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THE INFLUENCE OF WELD POOL HARMONIC OSCILLATIONS BY FREQUENCY UP TO 4,5 HZ ONTO THE METAL STRUCTURE FORMATION OF WELD BEAD AND HEAT AFFECTED ZONE

ВПЛИВ ГАРМОНІЙНИХ КОЛИВАНЬ ЗВАРЮВАЛЬНОЇ ВАННИ ЧАСТОТОЮ ДО 4,5 ГЦ НА ФОРМУВАННЯ МЕТАЛЕВОЇ СТРУКТУРИ НАПЛАВЛЕНИХ ВАЛИКІВ ТА ЗОНИ ТЕРМІЧНОГО ВПЛИВУ

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Abstract. A comparative metallographic analysis of the welded metal and heat affected zone of weld beads that obtained with application of the weld pool transverse harmonic oscillations with amplitudes of 0.5 and 4 mm and a frequency range from 0 to 4.5 Hz is given. The character of the structure formation in the cross section of each welded bead in the center, in the root part and at the fusion line is described. The main structural components of the welded metal are various forms of ferrite and perlite. The significant differences in the structure of the welded metal samples which obtained by surfacing process at an amplitude of 4 mm is shown. Corresponding illustrations are given.

Keywords: weld bead; acicular ferrite; amplitude; frequency; microstructure; crystallite.

Анотація. Наведено порівняльний металографічний аналіз наплавленого металу та металу зони термічного впливу валиків, отриманих наплавленням в умовах поперечних гармонійних коливань зварювальної ванни у частотному діапазоні від 0 до 4,5 Гц та з амплітудами 0,5 та 4 мм. Описано характер структурного формування кожного валика у центрі, біля лінії сплавлення та корні шва поперечного перетину. Основними структурними компонентами наплавленого металу є різні форми фериту та перліт. Найбільш суттєві відмінності у структурі наплавленого металу зразків спостерігаються при коливаннях з амплітудою 4 мм. Наведено відповідні ілюстрації.

Ключові слові: наплавлений валик; голчастий ферит; амплітуда; частота; мікроструктура; кристаліт.

Аннотация. Приведен сравнительный металлографический анализ наплавленного металла и металла зоны термического влияния валиков, полученных наплавкой в условиях поперечных гармонических колебаний сварочной ванны в частотном диапазоне от 0 до 4,5 Гц и с амплитудами 0,5 и 4 мм. Описан характер структурного формирования каждого валика в центре, возле линии сплавления и корне шва поперечного сечения. Основными структурными компонентами наплавленного металла являются различные формы феррита и перлита. Наиболее существенные различия в структуре наплавленного металла образцов наблюдаются при колебаниях с амплитудой 4 мм. Приведены соответствующие иллюстрации.

Ключевые слова: наплавленный валик; игольчатый феррит; амплитуда; частота; микроструктура; кристаллит.

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Problem statement. The increase of welding constructions technological strength is always being the actual problem. Nowadays, the more simplest and cheapest method of technological strength increase is mechanical low-frequency acting over weld pool melt or welding tool.

Latest research and publications analysis. However, methods are used that based on application of pulse welding processes managed by given algorithms [1], welding pulse-arc adaptive methods [2], methods of periodic influence on the weld pool melt by magnetic fields [3].

These technologies effectiveness is due to the use of frequencies above 5 Hz. The effect of the frequency range below 5 Hz with mechanical oscillations has not been studied enough.

THE ARTICLE AIM is detecting of influence character of mechanical low-frequency periodic influence on weld metal structure were carried out metallographic researches of surfacing samples are obtained at frequencies up to 4,5 Hz by technological mode: $I = 215$ A; $U = 26$ V; $V = 36$ m/h.

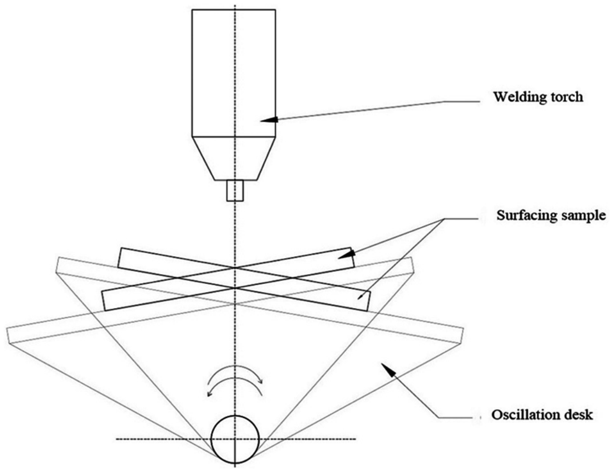

Fig. 1. Scheme of weld pool harmonic oscillations

Basic material. The weld pool oscillation character is shown by Fig. 1, herewith, under amplitude have to understand there the length of site of circumference on which the it is welding torch maximum bias from vertical axle. The angle value of deviation from vertical is not more than 10°. A surfacing samples are low-carbon steel plates with thickness of 8 mm. The surfacing process is acted by weld wire named ER70S-6 with diameter 1,2 mm. As gas used in the experiments was technical CO_2 — 99,5 %, gas flow rate of 9…12 l/min. The weld pool oscillations are carried through by a programming stepper motor. The amplitude-frequency modes of surfacing processes of samples are shown in table 1. Welded samples has had polished to 14 class of clean and then were etching in 4 % alcohol solution of nitric acid for a 10 sec. before microstructure researches. A research of structure of welded metal was carried out by microscope NEOPHOT – 32 and digital camera OLYMPUS.

The researches of cross-sections of weld beads have been carried out by scheme is shown on Fig. 2.

Researches of welded metal showed a formation of structure with classical crystallites orientation — crystallites are growing perpendicular to the divide

Table 1. The values of amplitude-frequency characteristics at which specimens were obtained

Specimen number	Frequency, Hz	Amplitude, mm
1	Without oscillations	
2	2,5	0,5
3	3	
4	4	
5	4,5	
6	3,7	4
7	3,8	
8	3,9	
9	4	

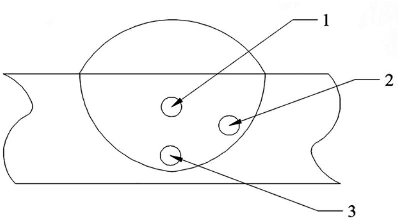

Fig. 2. The scheme of measure:
1 — center of bead; *2* — near fusion line; *3* — in a root part

plane of the weld pool metal and the base metal. The enlargement of crystallites occurs more intense with a distance increase from fusion area of the weld pool metal and the base metal [4]. The metal structure of all welded samples is the same and consists from different ferrite modifications (polygonal, polyhedral, acicular) and perlite. The polygonal ferrite is observed like a thin elongate phases located along of the cast crystallites borders. Polyhedral ferrite is observed like clusters of an equiaxial ferrite grains.

The acicular ferrite is observed in bodies of cast crystallites and looks like plates with so-called “basket weave”. The perlite is observed like dispersed phases located along of the ferrite grains borders. The described structure is more typical for the samples 3–5 (Fig. 3). The character feature of the primary structure of samples 1–3 is a dominance of the cellular cast structure in the root part of welded beads. The cells have some elongate form. The ferrite–perlite structure is observed in a base metal of all samples.

The mixture of lower and upper bainite with dominance of the first one is observed as in the large grain region (LGR) and as small grain region (SLR) of (HAZ) of samples 1–5.

The basic structural components of a metal of welded bead of sample 1 are small-acicular ferrite, narrow streaks of polygonal ferrite and a small areas of polyhedral ferrite (Fig. 4).

The characteristic feature of microstructure sample 2 is the exist thinner areas of polygonal ferrite and small areas polyhedral ferrite as well, by compared other samples (Fig. 5).

The characteristic features microstructure of sample 6 are observably more widely areas of polygonal ferrite located along boarders of cast crystallites, greatly enlarged plates of acicular ferrite as well. The HAZ-microstructure besides basic ferrite–pearlite structure contains small bainite areas near fusion line (Fig. 6).

The characteristic feature of microstructure sample 7 is an enlarged size of plates of acicular ferrite (Fig. 7). The HAZ-microstructure composition of samples 6–9 is a mixture of bainite, ferrite, perlite.

The welded metal crystallization of sample 8 has predominantly a cellular structure with the selection of polygonal ferrite phases, as well. A cellular character of crystallization is more inherent for root part. Besides, microstructure crystals are less elongated to direction of temperature gradient to compared other samples (Fig. 8).

The microstructure of sample 9 has a plates of acicular ferrite are some large compared other samples and it is observed more emphasizing of polyhedral and polygonal ferrite compared with sample 1 as well (Fig. 9).

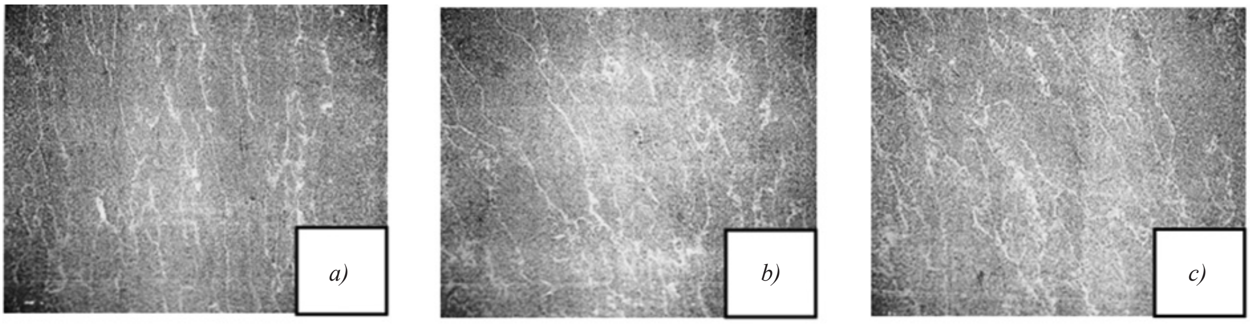

Fig. 3. Microstructure of sample 3, ×200:
a — center of bead; *b* — near fusion line; *c* — root part

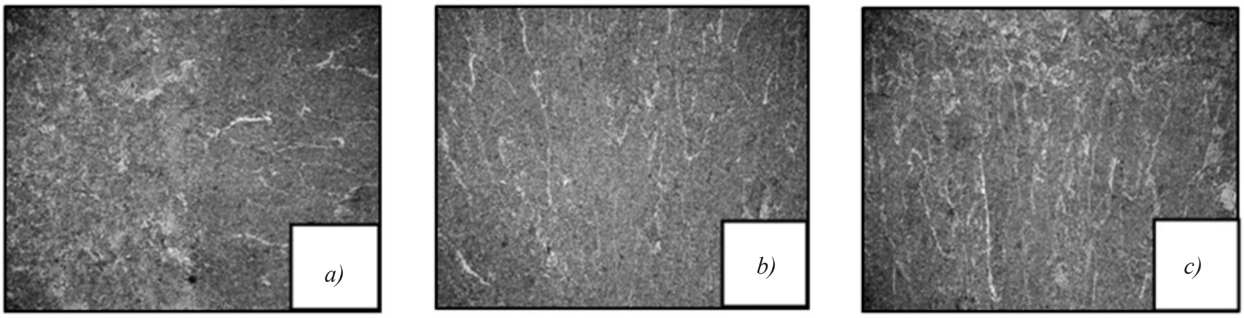

Fig. 4. Microstructure of sample 1, ×200:
a — center of bead; *b* — near fusion line; *c* — root part

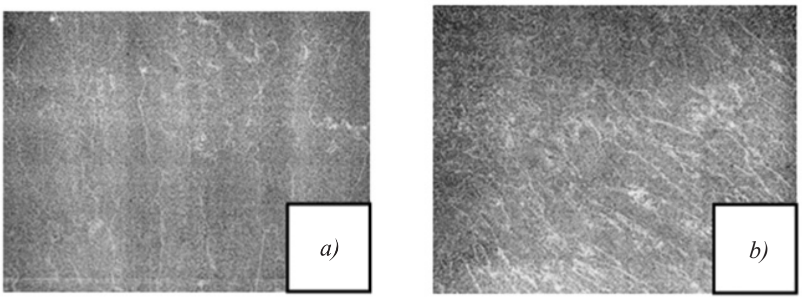

Fig. 5. Microstructure of sample 2, ×200:
a — center of bead; *b* — near fusion line

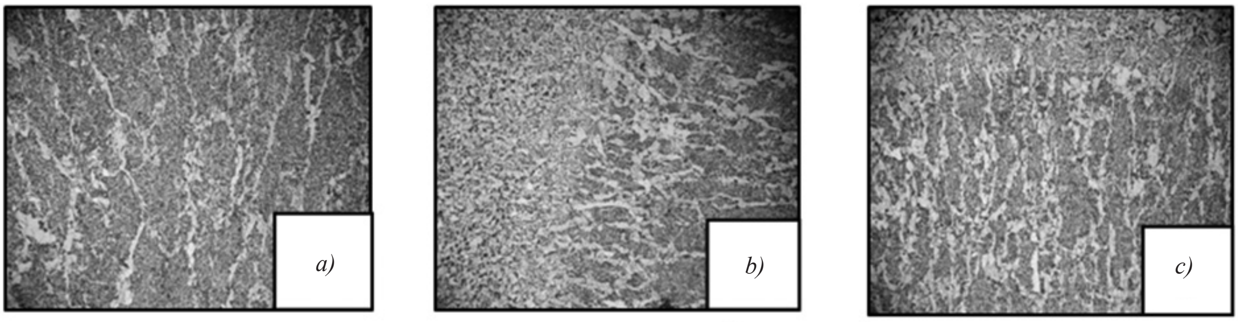

Fig. 6. Microstructure of sample 6, ×200:
a — center of bead; *b* — near fusion line; *c* — root part

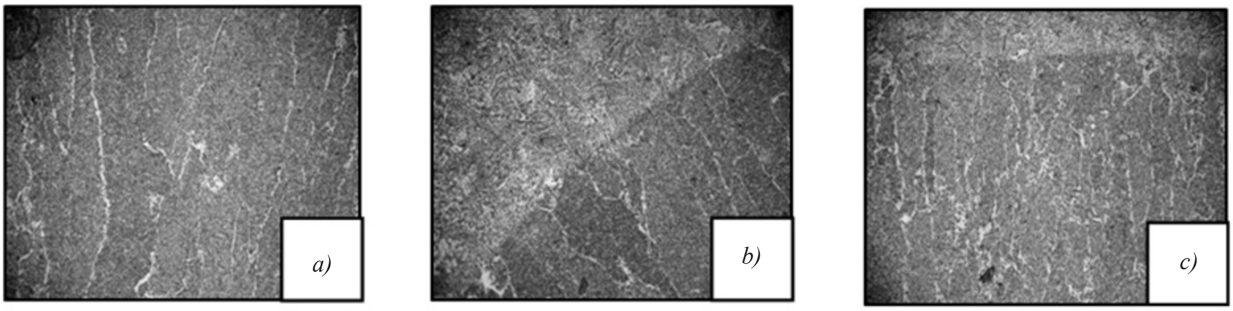

Fig. 7. Microstructure of sample 7, ×200:
a — center of bead; *b* — near fusion line; *c* — root part

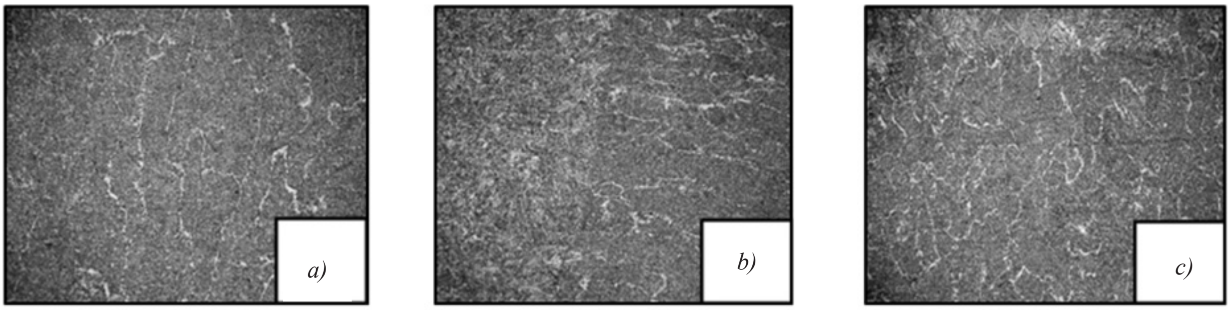

Fig. 8. Microstructure of sample 8, ×200:
a — center of bead; *b* — near fusion line; *c* — root part

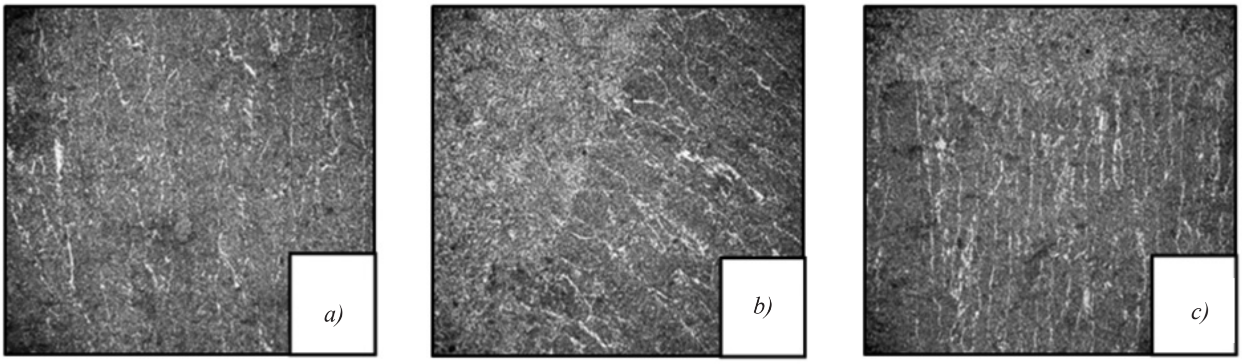

Fig. 9. Microstructure of sample 9, ×200:
a) center of bead; *b)* near fusion line; *c)* root part

CONCLUSIONS. The crystallites classical orientation is observed in all the samples, i.e. the crystals grow perpendicular to the separation plane of the weld pool metal and the base metal. Also, in all samples is observed the crystallites enlarged as the distance from the fusion zone increases. The weld metal of samples 2–5 which obtained at an amplitude of 0.5 mm and a frequency range from 0 to 4 Hz, has almost no structural differences from sample 1 which obtained without oscillations. In the weld metal of samples 6–9, i.e. obtained at an amplitude of 4 mm, is observed the proportion of polygonal and acicular ferrite increases and somewhat less than polyhedral ferrite with an increase in the oscillation frequency of the weld pool. If the HAZ-microstructure is a mixture of lower and upper bainite at an amplitude of 0,5 mm, then this structure is ferrite-perlite at an amplitude of 4 mm.

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