velocity providing formation of a welded joint, is described by the expression:

$$P = 4V_{\min} \cdot f \cdot \rho \cdot s, \quad (4)$$

where ρ - density of the protective ring's material.

Pulse-magnetic pressing-in of a stainless steel bush is conducted by the scheme similar to the scheme shown in Figure 2. It differs in that the faces of a bush and pipe coincide ($l=0$), value of the gap h is minimum, because it is not necessary to accelerate the bush to high velocities; moreover in connection with low electric conductivity of stainless steel, a layer of a high electric conductivity material is placed between the inductor and the bush, it may be made for example by winding of aluminum foil. Thickness of the layer must comprise about 1 mm.

Value of pulse-magnetic field pressure necessary for pressing-in is defined by the expression:

$$P = \frac{6\sigma_s \cdot k \cdot s}{D}, \quad (5)$$

where σ_s - yield limit of the bush's material; D and s – diameter and thickness of the bush, respectively; k – dynamic coefficient of the yield limit of the bush's material which is computed from the formula [6]:

$$k = 3.006 \cdot \exp(-0.036 \cdot 10^{-7} \cdot \sigma_s), \quad (6)$$

Calculation of parameters of the inductor and the pulse-magnetic installation's charging energy needed for fastening elements of corrosion protection is performed by the known procedure presented in the work [7]. The expression (4) is used when calculating a process of welding protectors with pipes, the expression (5) – for pressing bushes in pipes.

The fragments of tubes welded with new technology of protection of the zone of thermal action were put to rapid and production tests and showed high quality of protection.

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