A method of monitoring contact (pointed) welding

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Abstract. The technology of welding parts of different thicknesses from various materials is improved, which is why the range of applied types and methods of welding is constantly expanding. In this regard, the issue of monitoring welded joints is particularly acute. The goal was: to develop a method of non-destructive radiographic inspection of point welds with a high accuracy rating of its quality.

With the development of technology, the technology of welding parts of different thicknesses from various materials is improved, which is why the range of applied types and methods of welding is constantly expanding. Currently, parts are welded with a thickness of several micrometers to several meters, made not only from structural steels, but also from special alloys based on non-ferrous and refractory metals, and also from composite materials [1]. In this regard, the issue of monitoring welded joints is particularly acute.

Allowing finding welding defects of macro dimensions, existing techniques are not sufficiently sensitive to microdefects, as well as to structural changes and, accordingly, changes in the mechanical properties of materials. Special difficulties raises a question of quality control at contact (pointed) welding of products [2].

In this regard, the goal was: to develop a method of non-destructive radiographic inspection of point welds with a high accuracy rating of its quality.

The most important distinguishing feature of the use of microfocus sources for radiography (the so-called microfocus shooting) is the possibility of obtaining sharp enlarged X-ray images of various objects. Depending on the specific size of the focal spot, the geometric parameters of shooting and some other factors, the magnification ratio of the size of the object in image compared to its true dimensions may range from several units to several hundreds, while maintaining quality and informative image (figure 1).

The main feature of this scheme is that the subject is positioned at a certain distance from the focal spot of the radiation source (focal length) and the entrance window of the receiver. The ratio of the indicated distances determines the image magnification ratio. Obviously, the microfocusing method of surveying makes it possible at a much higher level to assess the main criteria for the quality of a spot weld, such as:
- kernel presence;
- kernel depth;
- presence of drip fraction and caverns.
The main interest is determination of spot welding kernel depth. To form an algorithm for determining this parameter, preliminary tomographic studies were performed on a prototype of microfocus computer tomograph developed at the department of electronic instruments and devices. As objects of a research double and threefold connections from steel plates were used. The results of the volumetric reconstruction for the internal structure of the investigated objects are shown in figure 2.

![Figure 1](image1.png)

**Figure 1.** The image of a spot welded joint obtained by a microfocus method of shooting.

![Figure 2](image2.png)

**Figure 2.** Tomography of samples with contact welded connections: (a) – three-dimensional reconstruction of two-layer sample; (b) – cut in the field of contact welding kernel for two-layer sample; (c) – cut in the field of contact welding kernel for three-layer sample.
Figures 2(b) and 2(c) clearly show an area of the kernel, thus there are all preconditions to create a method for control the kernel depth of contact (spot) welding.

To determine the depth it is necessary to capture the object from two angles: after the first (direct) image, it is necessary to move the radiation source a certain distance parallel to the plane of the sample under study (figure 3). This operation is necessary for a more accurate assessment of the welded joint quality as depending on the location of welding can significantly change the physical parameters of the resulting structure.

By measuring the image size, the distance from the axis of the radiation source to the image, the distance to the object under study and the source shift, it is possible to determine the actual size of the spot welded joint, and, as a consequence, its position in the material.

Figure 3. Scheme for obtaining the images to determine the depth of welded joints: \( d \) – actual size of the weld; \( D \) – its enlarged image; \( D_1 \) – distance from the axis of the radiation source to the image; \( a \) – shift of radiation source; \( h_1 \) – distance from the source to the center of the object under control; \( h_2 \) – distance from the center of the investigated object to the receiver.

The relationship between the true size of the object and its magnified image described by the formula:

\[
D = \frac{h_1}{h_1 + h_2} d. \tag{1}
\]

Also by means of elementary mathematical transformations we can receive the following formula by analogy:

\[
D + D_1 = \frac{h_1 + h_2}{h_1} \left( a + d / 2 \right). \tag{2}
\]

Expressing parameter \( d \) in a formula (2) and substituting the received expression in a formula (1):

\[
\frac{h_1}{h_1 + h_2} = \frac{2a}{D + 2D_1}. \tag{3}
\]

Representing parameter \( h \) instead of \( h_1 \) and \( h_2 \) sum (distance from a source to the receiver which can be measured unambiguously), we will receive a final formula for calculation of a depth of pointed welded connection:
\[ h_t = \frac{2a \cdot h}{D + 2D_i}. \]

The offered control method of the products made by means of contact (pointed) welding allows to determine with high precision one of key parameters – a kernel depth.

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**References**

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