J. Indian Chem. Soc.,
Vol. 97, May 2020, pp. 783-785

Sulphide stress corrosion cracking of AA7050 hybrid composites

R. Ranjith*, B. Karthick and P. Vivekanandan

Department of Mechanical Engineering, SNS College of Technology, Coimbatore-641 035, Tamilnadu, India

E-mail: ranjith.mecs@gmail.com

Manuscript received online 02 December 2019, revised and accepted 18 January 2020

In this work, an effort was made for the first time to enhance the Sulphide Stress Corrosion Cracking (SSCC) of AA7050 aluminium alloy by adding reinforcing particles. The composite was tested in H_2S environment according to NACE TM0177-2005 standards under constant load. The susceptibility was evaluated in terms of time to failure ratio. The composite shows lesser susceptibility to SSCC than AA7050 owing to the formation of grain boundary precipitates.The fractography was analysed with the aid of optical microscopy and scanning electron microscopy.

Keywords: Sulphide stress corrosion cracking, grain boundary precipitates, AA7050 composites, fractography.

Introduction

Stress corrosion cracking (SCC) is a series problem encountered in Main Landing Gear (MLG) links. AA7050 with combination of strength and confrontation towards stress corrosion cracking became favourable material for MLG links. The Retrogression and Re-Aging (RRA) process improves resistance to exfoliation and inters granular corrosion[1]. Addition of scandium prevents recrystallization hence improves resistance towards Stress corrosion cracking[2]. Annealed samples showed superior resistance to SCC because of random distribution of β-phase precipitates[3]. Shape of the grains influenced the susceptibility of stress corrosion cracking[4]. Discontinuous and finer grain boundary precipitates improve stress corrosion cracking. Resistance towards dislocations of cutting particles enhances stress corrosion cracking[5,6]. The peak aged alloy has smaller precipitates and a higher precipitate density than overaged which augments corrosion potential[7]. The presence of disperoids effects the movements of grains thus deters recrystallization[8]. Friction stir welded aluminium alloy offers better resistant to stress corrosion in sea water[9]. No literature was available for improving sulphide stress corrosion cracking by adding reinforcing particles in the aluminium alloy. Hence in this work we focused on improving stress corrosion cracking by adding reinforcement.

Experimental

Three sets of samples AA7050, AA7050/7.5B_4C_p/2.5SiC_p and AA7050, AA7050/7.5B_4C_p/7.5Gr were fabricated by stir casting technique was utilised for studies. The sulphide stress corrosion cracking behaviour of AA7050 composites in environment containing H_2S was tested according to NACE TM0177-2005 solution 'A' (50 g of NaCl + 5 g of glacial acetic acid in 945 ml regent water) under a constant load of 780N. The test temperature was 24±1°C and initial pH of the solution was 2.70. The applied stress was 25 Mpa. The purity of H_2S gas is 99.9% and positive pressure has been maintained throughout the duration of test. The final pH value of the solution was less than 4. Stress corrosion cracking is evaluated in terms of index ratio i.e. time to failure ratio. The constant load is applied under the corrosive environment and time taken to failure of specimens was observed. Higher the SSCC index, better resistance to stress corrosion cracking.

Results and discussion

The sulphide stress corrosion setup and tested samples were shown in Fig. 1 and Fig. 2 respectively. The Table 1 specifies the index values of 0.660, 0.632 and 0.60 for AA7050/7.5B_4C/7.5Gr, AA7050/7.5B_4C/2.5SiC and AA7050 respectively in the corrosive medium of 5% of NaCl and 0.5% glacial acetic acid at room temperature. It is noticeable that

Fig. 1. Photograph of sulphide stress corrosion cracking apparatus.

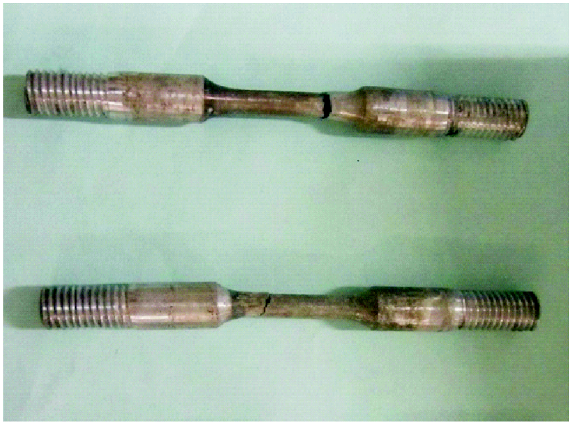
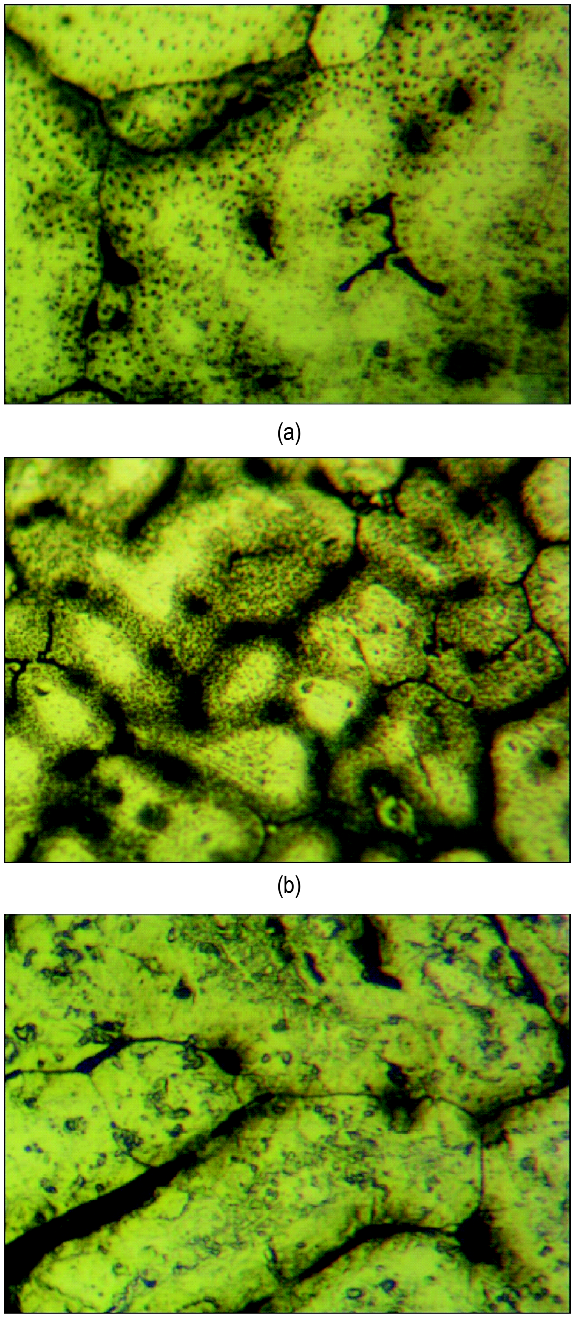


Fig. 2. Sulphide stress corrosion cracking tested samples.

reinforcing particles improves the sulphide stress corrosion resistance of AA7050 composites. Due to the addition of reinforcing particles, Eta(η) precipitates along the grain boundaries occurs as shown in Fig. 3a and Fig. 3b which was absent in AA7050 alloy as in Fig. 3c.

This η precipitation along grain boundary prevents propagation of crack and hence improves resistance to SSCC. SEM images of AA7050 SCC fracture surface shows inter-



(a)

(b)

(c)

Fig. 3. Grain boundary precipitates of (a) AA7050/7.5B_4C_p/2.5SiC_p, (b) AA7050/7.5B4C/7.5Gr and (c) AA7050(100X).

Table 1. Sulphide stress corrosion test in dry air and (5% NaCl + 0.5% glacial acetic acid) corrosive environment

Materials	Tensile strength (Mpa)	% Elongation	t_{fa} (h)	t_{fc} (h)	$r_{tf} = t_{fc}/t_{fa}$
AA7050/7.5B_4C/7.5Gr	180	12	112	74	0.660
AA7050/7.5B_4C/2.5SiC	224	08	117	74	0.632
AA7050	190	11	116	70	0.603

granular cracking with skillet shaped grains and brittle structure as shown in Fig. 4a. The cracks initiated at the boundaries and penetrated through are clearly visible which reveals intergranular crack. The fractograph of AA7050/ $7.5B_4C_p/2.5SiC_p$ composites shows cleavage facet and mushy structure as shown in Fig. 4b. The fracture surface of graphite reinforced composites shows dimple structure which is the characterisation of ductile failure. The micro void coalescences and mushy surfaces are clearly visible. There is no intergranular crack which reveals that hybrid composites exhibits enhanced resistance to stress corrosion as shown in Fig. 4c, which is in good agreement with the observed testing results.

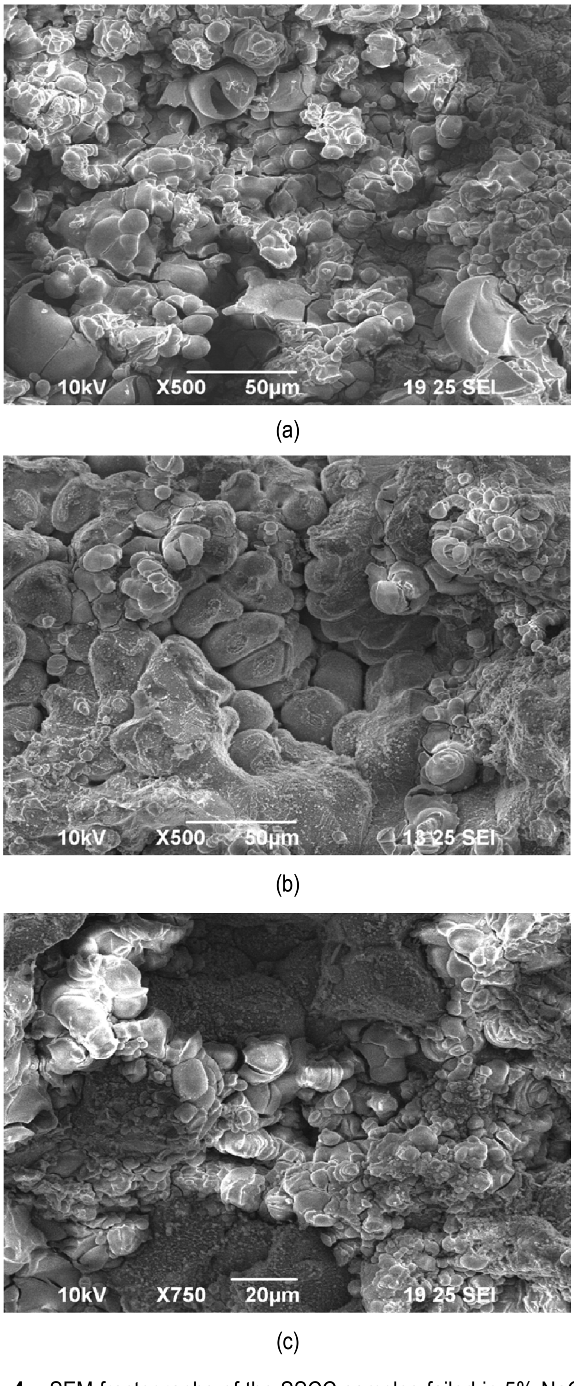


Fig. 4. SEM fractographs of the SSCC samples failed in 5% NaCl + 0.5% glacial acetic acid: (a) AA7050, (b) AA7050/$7.5B_4C_p$/ $2.5SiC_p$ and (c) AA7050/7.5B4C/7.5Gr.

Conclusion

SSCC susceptibility index was evaluated in terms of time to failure ratio. AA7050/$7.5B_4C_p/7.5Gr_p$ exhibits better resistance to sulphide stress corrosion cracking. Grain boundary precipitates is the prime factor that convalesces the SSCC resistance of the composites. The existence of η precipitation along the grain boundaries in AA7050 hybrid composites thwarts the propagation of stress corrosion crack through the grain boundaries which improves resistance to SSCC compared to base alloy.

Reference

1. Y. P. Xiao, Q. L. Pan, W. B. Li, X. Y. Liu and Y. B. He, *Materials and Design*, 2011, **32(4)**, 2149.
2. F. Sun, G. L. Nash, Q. Li, E. Liu, C. He, C. Shi and N. Zhao, *Journal of Materials Science and Technology*, 2017, **33(9)**, 1015.
3. P. S. Chang, C. H. Chen and C. G. Chao, *Materials Transactions*, 2016, **57(9)**, 1498.
4. L. Chen, Y. Bin, W. Zou, X. Wang and W. Li, *Journal of the Mechanical Behavior of Biomedical Materials*, 2017, **66**, 187.
5. C. Meng, D. Zhang, L. Zhuang and J. Zhang, *Journal of Alloys and Compounds*, 2016, **655**, 178.
6. J. Li, F. Li, X. Ma, J. Li and S. Liang, *Materials Science and Engineering: A*, 2018, **732**, 53.
7. J. Liu, P. Yao, N. Zhao, C. Shi, H. Li, X. Li and S. Yang, *Journal of Alloys and Compounds*, 2016, **657**, 717.
8. P. K. Rout, M. M. Ghosh and K. S. Ghosh, *Materials Science and Engineering: A*, 2014, **604**, 156.
9. K. Dudzik and M.Czechowski, *Solid State Phenomena,* 2010, **165**, 37.