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Recent Corrosion Research Trends in Weld Joints

† Hwan Tae Kim[1], Sang Cheol Kil[2], and Woon Suk Hwang[3]

[1]Senior Research Fellow, Korea Institute of Science and Technology Information
206-9, Cheongnyangni-dong, Dongdaemun-gu, Seoul 130-742, Korea, Korea
[2]Technology Information Analysis Dept., Korea Institute of Science and Technology Information
206-9, Cheongnyangni-dong, Dongdaemun-gu, Seoul 130-742, Korea, Korea
[3]School of Materials Science and Engineering, Inha University, Yonghyun-dong 253
Nam-gu, Incheon 420-751, Korea

The increasing interest in the corrosion properties of weld joints in the corrosive environment is placing stringent demands on the manufacturing techniques and performance requirements, and the manufacture employs the high quality and efficiency welding process to produce welds. Welding plays an important role in the fabrication of chemical plants, nuclear power plant, ship construction, and this has led to an increasing attention to the corrosion resistant weld joints. This paper covers a recent technical trends of welding technologies for corrosion resistance properties including the COMPENDEX DB analysis of welding materials, welding process, and welding fabrications.

Keywords *: corrosion resistant weld joints, welding technology, welding process, welding fabrications, friction stir welding*

1. Introduction

Welding is a critical technique for fabricating the chemical plant and power plant etc, however, welding fabrication introduces many deleterious mechanical, chemical, and metallurgical conditions against the corrosion-resistant properties of the weld structures. The integration of the various corrosion behaviours into the investigation of welding technology will be a key component to the successful weld quality of the chemical plant and power plant etc.

The purpose of this report is to investigate the recent research trends of corrosion behaviours in the weld structure including the general corrosion, stress corrosion cracking, and corrosion fatigue which is based on the published research works in the 'corrosion behaviour of the weld' obtained from the KISTI's database, COMPENDEX DATA BASE SYSTEM and deals with the details of the background data of the corrosion resistance and the welding processing.

† Corresponding author: htkimm@kisti.re.kr

2. Characteristics and trend of the corrosion research in weld joints

It is well known that the weld joint is more susceptibile to corrosion than the base metal. The sulphide stress cracking susceptibility of the modified 13%Cr steel weldment with both duplex stainless steel and matching 13%Cr filler welded by the gas metal arc welding and gas tungsten arc welding was evaluated and the results showed that sulphide stress cracking 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, sulphide stress cracking initiated from the bead toe.

The stainless steel is one of the best anti-corrosion structural materials. When the stainless steel, especially AISI 316 austenitic stainless steel, is welded,. 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 weld joints. The 5% delta-ferrite content of most austenitic stainless steel 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. High nitrogen steel welding must consider the risk of nitrogen escape from the weld pool.

Nitrogen addition increases the pitting corrosion resistance in weld metals whereas decreases resistance to stress corrosion cracking because of delta-ferrite reduction.

Fig. 1 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. Fig. 2 shows the trend of the amount of annually published papers by the main, and it is observed that USA, Japan, and China published many papers about the corrosion behaviour of weld joints.

The weld joint of aluminum alloys needs particular precautionary measure for the anti-corrosion properties because of their inherent properties such as higher oxidation tendency and low vaporization temperature, so it is important to adapt the proper welding process of magnesium alloy, especially, when the part included the welding joint is located in the corrosive environments.

Friction stir welding, which is developed by The Welding Institute(TWI) Cambridge, UK, is a solid state bonding process, using a non-consumable rotating tool plunged into the joint line of the workpieces. Friction stir welding has showed the feasibility for joining aluminum alloy and magnesium alloy, and it is considered to be the most significant development in metal joining in a decade. Fig. 3 shows the friction stir welding process model as a metalworking process in terms of five conventional metal working zones: (a) preheat, (b) initial deformation, (c) extrusion, (d) forging, and (e) post heat/cool down.

Friction stir welding results in generation of various microstructural zones, i.e., the nugget zone, the TMAZ(, and the HAZ(heat affected zone). These zones exhibit different microstructural characteristics such as grain size and dislocation density, residual stress and texture, and precipitate size and distribution. Therefore, it is expected that the various microstructural zones will exhibit different

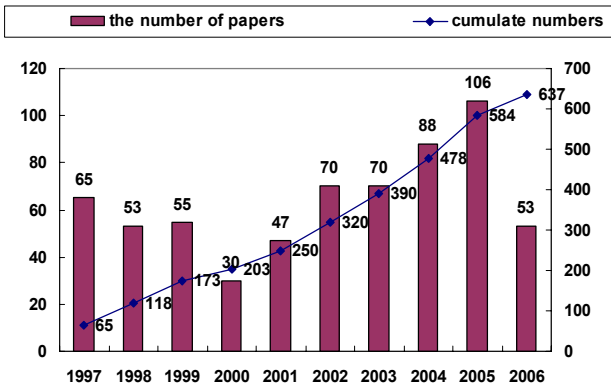

Fig. 1. Annual Trend of the Published Papers (COMPENDEX DB)

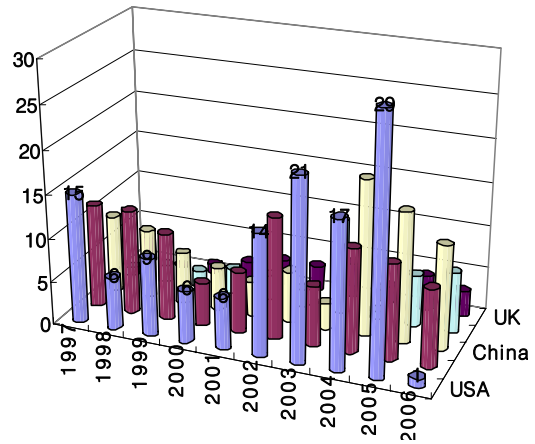

Fig 2. The amount of annually published papers by the main countries

Table 1. Annual Trend of the Published Papers (COMPENDEX DB)

		Published Year							
		2000	2001	2002	2003	2004	2005	2006	Total
Number of Papers		3	2	4	16	9	10	5	49
Type	General Corrosion	2	1	3	10	6	5	3	30
	Stress Corrosion Cracking	0	0	1	2	2	4	2	11
	Corrosion Fatigue	1	1	0	4	1	1	0	8
Material	7000 series Al alloy	1	2	4	9	3	4	3	26
	6000 series Al alloy	0	0	0	1	0	2	0	3
	5000 series Al alloy	0	0	0	0	2	2	1	5
	2000 series Al alloy	2	0	0	6	2	1	1	12
	Mg alloy	0	0	0	0	1	0	0	1
	Stainless Steel	0	0	0	0	1	1	0	2

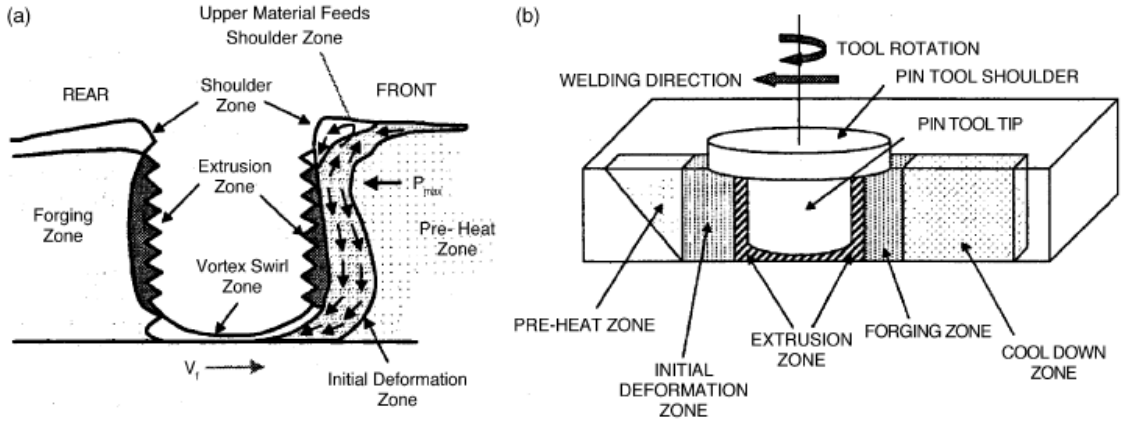

Fig. 3. Metal flow pattern(a) and metallurgical processing zones(b) during friction stir welding(FSW)

corrosion susceptibility. For practical applications, it is very important to understand corrosion behavior of the friction stir welds and elucidate the prevailing mechanisms for corrosion in various friction stir welding alloys and various microstructural zones. Table 1 shows the annual trend of the published papers.

The corrosion susceptibility of the high-strength aluminum friction stir welding welds is a concern for wide range of engineering applications of friction stir welding. A few postweld treatments have been evaluated to improve the corrosion resistance of friction stir welds. Hannour et al investigated the effect of postweld surface laser treatment on corrosion resistance of friction stir welding aluminum welds. Corrosion tests and electrochemical studies indicated that the excimer laser treatment led to a remarkable improvement of the corrosion resistance of friction stir welds in 2024Al-T351 and 7010Al-T651 with lower cathodic current density and higher pitting potential. Intergranular corrosion within the HAZ was suppressed with corrosion occurring instead through the general pitting attack of the untreated parent material. This was attributed to the development of a more homogenous surface layer of 10 mm with a reduction in the undesirable precipitate and a change in the grain boundary chemistry

3. Conclusions

Investigation was carried out to study the recent technical trends of welding technologies for corrosion resistance properties of weld joints including the general corrosion, stress corrosion cracking, and corrosion fatigue. The study shows that much efforts are focused to the corrosion behaviour of friction stir welding process which have great potentials application and flexibility with the advantages of high efficiency for use in the welding of modern structures.

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