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Investigation on the Corrosion Behaviour of Weld Structure

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Welding technology plays an important role in the fabrication of structure, and this has led to an increasing attention in the use of high quality advanced welding technology such as power beam welding, friction stir welding, and laser-arc hybrid welding, etc. At the same time, welding can influence various factors in the performance of plant and equipment, and corrosion behaviour of weldment has been one of the major issues for both welding and corrosion research engineers. The aim of this paper is to give a short survey of the recent technical trends of welding and corrosion behaviours including the electrochemical corrosion, stress corrosion cracking, and corrosion fatigue in connection with the welding materials, welding process, and welding fabrication.

Keywords *: electrochemical corrosion, stress corrosion cracking, corrosion fatigue, welding material, welding process, welding fabrications*

1. Introduction

Welding introduces many chemical, mechanical and physical conditions in a fabricated weld structure and the weld joint is very susceptible zone of localized aggressive attack like corrosion as it is characterized by chemical and microstructural inhomogeneities. The integration of corrosion into the investigation of welding technology will be a key component to the successful quality of the welded structure. Recently the number of research programs with regarding to subjects on the corrosion properties of the advanced welding technologies, such as corrosion behaviour of laser trested friction stir welds, are carried out, and many reports or papers are published. This paper concerns with corrosion, stress corrosion cracking, and corrosion fatigue which is based on the published research works in the 'corrosion of weld joint' obtained from the KISTI's database, COMPENDEX DATA BASE SYSTEM and deals with the details of the background data of the welding technology and corrosion.

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2. Characteristics and trend of corrosion research in weld joint

2.1 Steel structure weld joint

The weld metal and the heat affected zone whose microstructure is markedly different from the base metal may display localized corrosion susceptibility and generate a potential difference thus the emf can trigger galvanic attack. The weld joint is nore susceptibile to corrosion than the base metal. The SSC(sulphide stress cracking) evaluation of GMAW(gas metal arc welding) and GTAW(gas tungsten arc welding) welded modified 13%Cr steels with both duplex stainless steel and matching 13%Cr filler showed that SSC formed in the hardening portion of the HAZ when the root bead shape was low and smooth and when the root bead was high and sharp, SSC initiated from the bead toe.[1)] IGCAR performed the Huey Test of the solid state welded titanium-AISI type 304L stainless steel in order to develop the dissimiliar welded joint with high corrosion resistant property, and the results are shown in Table 1.[2)]

The melted but unmixed nature of the UMZ(unmixed zone) makes the stainless steel weld joint less resistant to corrosion than the base metal in many environments. The partitioning(segregation) of Mo between the dendritic and interdendritic cast structure of the weld is partically detrimental to the anti-corrosion property of the weldment. The 5% ferrite content of most austenitic stainless steel

Table 1. Corrosion Rate of Dissimiliar Welded Joint

orrosion Test	Friction Welded Joint	Explosive Bonded Joint
Liquid Phase(mpy)	0.48	0.44
Vapour Phase(mpy)	0.72	1.5
Condensate Phase(mpy)	10.07	12.03

weld metals substantially reduces the "hot cracking", but higher ferrite, in the 11-27% range, led to continuous stringers of ferrite and lower resistance to corrosion in acidic chloride solution.[3] High nitrogen steel welding must consider the risk of nitrogen escape from the weld pool. Avoiding nitrogen losses may be accomplished by controlling shielding gas, welding parameters and compositions of filler metal. The increase of nitrogen in the weld metal decreases in the delta-ferrite content. The reduction of delta-ferrite in austenitic weld metals will result in an increase in the solidification cracking susceptibility. However, the role of nitrogen in affecting the solidification cracking susceptibility of fully austenitic weld metals is unclear. Nitrogen addition increases the pitting corrosion resistance in weld metals whereas decreases resistance to stress corrosion cracking because of delta-ferrite reduction.

2.2 Aluminum alloy weld joint

The corrosion resistance of the weld joints containing a higher amount of Mg (> 3.5 % Mg) it is to be observed that no structural changes reducing the corrosion resistance appear due to the heat input during welding. Thus, in the temperature range of 100 - 230 ℃ anodic precipitations (β-phase) can be formed at the grain boundaries that impede the resistance against stress corrosion cracking and intergranular corrosion. With many heat treatable aluminium alloys the highest resistance against stress corrosion cracking is obtained by artificial ageing or even overageing. The corrosion resistance in the heat affected zone of these alloys is affected by the heat input during welding. A deterioration of the corrosion resistance can further be given by a potential difference between the base and the filler material, for example, with 7000 series materials a correspondingly influenced HAZ(heat affected zone) reacts as an anode to the basic material as well as to a 5000 series filler material, and the consequence is an elevated local corrosion attack. Recently the corrosion behaviours of the friction stir welded aluminum alloy hsa been extensively studied. The effect of surface laser treatment on the electrochemical behaviour and corrosion properties of friction stir welded aluminum alloy has been studied and it showed that the laser treatment decreased the anodic and cathodic reactions of the weld metal and HAZ.[4] Lumsden investigated the stress corrosion cracking resistance and the effect of postweld heat treatment on the corrosion properties of FSW 7050Al-T7541 and 7050Al-T7651 alloys. The failure by SCC occurred within the thermo-mechanically affected zone(TMAZ) near the boundary between the weld nugget(fully recrystallized grains) and deformed but non recrystallized larger grains on the advancing side of the FSW 7050Al-T7541 alloy. Fig. 1 shows typical stress-strain results for naturally and artificially aged FSW 7050Al-T7651 alloy joints tested at 10^{-6} s^{-1} in a 3.5% NaCl solution. Clearly, an artificial aging at 100 ℃ for 1 week restored a significant amount of the SCC resistance. Other artificial aging treatments investigated also restored the SCC resistance, but caused an unacceptable loss in mechanical properties under ambient conditions.[5]

The corrosion-fatigue crack propagation of friction stir welded and gas metal arc welded armor alloy Al2519 were tested and the results showed that in 3.5% NaCl solution

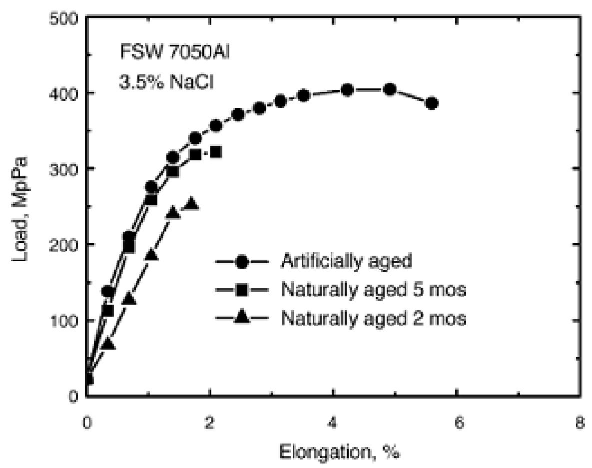

Fig. 1. Stress-strain curves for naturally and artificially aged FSW AA7050Al-T7651 tested at slow strain rate of 1×10^{-6} s^{-1}

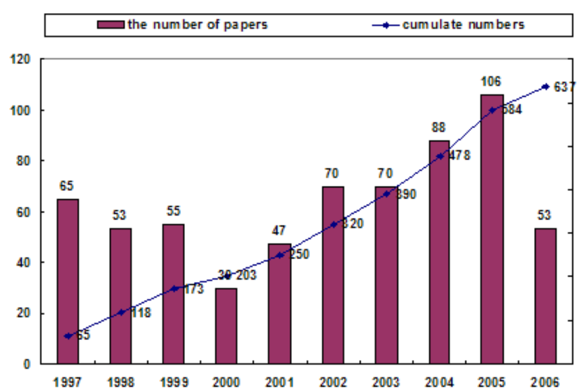

Fig. 2. The amount of annually published papers concerning about the corrosion behaviour of weld joints.

the fatigue resistance of friction stir welded Al2519 and the base metal becomes comparable and is better than that of gas metal arc welded Al2519.[6)]

Fig. 2 shows the trend of the amount of annually published papers concerning about the corrosion behaviour of weld joints, and it is observed that the amount of papers has increased rapidly between 2004 and 2005.

3. Summary

In this study, the recent research & technical trends of 'corrosion and welding' including the electrochemical corrosion, stress corrosion cracking, and corrosion fatigue in connection with the welding materials, welding process, and welding fabrication are investigated. It was found out that corrosion behaviour of power beam welded and friction stir welded joints are extensively studied. The wide application of these advanced welding processes for the corrosion-resistant weld joint and structure will expected in near future,

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