The Effects of Vibration Treatment in the Process of Welding on the Structure of Metal of Seam Weld

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Abstract. Today a sufficient number of works are known, which indicate the positive effect of vibrational oscillations superimposed both during the welding process of the structure and after it. The article discusses the features of the influence of low-frequency vibration oscillations during the welding cycle on the structure of the weld metal of steel 09G2S. Experimental survey of the influence of the vibration effect of the weld pool in the welding process on the physicomechanical properties of the metal of welded joints made it possible to prove the positive effect of this technology, manifested in an increase in the strength and fatigue endurance of the welded joints. This fact will allow expanding the application of vibration processing technology in the process of welding metal structures.

1. Introduction
One of the disadvantages of welded structures is that the properties of welded joints rarely reach 80% of the properties of the base metal.

This is explained by the fact that the welded joint is a stress concentrator due to thermal deformations, various defects, and structural changes.

To improve the mechanical properties of welded joints and increase the service life, various methods of heat treatment are used.

The disadvantage of such actions is the significant energy and labor costs, the inability to use in hard-to-reach places, reduced surface quality, etc.

A relatively new, yet unexplored way to improve the quality of welded joints is vibration treatment: treatment of hardened, molten and crystallizing metal [1-2].

More effective is the method of background vibration processing of joints directly in the welding process.

During vibration, the liquid metal during its solidification is exposed to rapidly alternating dynamic pulses, which cause the loss of weight, the compression of the metal due to a sharp change in its effective weight. With the loss of weight, the release of dissolved gases and the coagulation of their bubbles increases; with the subsequent compression of the metal, these bubbles are forcefully pushed to the surface.

The same happens with non-metallic inclusions [3].
Nascent crystals under the action of vibration pulses are not able at the beginning of the process of solidification of the metal to stay on the surface of the mold, especially if the acceleration is significant. They will be repelled by more heated particles towards the center and at the same time rush down. As a result, the uniformity of the metal structure in the thickness of the seam increases.

The structure shows a significant grinding of the metal: mechanical properties are improved, the physical density of the metal is significantly increased.

This allows you to get a wider range of positive effects.

Vibration processing involves local input of elastic vibrations, which significantly reduces the required power of vibration devices and increases the versatility of the method.

From various sources it is known that the vibration is also observed an increase in the shrinkage funnel profit. Liquation is practically eliminated. It is also possible to obtain special alloy structures [3-4].

This article presents the study of the influence of the main parameters of vibration loading on the weld pool by elastic vibrations, as well as the determination of the limit modes of vibration treatment in the welding of welded joints of low-carbon steels.

As confirmed by numerous studies, the best effect of the application of vibration treatment in the welding process is achieved at vibration amplitudes of 1.0 mm, at a frequency of 50 and up to 400 Hz.

When casting, the vibration amplitude is increased to 3...10 mm, while the vibration frequency is reduced to 30 Hz. This is largely due to the fact that with an increase in the amplitude of vibration (with an increase in the power of the introduced elastic vibrations), there is an increase in free energy, which is spent on breaking off the branches of dendrites and creating additional crystallization centers in the system.

However, in the welding process, the use of vibration amplitude of more than 1 mm leads to a decrease in the mechanical properties of the weld metal, the formation of cracks, pores and other defects.

Studies to determine the effective modes of vibration treatment in the welding process were carried out in the laboratory using a vibrating table VEDS-400 and a specially designed vibrating table, which was attached to an Electromechanical or pneumatic vibrator.

Analyzing the study of the limiting parameters of vibration processing, it can be established that a visually high-quality welded joint can be achieved in vibration modes with different vibration frequencies, but with an amplitude of vibration displacement of no more than 1...1.2 mm. the use of amplitudes above these values increased the likelihood of visually detectable defects in the form of pores or hot cracks in the weld.

This is due to the low deformation ability of the metal at the initial moment of crystallization, characterized by a temperature range of brittleness.

The influence of such parameters as frequency, vibration velocity and acceleration within the permissible vibration amplitude is not observed.

In this paper, a series of different studies confirming the impact of vibration treatment in the welding process on the structure of the metal and the weld pool.

Author Eldarhanov A.S. and others the researchers in their works have proved the increase of density of castings under vibration treatment, which further has a positive effect on the other properties of the metal.

However, the influence of the vibration effect of the weld pool on the increase in the density of the weld metal is not considered in the known works.

In order to determine the effect of vibration treatment on the density of the weld metal, the structure images were studied using a jeoljsm-6610LV scanning electron microscope.

The obtained images of the microstructure of the weld metal steel 09G2S with a 1000-fold increase are shown in figure 1.
As can be seen from these images, vibration processing can significantly reduce the size and area of the micro fields in the weld metal, reduce the grain size and increase the uniformity and to some extent the density of the structure.

Processing of these images showed that the diameters of the maximum micro fields with the use of vibration impact on the metal of the weld pool are reduced by almost 2.8...3 times, and the total area of the cavities - 1,48.

To assess the effect of modes of vibration treatment on the features of the microstructure of welded joints of the plates were made for the analysis of the microstructure of the sample.

Visual analysis of the weld metal microstructure was carried out using the EU METAM RV-21 optical microscope.

![Microstructure of weld metal](image)

**Figure 1.** Microstructure of weld metal x1000.

The analysis of the images allowed to establish that with the increase in the perturbing frequency of concomitant vibration processing, there is a decrease in the direction of the microstructure of the metal of the face roller of the weld due to the appearance in the dendrite structure of the branches of dendrites of the second and third order, which are characterized by smaller sizes and greater multidirectional in the transverse plane of the seam.

The increase in strength properties from the point of view of the microstructure is explained, firstly, due to the decrease in the average grain area, and secondly, due to the increase in the number of perlite phase in the weld metal with an increase in the intensity of vibration treatment.

The increase in the strength of the processed welded joints is confirmed by the results of measuring the microhardness of the metal.

Evaluation of hardness was carried out by using hardness testing of PTM-3M1 pressed trihedral diamond pyramid with a load of 0,981 N in grains of pearlite phase.

The measurement step on the weld area was 0,25 mm, in the zone of thermal influence – 0,50 mm.

The distribution of the values of micro hardness of the metal on the width of the welded joint is shown in figure 2.

Analysis of micro hardness distribution curves for different parts of the welded joint shows that with increasing frequency of vibration action there is a displacement of curves up the grid, i.e. there is an increase in the mechanical characteristics of the grains of the pearlite phase.

This, in turn, is confirmed by the results of mechanical tests of the weld metal presented in works [5-7].

At the same time, with increasing frequency of vibration action, smoothing of microhardness curves occurs, which indicates a decrease in the inhomogeneity of mechanical properties across the width of the welded joint.
This in turn increases the volume of weld metal involved in plastic deformation under static loading of welded joints, which is a factor increasing the characteristics of static strength.

![Figure 2. Distribution of the microhardness of the metal across the width of the weld from the center of the weld.](image)

2. Conclusion
The studies prove the positive effect of vibration on the structure of the crystallizing metal of the weld pool.
It is established that in the process of welding, vibration treatment should be carried out at a frequency of 100 to 200 Hz and an amplitude of up to 1 mm.

3. References
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