Journal of Metallurgical and Materials Engineering, Vol.31, No.2, 2020.

Investigation Spot Welding in Similar Joins of Martensitic Advanced High Strength Steels (AHSS)

Mehran Tadayonsaidi[1*] Babak Ghorbanian[2]

1. Introduction

Because of high speed, availability, and automatability, spot resistance welding is used in industries such as car and airplane manufacturing and other similar industries. Despite all of these advantages, it is remarkable that factories pay lots of moneys in order to control this process and have optimum welding. To have a flawless welding, many parameters have to be considered optimally and conditions have to be controlled in a way that set of conditions are kept in a constant form. In processes of spot welding, junction on the surface by pressure and heat is done continuously. Since metals have electrical resistance, their temperature rises in response of electric current, if this increase in temperature is as mush that the metal gets to its melting spot, it melts. The needed heat of metals to melt is determined by the equation 1.

Eq.1: $Q= RI^2T$

T= temperature

I= electric current

R= resistance

Q=heat

According to this, spot welding is done by applying a high current in a short period of time, which its continuity is obtained by a pressure force from electrodes. This process results in a local rise in temperature in a small area of parts that, in turn makes a plastic area that because of applying pressure (without current until the metal cools), changing in shape continues and results in a permanent conjunction with high strength.

2. Experimental

Multi-phase martensitic steels have the highest tensional strength between high strength martensitic steels. Elements such as magnesium, silicon and chrome are found in these steels, which their presence is to increase hardness. Carbon is also used to increase strength. In this study choosing steel has been according to chemical compound. For this purpose, micro-alloy st52 steels with low carbon were used. Results of chemical analysis of this sheet has been mentioned as quantometer in Table 1.

Table 1. Chemical specifications of steel

P	S	Si	Mg	C	Steel
0.002	0.03	0.06	0.48	0.14	St52

After chemical analysis and before any thermal work on sheets, each of them was cut according to the standard of ANNI/AWS/SAE/D8.9-97 for doing tensile test. A standard sample of this test is mentioned in Figure 1.

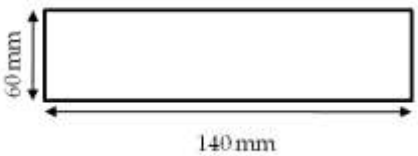

Figure 1. Dimensions of a standard sample for tensile test (Length: 140mm, width: 60mm, and thickness: 1mm)

3. Results and Discussion

Figure 2 shows the macro structure of weld for similar junction of advanced high strength martensitic steel in low currents of welding. As it can be seen, because of the thermal cycle of the point welding process, a heterogeneous structure is formd in the area of junction and all junctions in the melting zone have oriented freezing with pillar pieces. These pillars have grown from around the welding button to the center. Additionally, in similar junctions of high strength martensitic steel, melting in both upper and lower sheets is same.

Figure 2. Macro-structure of welding sample of similar junction M/M

Figure 3a shows micro-structure of the welding metal, which martensitic micro-structure and dendritic pieces can be seen inside it. In this figure the percentage of martensitic phase has been estimated about 60. Figure 3b shows micro-structure of the base metal, which acicular martensitic phase can be seen in it. This structure can be seen in steels with low percentage of carbon. Martensitic units in this figure look like needles that are in bigger packs. Micro-structure of the seen melting zone is martensitic for each of the studied welds, which has oriented and acicular freezing from the welding boundary to the center. Figure 3.B shows HAZ critical micro-structure and Figure 3.C shows coarse particle HAZ. These figures show that HAZ micro-structure has also been made up from martensitic phase, but as some studies have shown, by cooling austenite and according to factors such as carbon percentage and cooling speed, it can change to phases such as perlite and Bainite (which weren't seen in this test). In mid critical HAZ zone (Figure 3.c), since austenite gets in the ferrite-austenite zone, this phase enriches from carbon and its hardness increases,

[1] Corresponding Author: Assistant Professor, Department of Materials Engineering, Karaj Branch, Islamic Azad University, Karaj, Iran.
Email: tadayon@kiau.ac.ir
[2] M.Sc., Department of Materials Engineering, Amirkabir University of Technology, Tehran, Iran.

which results in creation of martensitic. In coarse particle HAZ zone (Figure 3d), where temperature is much more than AC_3, HAZ micro-structure is coarse particle martensitic. High cooling speed and increasing size of the primary particle propels phasic transformation to making martensitic.

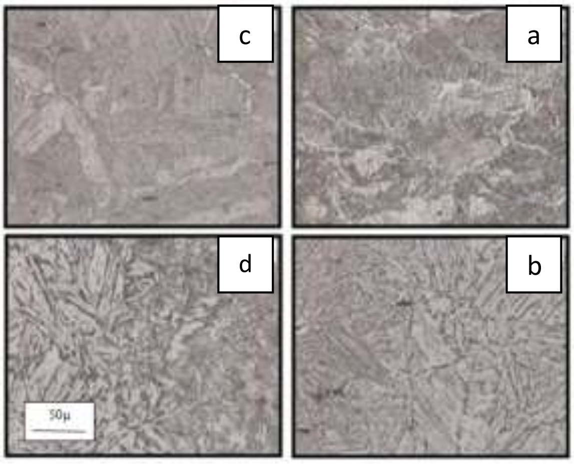

Figure 3. Micro-structure of different resistance spot welding zones of martensitic high strength steel with magnifying of 200 (a). Welding metal; (b). Base metal; (c). Mid critical HAZ; and (d). Coarse particle HAZ

High strength steels have a hardness of about 400 Vickers, which increases by increasing the martensitic phase. The amount of magnesium in St52 steel is high and since magnesium stabilizes ferrite, it is predictable that ferrite phase increases in the welding zone, which results in decrease hardness because of phase changing from martensitic to ferrite. Figure 4 is about hardness number of welding zone. According to hardness of the samples for similar junctions, hardness of these steels is about 200-380 Vickers. Therefore, as predicted, hardness of welding zone decreased in compare with base metal.

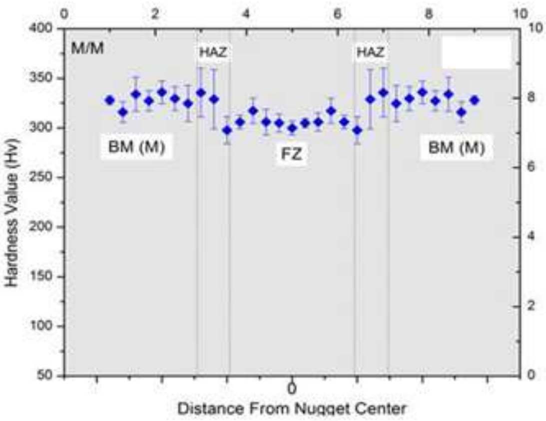

Figure 4. Profile of similar junction of high strength advanced martensitic steel

4. Conclusion

HAZ in similar junctions of high strength martensitic steels gets softer.

In low currents, fracture is an intersection, but as the current gets higher than 9.5 kA environmental break occurs. In very high currents no junction forms.

Diameter of welding button rises by increasing current and when critical current (9.5 kA) is applied in advanced high strength martensitic steels, critical size of welding button is about 9.2mm.