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Alloying Elements Transition Into the Weld Metal When Using an Inventor Power Source

R A Mamadaliev[1], V N Kuskov[2], A A Popova[3], D V Valuev[4]

[1,2,3,] 625000, Tyumen, 38 Volodarskogo st.,Tyumen State Oil and Gas University
[4] 652050, Kemerovo region, Yurga, Leningradskaya str.26 Yurga Technological Institute branch of Tomsk Polytechnic University

E-mail: mamadaliev_it@mail.ru

Abstract. The temperature distribution over the surface of the welded 12Kh18N10T steel plates using the inventor power source ARC-200 has been calculated. In order to imitate multi-pass welding when conducting the thermal analysis the initial temperature was changed from 298K up to 798K in 100K increments. It has been determined that alloying elements transition into the weld metal depends on temperature. Using an inventor power source facilitates a uniform distribution of alloying elements along the length and height of the weld seam.

1. Introduction

Multi-pass manual arc welding is one of the well-known and common welding techniques used in the industry. Despite its widespread use, problems frequently occur due to a number of drawbacks which result in lack of penetration, possible deformations, slag inclusions, discontinuities, as well as an increased heat affected zone.

Steel 12Kh18N10T is widely used for manufacturing products utilized in aggressive media. However, it is worth mentioning that the main difficulties when welding this steel are its tendency to form crystallization cracks, increased electrode heat and possible loss of corrosion resistance by the weld seams. The base metal for the experiment was selected considering the construction materials applied in the power, oil and gas, instrument-making and other leading sectors of Tyumen region.

The research objective is to calculate thermal cycle curves at varying distances from the heat source and demonstrate temperature influence on alloying elements transition into the weld metal.

2. Materials and methods

Plates 150x50x26 mm in size (length x width x thickness) were butt welded with an OK 61.30 ESAB grade electrode using an inverter power source ARC-200 [1,2]. Welding was performed using the reversed polarity direct current with the amperage specified according to the electrode grade, the number of passes being 5.

In order to imitate multi-pass welding when conducting the thermal analysis on personal computer using «Tpole» software the initial temperatures were taken from 298K up to 798K in 100K increments. The *x*-axis is directed along the weld, the *y*-axis – perpendicular, and the *z*-axis – along the height of the plate.

At the first stage the input data are thermophysical parameters, plate sizes, welding variables. Calculations are performed for each plate separately. Then, according to the given conditions of

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welding, a computational diagram is determined: a moving (fast-moving) point source on the surface of a semi-infinite body, a moving (fast-moving) point source on the surface of a plane. Values X, Y, Z are given in centimeters, assuming Z = 0, i.e. temperature is calculated on the surface of the welded plates. Based on the obtained results thermal cycle curves were constructed. Figures 1-4 give examples for various initial temperatures.

Thermal cycle curves are constructed in the coordinate system where:

1) Y values are plotted on the axis of ordinates at constant X values, and on the axis of applicates – temperature values (Figures 1 and 4);

2) X values are plotted on the axis of ordinates at constant Y values, and on the axis of applicates – temperature values (Figures 2 and 3).

To determine the chemical composition of the weld metal, electrode rod and coating we used the X-ray fluorescence analysis (XRF) of a ground weld on a spectrometer X-MET 5000 with a software suit X-MET. The excitation source was an X-ray tube with a rhodium anode PW 1404/00 (voltage – 60 kV, amperage – 50 mA). The time it took to identify one element at a depth of 0.1 – 0.5 mm from the surface was approximately 1 minute.

3. Results and Discussion

Figure 1 shows thermal cycle curves at the initial temperature of 298K. The graph lines show heat distribution from the weld to the plate edges (along the *x*-axis). Along the *y*-axis they are symmetrical to the weld axis.

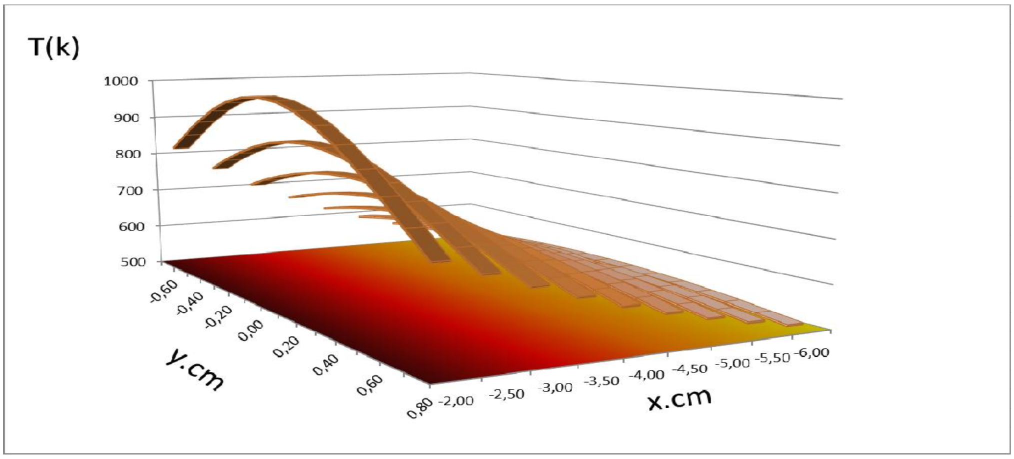

Figure 1. Thermal cycle curves at constant X values and the initial temperature of 298 K.

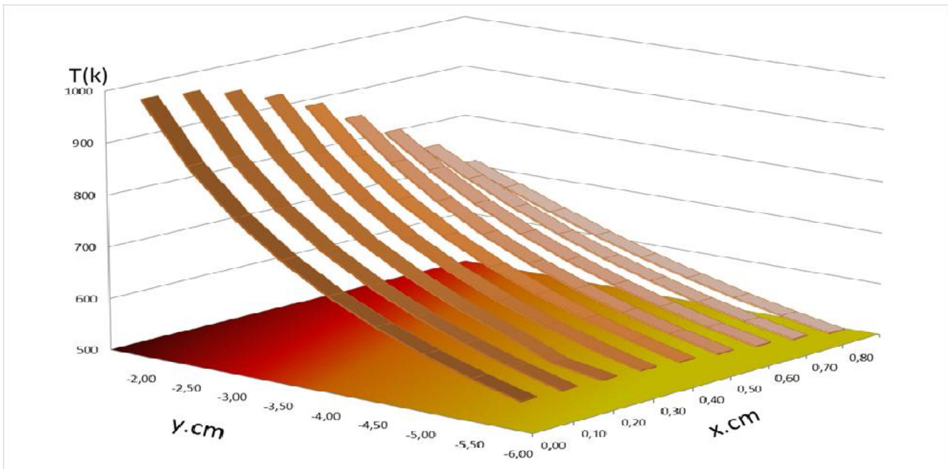

Figure 2. Thermal cycle curves at constant Y values and the initial temperature of 398 K.

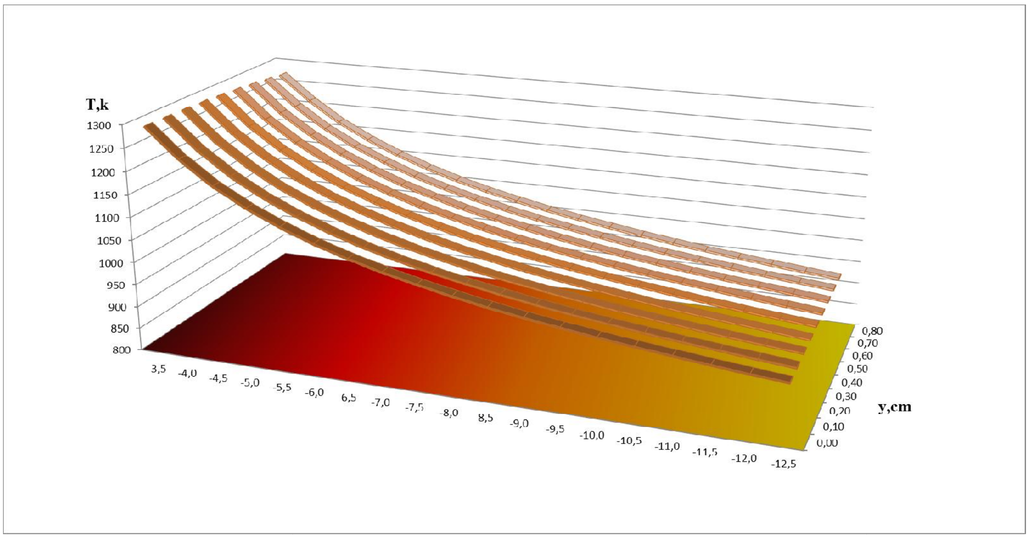

Figure 3. Thermal cycle curves at constant Y values and the initial temperature of 698 K.

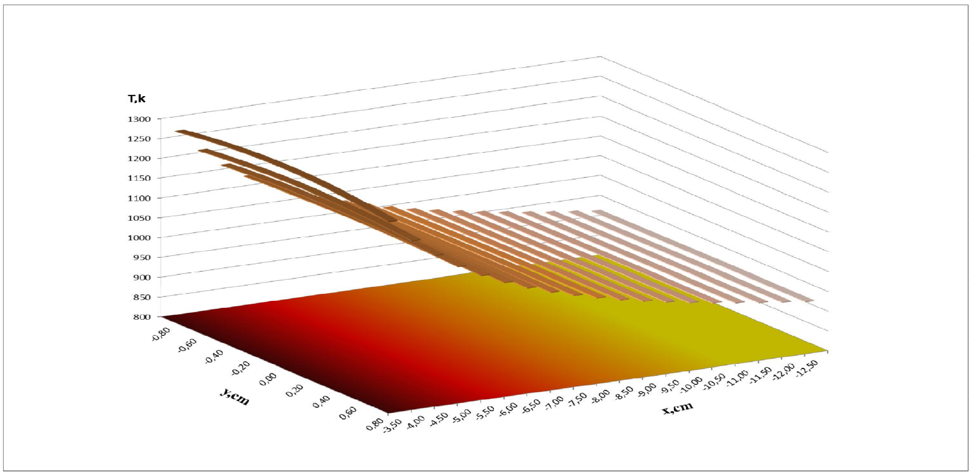

Figure 4. Thermal cycle curves at constant X values and the initial temperature of 798 K.

Naturally, as the initial temperature increases the maximum heat temperatures and heat affected zone width increase as well. From the calculated curves one can evaluate the areas of superheat, hardening, etc. The dependence of alloying elements transition into the weld metal on temperature has been established (Figure 5).

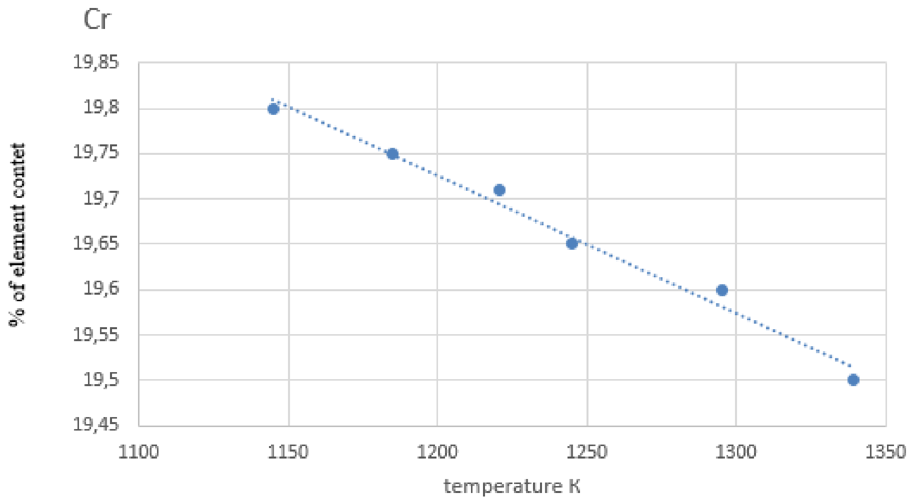

Figure 5. The dependence of chromium content in the weld metal on temperature.

Figures 6 and 7 give the examples of alloying elements distribution along the weld length in its top layers (equal numbers on the *x*-axis correspond to one pass). Chromium and titanium content differs within the measurement accuracy [3]. The content of alloying elements in the top layers is slightly less compared to the middle layers.

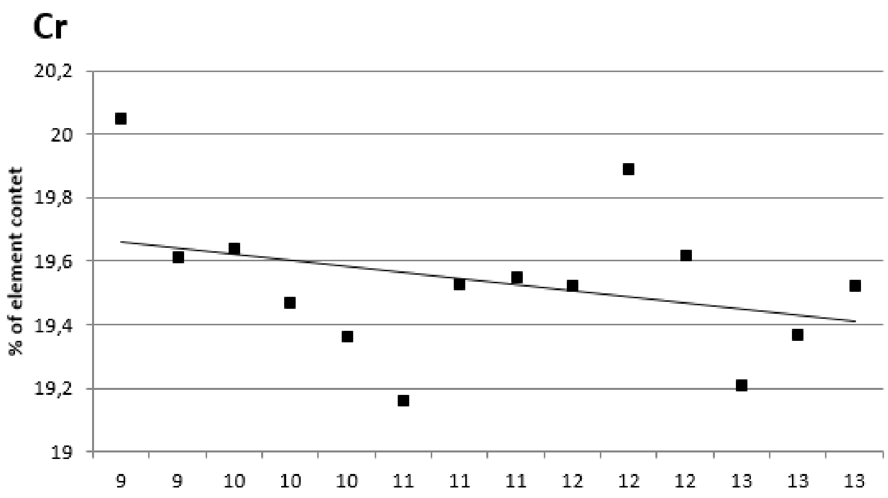

Figure 6. The content of chromium in the weld metal of a multi-layer weld.

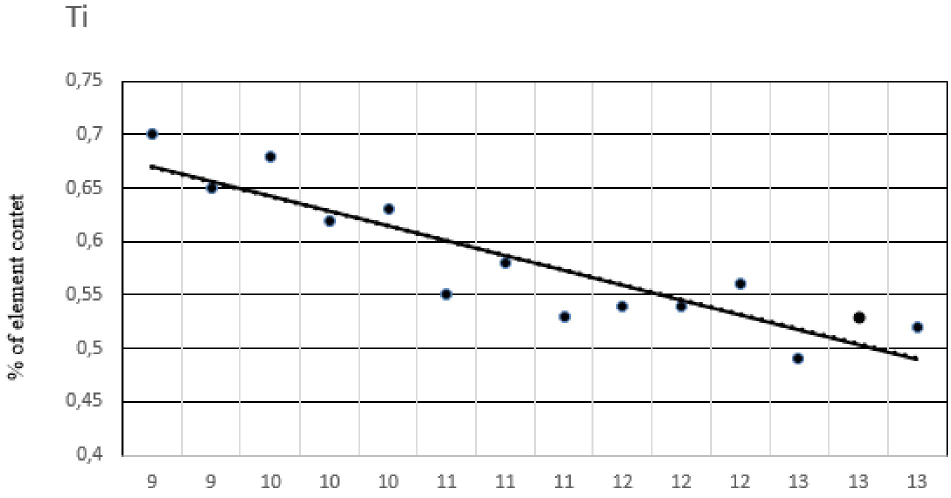

Figure 7. The content of titanium in the weld metal of a multi-layer weld.

Figure 8 shows the example of the structure of weld (cast) and base (austenite) metals. Both the fusion line between them and the layer fusion area can be observed.

Figure 8. The fusion zone microstructure.

4. Conclusion

The results of the investigation allow us to make the following conclusion. Chromium content in the weld metal is from 19.5 to 19.8 %, nickel - from 9.9 to 10.3, which complies with GOST requirements, and manganese and titanium – less than 0.7%. At the same, time the burn-off of manganese and titanium reaches up to 30-50%, although the values of their concentration decrease are 0.3 and 0.2%, correspondingly.

Chromium content in the weld metal decreases insignificantly (1.5%). It is comparable with the measurement accuracy. Changes in cobalt, vanadium and copper concentrations are within the measurement accuracy as well.

Thus, using an inverter power source facilitates a uniform distribution of alloying elements along the length and height of the weld [4, 5].

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