E. Isothermal Decomposition of Austenite in ANSIIAWS A5.29-98 E81T5-G MCAW C-Mn-Nil All-Weld Metal

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The study of phase transformations constitutes an important part of the understanding of the phenomena taking place in the weld metal and in the prediction of the mechanical properties of the welded joint. The objective of this work is to study the austenite isothermal decomposition in ferritic all weld metal, of the system C-Mn-Ni 1 produced with a metal cored electrode of the ANSI/AWS A5.29-98 E8 1 T5- G type.

Samples of 8 x 8 x 2 mm size were extracted from the all weld metal test coupon welded under $C0_2$ shielding, using a metal cored wire of the ANSI/AWS A5.29-98 E8 1T5- G type, according to this standard.

The samples were heated to 1200°C (2192°F) in order to achieve complete austenization, and then cooled to 600, 550, 500 y 460 "C (*) (1112, 1022,932 and 860°F) and held at those temperatures for 2,5, 10,30,60,300 and 600 seconds in constant temperature salt baths. Vickers hardness was measured (Hv 1kg) taking the average of five determinations and the microstructure analyzed with light microscopy. For this last analysis, a grid of 49 points was used on **8** zones randomly selected on each sample resulting in a total of 392 points at 500 X.

*The temperatures were chosen taking into account the following values: Ar_1=760°C (1400°F), Ar_3=635°C (1175°F), M_s=450°C (842°F) and M_{90}=2150°C (419°F), determined by the authors in a previous work.

The metallographic quantification was performed with the samples that had been kept in the salt bath at constant temperatures for different times up to 30 seconds, since in that interval the austenite decomposition was completed. Martensite (M), acicular ferrite (AF), ferrite with second phases (FS) (including ferrite with side-plates-Widmanstaten (FW) that is a high temperature product, and bainite (B) that is a low temperature austenite decomposition product), and primary ferrite, composed by grain boundary ferrite PF(G) and polygonal or intragranular ferrite PF(I), was identified.

For each holding temperature the curves representing the percentage of austenite transformation into the different transformation products vs. holding time were plotted, and expressions fitting the sigmoidally shaped curves for the different kinetics involved in the decomposition of austenite in the temperature range considered were found. These curves allowed us to determine that austenite started its decomposition after around 1 second at all temperatures as well as 90% of the transformation was completed at around 10 seconds, while no further changes could be detected after 30 seconds.

It was also found that transformation of austenite into PF started at 600°C. This transformation resulted in PF growth, and FW nucleation starting from the PF grain boundaries. Finally, intragranular nucleation and growth of AF occurred until the transformation was completed. The final microstructure was made of PF (50%), FS (30%) and AF (20%).

At 550°C the beginning of austenite decomposition took place earlier than at 600°C, starting with the formation of PF(G). FS nucleated from PF(G) also at a faster rate than at 600°C, strongly developing the growth of this phase. AF nucleation and growth started later but the nucleation time was shorter than at 600°C. The final microstructure was made of FS (essentially FW) reaching its maximum value (4 1 %), PF (34%) and AF (25%).

At 500°C the beginning of austenite decomposition was somewhat delayed with PF and AF nucleation occurring simultaneously at a faster rate than at higher temperatures and delaying the formation of FS. FW was partially replaced by B. At this temperature the maximum content of AF (38%) was obtained along with the minimum of FS (28%), with PF (34%).

At 460°C decomposition of austenite started with the formation and growth of PF(G). FS formation followed partially replacing PF(G) with an increased growth rate as compared to 500°C. Finally, AF nucleation started (at a longer time than at 500°C) and was rapidly completed. FS, essentially B, increased, leading to the maximum value (42%); the AF content was high (33%), although somewhat lower than at 500°C, and PF took its least value (25%). All these effects are shown in the corresponding photomicrographs.

With the hardness measurements it was possible to find the following expression to predict hardness as a function of isothermal treatment temperature for 30 seconds of permanence at temperature (complete transformation).

HV = -0.2451 (T ("C) + 338.81

Isothermal decomposition of austenite was completed after 30 seconds of permanence at any of the temperatures considered, reaching 90% after around 10 seconds.

Expressions of the sigmoidal type were found for the different kinetics involved in the austenite decomposition between 600°C and 460°C.

An expression to predict the resulting hardness as a function of transformation temperature was developed. At 500°C the largest amount of AF was obtained, with the smallest proportion of FS and a low amount of PF. At 460°C the smallest amount of PF, a high content of AF and the largest fraction of FS, mainly bainite, was obtained.

Given the relationship existing between isothermal and continuous cooling, this last one representing the real situation during welding, this information becomes a useful tool to incorporate in predictive models that establish correlations among process variables, microstructure and mechanical properties.