Technology of thermic welding with ultrasonic effect during a process of welding

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Abstract: In the presented paper a technology of thermic welding of pipelines and pipeline fittings with ultrasonic effect during the welding process is proposed. The technology allows to significantly increase strength of a welded joint by means of residual stresses' reduction, a reduction of grain sizes and degassing of a welded joint. Effect of ultrasonic increases speed of welding with a decrease of current, which results in energy saving. Results of theoretical and experimental studies of ultrasonic effect on welded joint and heat-affected zone are presented.
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Key words: Welding, Residual Stresses, Effect of Ultrasonic, Heat-Affected Zone.

Introduction

As it is well known, strength of welded joints is lower then strength of base metal. That is related with an appearance of inner and residual stresses during a process of welding, which are added to the operating stresses, which results in a failure of welded joints' metal.

Nowadays, in order to reduce residual stresses in welded joints of circulation pipelines and equipment of nuclear power stations a method of thermal tempering and deformation methods are implemented [1, 2].

Thermal and deformation methods allow to reduce residual stresses in heat-affected zone, but do not eliminate structural instability and physico-chemical heterogeneity, which result in a formation of internal stresses in a welded joint's metal and microcracks [3].

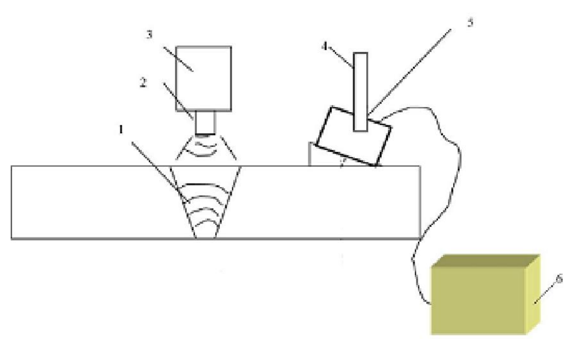


Fig. 1. Scheme of ultrasonic influence on welded joint during welding process:
1 – welded joint, 2 – electrode, 3 – holder, 4 – mounting bracket, 5 – ultrasonic transducer, 6 – ultrasonic generator

Main part

In National Research Nuclear University «MEPhI», the technology was developed, which comprises thermic welding with ultrasonic ultrasonic effect during welding process, as a result of which metal structure becomes fine-grained and homogeneous. As a result, internal stresses are excluded, residual stresses in heat-affected zone are removed. Scheme of ultrasonics influence on welded joint during welding process is presented in fig.1. Diagram of a mechanism of ultrasonic effect on crystallization process of a welded joint's metal is presented in fig.2. The role of individual factors of ultrasonic field in a creation of certain structural changes in metal depends on crystallization conditions. In different zones of crystallizing melt an influence of a certain factor of ultrasonic field can be prevailing. For example, crystals dispersion can occur in two-phase zone, but acoustic streams and agitaion may occur only in liquid phase. If a decrease in size of grain and removal of columnar structure occur as a result of ultrasonic dispersing, then a change in nature of phases' distribution and a process of dendritic segregation are determined, generally, by a change in temperature gradient in melt and agitation. Due to those reasons, main causes of dispersion are cavitation, forces of viscous friction, oscillatory and radiation pressures. An increase in speed of crystallization centers emerge is related with the same parameters [4-7].

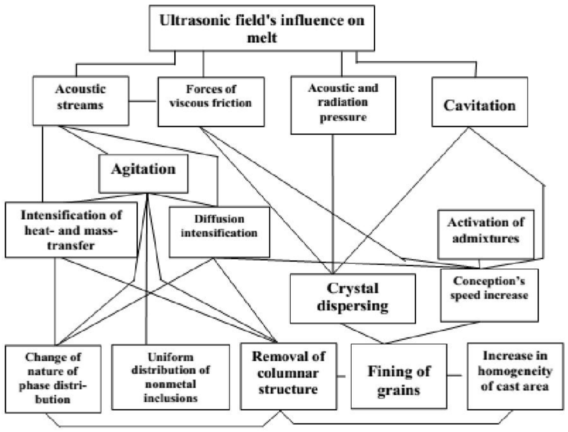


Fig. 2. Diagram of a mechanism of ultrasonic effect on crystallization process and degassing of metal

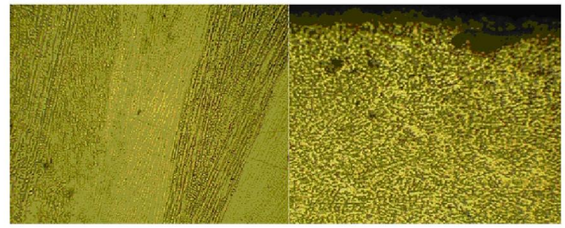
Cavitation phenomena in melt may appear, if oscillatory pressure in it is greater, than a value which is specific and characteristic for the given substance. In molten metal conditions for a development of cavitation processes are favorable. One of the reasons for that is a large saturation of melts with dissolved gases, which promotes a formation of cavitation bubbles. Moreover, due to different solubility of gases in solid and liquid phases, excess amount of free gas is formed at crystallization front, which creates an additional source of caviation formation centers and reduces cavitation threshold in that zone.

During melt's degassing in ultrasonic field in developed cavitation mode, following processes take place: a formation of cavitation bubbles; growth of bubbles as a result of directed diffusion of melt in a cavity and carryover of bubbles on melt's surface [8].

The mechanism of ultrasonic influence on heat-affected zone consists in that effect of ultrasonic also leads to an increase of internal energy of metal due to an increase excitation of lattice oscillation, point defects, dislocations and temperature increase.

Results of the investigations of ultrasonic effect on welding process of welded joints of nuclear power station's equipment are presented below (fig.3) [9].

Nowadays, for nuclear power stations with RBMK-1000 reactors the most problematic are DN300 circulation pipelines welded joints, for nuclear power stations with WWER reactors – welded joints of steam generators PGV-1000 and PGV-440.

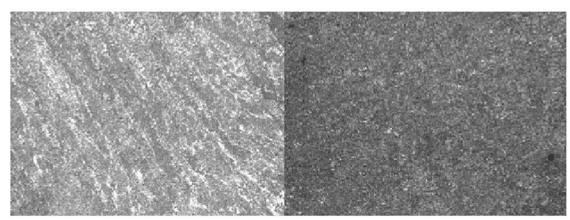


a b

Fig. 3. Microstructure of austenite metal of welded joint of DN300 pipeline (steel type is 08X18H10T according to Russian standard designation), which was obtained: a – without ultrasonic effect, b – with ultrasonic effect (×125 magnification).

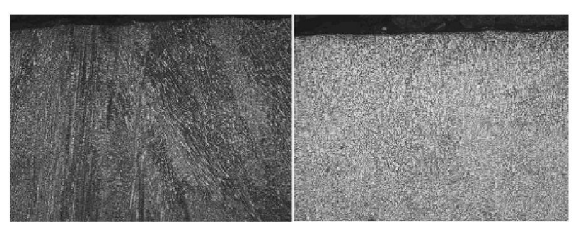
The results of the studies of welded joints of DN300 pipeline, produced with ultrasonic effect, showed that the structure of a welded joint's metal becomes fine-grained and homogeneous (fig.3). Also, a significant decrease in residual stress and an improvement of plastic properties are detected. Specific elongation of a welded joint's metal specimens, produced with ultrasonic effect, increased in 4, 5 times.

The study of welded joint specimens #111 PGV-1000 and #23 PGV-440, which were produced with ultrasonic effect, demonstrated similar results. Structure of welded joint metal after ultrasonic processing had changed and became fine-grained and homogeneous (fig.4, fig.5), residual stresses had decreased in 2.5-3 times [10].



a) b)

Fig. 4. Microstructure of welded joint #111 PGV-1000M:
a) produced without ultrasonic effect, b) produced with ultrasonic effect.



a b

Fig.5. Microstructure of welded joint #23:
a) produced without ultrasonic effect, b) produced with ultrasonic effect.

Conclusions

Ultrasonic processing of welded joints during the welding process has a significant influence on strength characteristics and, respectively, on service life of energy facilities' equipment. Microstructure of metal in heat-affected zone of welded joint becomes fine-grained and homogeneous. Residual stresses decrease significantly. Mechanical and strength properties of nuclear power station equipment increase.

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References

1. Larionov, V.P., V.R. Kuz'min, O.I. Slepcov et al., 2005. Cold-resistance of materials and structural elements. Results and perspectives, pp: 288.
2. Statnilov, E.Sh. and V.O. Muktepavel, 2003. Technology of ultrasonic impact treatment as a method of an increase of reliability and durability of welded metal structures. Welding engineering, 4: 25-29.
3. Marushchak, P.O., U.V. Salo, R.T. Bishchak and L.Ya. Poberezhnyi, 2014. Study of Main Gas Pipeline Steel Strain Hardening after Prolonged Operation. Chemical and Petroleum Engineering, 1-2(50): pp: 58-61.
4. Pleshanov, V.S, V.V Kibitkin and V.E. Panin, 1998. Mesomechanics and Fatigue Fracture for polycrystals with macroconcentratrs. Theoretical and Applied Fracture Mechanics, 1(30): 13-18.
5. Blaha, F. and B. Langenecker, 1955. Naturwi, 9(20): 556.
6. Prokopenko, G.I. and T.A. Lyatun, 1977. Study of Surface Hardening Conditions by Means of Ultrasonic. Physics and Chemistry of Material Processing, 3: 91.
7. Kudryavtsev Y., J. Kleiman, G. Prokopenko, P. Mikheev and V. Knysh, 2001. Optimum Application of Ultrasonic Peening. SEM Annual Conference and Exposition: Experimental Mechanics in Emerging Technologies. Portland. Oregon. USA, pp: 179-182.
8. Trofimov, A.I., M.A. Trofimov and S.I. Minin, 2009. Mechanism of residual stresses hange in metals and alloys with effect of ultrasonic. Scientific discovery, Diploma #375.
9. Trofimov, A.I., 2009. Physical foundation of ultrasonic method for residual stresses removal in metals and alloys. M.: Energoatomizdat, pp: 239.
10. Trofimov, A.I., M.A. Trofimov, S.I. Minin and Yu.A. Kirillov, 2012. Innovative ultrasonic technologies for an increase of nulclear power stations equipment's service life during its production. News of higher educational institutions. Nuclear power engineering, 2: 48-54.

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