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Elimination of starting pores in manual shielded-metal arc welding

Tomsk Polytechnic University

Butsykin S.E. [a], Kiselev A.S. [b]

[a] School of Advanced Manufacturing Technologies, Tomsk Polytechnic University
[b] School of Non-Destructive Testing, Tomsk Polytechnic University

Abstract

The paper studies the influence of the amplitude-time parameters of the welding current modulation at the initial moment of welding on the value of starting porosity. The authors investigated the butt welds of two identical 17GS plates were investigated. The dependence of starting pore formation on the value and duration of the modulation of the welding current, as well as its polarity were revealed using radiation introscopy of deposited weld metal. The results showed that stabilization of the transfer of electrode metal occurs in a shorter time when using a hot start. With the right choice of the hot start mode, the danger of the electrode sticking is completely eliminated, which in turn will reduce the number of ignitions of the arc discharge and, hence, the starting porosity.

Keywords: Starting pores, hot start, weld metal, electrode coating;

1. Introduction

Currently, one of the most common methods for producing permanent metal structures is manual shielded-metal arc welding due to its functional simplicity and versatility. However, there is a high probability of pore formation of the initial weld section when using this method due to the lack of gas protection of the weld pool during the arc ignition period. This is due to the fact that at the initial moment of welding when the arc is ignited, the process of its burning is unstable which leads to a large number of short circuits (i.e., it is not possible to excite an arc discharge by touching the electrode once with a metal) [1]. Therefore, with short-term ignitions the coating does not have time to melt. At these moments, the metal is transferred without protection resulting in arising of starting pores. Therefore, improving the conditions of arc ignition or providing high-quality initial gas protection for metal transfer, we should reduce the formation of starting porosity.

Elimination of weld metal porosity by subsequent welding of the samples leads to a significant cost increase, decline in productivity and reliability of welded assemblies during operation [2]. The development of methods and algorithms for eliminating starting pores directly during the welding process is an urgent task as it will increase the quality of the weld, productivity and reliability of the structure.

The use of a hot start was proposed to prevent starting porosity (the method of increasing the current density during the initial ignition of the arc by increasing the value of the welding current).

2. Materials and methods

The inverter-type welding rectifier Invertec V350-PRO of the Lincoln Electric was chosen as the power source, because it has a “Hot start” regulator, which enables to adjust the initial current at the moment of arc ignition. The determination of the influence of the amplitude-time parameters of the hot start was performed on steel specimens of grade 17GS (structural low-alloy steel) by cladding with coated electrodes LB-52U Ø3.2 mm (sample sizes 3×100×40 mm).

The surfacing on steel samples was performed in the downward position. The mode parameters are shown in Table 1. Three beads were surfaced on each sample in order to exclude the possibility of a disturbing effect on the experiment. After each surfacing, the samples were cooled to room temperature to prevent thermal influence on the deposited metal. The duration and volume of the initial current were recorded using an AK4P-4122/1V digital storage oscilloscope.

Table 1. The mode parameters

№	Polarity	Preset welding current I_{nom}, A	Hot start volume I_{hs}, A	Initial current duration t_{hs}, s
1	Reversed	75	75	-
2	Direct	75	75	-
3	Reversed	75	112	1
4	Direct	75	112	1
5	Reversed	75	150	1.6
6	Direct	75	150	1.6

3. Results and discussions

To obtain an image of the internal state of the weld metal for determining the internal structure of the weld radiation introscopy methods were performed. Based on the findings, we constructed the dependency plots of the number of pores (n) in the deposited metal on the starting value of the current (I_{hs}) (Fig. 1, 2).

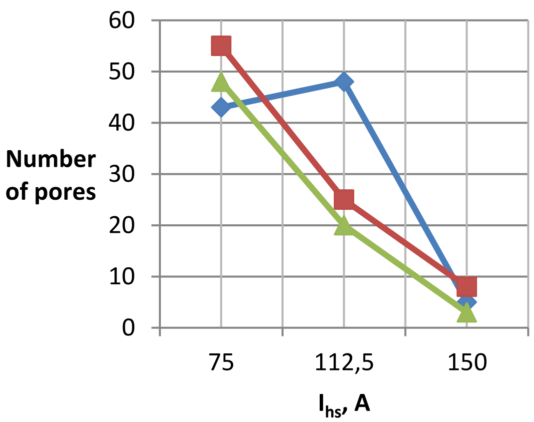

Fig. 1. Porosity for reverse polarity welding

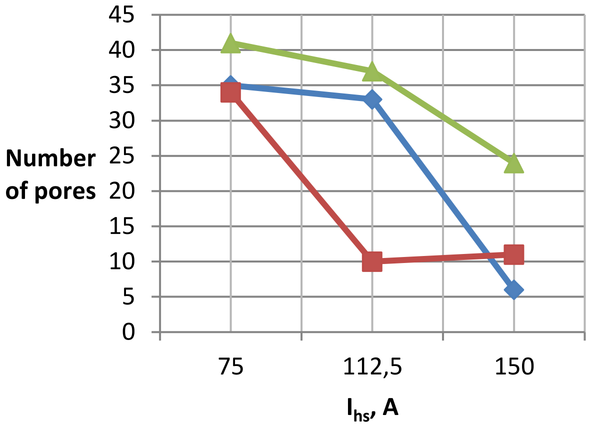

Fig. 2. Porosity for direct polarity welding

According to the graphs with an increase of the preset welding current by 100%, the pore formation in the zone of unsteady arc burning is minimized (from 3 to 10 pores in the weld metal) regardless of the polarity of the welding current. With an increase in welding current at the initial moment by 50%, pore formation also decreases, but much less.

In cases where an increase in the welding current at the initial moment was not performed ($I_{hs} = I_{nom}$), the number of pores in the weld for reversed polarity is 1.5 times greater than the direct polarity porosity. This is explained by the fact that with direct polarity, the cathode region is in the near-electrode region where the electric field strength is $E_k = 2{\cdot}10^6$ V/cm, which is much larger than in the anode region - $E_a = 10^4$ V/cm [3]. Consequently, the cathode region temperature is several thousand degrees higher than the anode one and, consequently, melting of the electrode coating occurs faster in direct polarity providing atmospheric protection of the weld zone.

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