EFFECT OF SHOT PEENING ON STRESS CORROSION CRACKING (SCC) OF 7075-T6 ALUMINIUM ALLOY

Rahmatalla H*, Al-Rimawi M**, and Al-Hadid T**
University of Jordan, Jordan Royal Jordanian Airlines, Jordan**

ABSTRACT

Shot peening, using cast steel particles at different intensities, varying from 6-10A, was utilised to improve Stress Corrosion Cracking (SCC) of welded 7075-T6 Aluminium alloy. Three-point loaded specimen was used as a necessary technique to evaluate the SCC in chloride enviroment. Specimens were tested in Long Transverse (LT) and Short Transverse (ST) directions. An appreciable improvement due to shot peening, using all intensities was detected in the LT direction. However Lower SCC resistance improvement in ST direction was obtained when the specimen was shot peened at 8A intensity, only. Other intensities produced appreciable improvement. This improvement was attributed to the development of a homogenous compressive layer. The developed layer was able to inhibit, crack intiation and propogation in the low temperature Heat Affected Zone (HAZ) of the welded 7075-T6 Aluminium alloy, where high susceptibility to SCC in unpeened condition was observed.
In this investigation an experimental program could be predicted using shot peening to improve SCC resistance.

KEYWORDS

Shot peening, Stress Corrosion Cracking (SCC), 7075-T6 aluminium alloy, Weldment, Heat Affected Zone (HAZ), Short Tranverse (ST), Long Transverse (LT).

INTRODUCTION

Shot peening process, is a well known industrial technique that can be employed to retard mechanical or mechanical-enviromental failures, in the several engineering compoenents [1,2,3]. Stress Corrosion Cracking (SCC), is among the failures that can be retarded by shot peening [1,4,5,6].
It was demonstrated that shot peening had improved both, the time to failure and the threshold applied stress, below which no failure can be ovserved in the allowed

testing time [7,8,9]. Those beneficial effects are attributed due to the build-up of the residual compressive stresses [3,9,10,11].

The lower SCC resistance exhibited by the welded 7075-T6 aluminium alloy plates than that of the un-welded alloy mainly in the Short Transverse (ST) direction in the chloride enviroment, has been well documented and observed by several investigators [4,5,6].

The loss of SCC resistance and other corrosion resistances is due to the development of a certain metallurgical structure in the low temperature Heat Affected Zone (HAZ) of the welded 7075-T6 alloy [4,6,12].

Accordingly, it is intended by this work, to explore the role of the shot peening process, in order to be used as a tool to improve the SCC resistance of the welded 7075-T6 aluminium alloy, in the direction where a pronounced loss in SCC resistance is usually observed, i.e. the ST direction. Also it is intended to identify the shot peening parameters that can produce optimum improvement in SCC resistance, for welded and un-welded 7075-T6 aluminium alloy.

EXPERIMENTAL PROCEDURE

High strength aluminium alloy, type 7075-T6 was used in this investigation. LT & ST specimens of 140x25.4x2.3mm dimensions, were prepared from 25.4mm thick plate. Specimens were tested in welded and un-welded conditions. A bead on plate on one side of the specimen, using the GAS Tungeston Arc Welding (GTAW) process. The beads were deposited in a transverse direction, with respect to the rolling direction.

Shot peening was conducted using an air-blast shot peening machine type Pangborn ES-1580, using standard cast steel shots (S230 grade). Three shot peening intensities were employed, 6, 8, and 10A. Peening conditions to produce such intensities are given in table 1. Peening with glass beads at 15psi pressure, was used after each cast steel peening. The purpose of this, was to remove the residues remaining on the specimen surface due to cast steel shots, thus preventing the harmful effect of these residues that may cause galvanic corrosion.

Peened and un-peened specimens were tested for their SCC resistance, using three-point bending system, according to ASTM G39-90 [13]. Specimens were tested at an outer fibre stress, corresponding to 95% of the yield strength. Testing enviroment and testing conditions were selected to be a solution containing 3.5% $NaCl$+0.5%Na_2CrO_4 at a temperature of 40°C and pH=3. This chloride solution, containing the sodium chromate, is known to be a SCC promoter only, but not a pitter, since the sodium chromate, is pitting corrosion inhibiter in chloride

enviroments [14]. Failure criterion was based on the first detection of the crack, using low magnification power lens.
Metallography was employed to examine, the surface texture and the microstructural changes due to welding and shot peening.

Table 1: Shot Peening Conditons.

Peening Angle	50°
Start of Distance	150mm
Turntable Speed	3 rpm
Coverage	200%
Peening Pressure	40-60 psi

RESULTS AND DISCUSSION

Fig 1,2 and 3 show the effect of increasing shot peening intensity, on the depth of the residual compressive stress introduced. It can be seen that as the intensity increases from 6A to 10A the depth of the compressive layer was found to increase from 0.24mm to 0.53mm. Several other investigators obtained similar results on 7075-T6 aluminium alloys [1,2,8,9]. No overpeening has been observed, even when using the higher intensity, (10A). This indicates that no overpeening can be produced when using the 6-10A intensities range. Moreover, this intensity range produced a uniform compressive layer, as can be seen from Figs 1,2 and 3.
Un-peened welded specimens of 7075-T6 alloy, showed poor resistance to SCC, when tested at both directions, LT & ST. Those speciemens began to crack in a localised region, in the HAZ, after a relatively short exposure time as shown in Fig 4. Those times were 17hr for the ST specimen, and 36hr for LT specimen. This failure, is due to the well known selective attack in the low temperature HAZ. It was attributed to the metallurgical structure developed in this area because of the fusion welding [10,11,12]. This metallurgical structure produced a lower potential at this region, different from that in the weld and the rest of the HAZ. This selective protential can promote several local attacks, among them is the SCC [10].
Peening welded LT, 7075-T6 specimen, using all intensities, produced no SCC failure, even when exposed for 336hr as shown in Fig 5. Nevertheless peened surface at 8A intensity suffered minor pitting only, but no crackings. However ST peened specimen, did not show SCC failure when using 6 & 10A intensities, but it failed due to severe pitting then cracking after 211hr, when it shot peened by the 8A intensity, as shown in Fig. 6. Accordingly shot peening using the 8A intensity is

not recommened to improve the SCC resistance in the ST only. The resistance in the ST direction is very low to compared that in the LT direction, such that peening with certain intensities can not built the required compressive layer for protection. The lower SCC resistance in the ST direction of the un-welded un-peened specimen was observed in the present investigation, as the time to faiulre was 17hr, compared to 36hr in LT direction. Other investigators have also observed a higher SCC susceptibility in the ST direction [4,5,6].
The exact explanation, of why the 8A intensity, could not prevent SCC failure in the welded specimen, while the 6 and 10A intensities did, is not well understood. It seems to be related to the mechanism of the initiation and the propogation of the cracks causing this failure, in the particular enviroment. This mechanism is highly influenced by the distribution of the stresses in affected peened layer. So in order to explain this result, a complete picture of the stress profile, should be obtained, using the x-ray technique.
It is worth stating that the SCC resistance of the un-peened edges of the peened welded specimen, is higher than that of the un-peened welded specimen. This can be attributed mainly to the ofsetting tensile stress at the subsurface of the peened specimen, which usually balances the compressive stress layer. Thus a complete coverage for the all exposed surface is essential, if the shot peening is to be used as a preventive measure against SCC, An incomplete coverage may accelerate SCC attack, due to the tensile stresses which usually balances the compressive stresses.

CONCLUSIONS

1. Welded 7075-T6 aluminium alloys are highly susceptible to SCC in both LT and ST directions. A higher susceptibility in ST direction was found.
2. Shot peening using 6, 8, and 10A intensities, produced pronounced improvement in SCC resistance in the LT direction, while only 6 and 10A intensities increased the SCC resistance in ST direction. This range of intensities does not produce overpeening.
3. Shot peening is very beneficial in preventing or delaying SCC, given that the resulted compressively stressed layer is not pentrated by pitting and all exposed surface are shot peened to attain complete coverage.

Fig 1: Effect of shot peening at an intensity of 6A (100X) (Depth of compressive layer-0.24mm)

Fig 2: Effect of Shot peening at an intensity of 8A (100X) (Depth of Compressive layer=0.35mm),

Fig 3: Effect of Shot Peening at an intensity of 10A (100X) (Dept of compressive layer=0.53mm).

Fig 4: The attack in HAZ of the
un-peened specimens

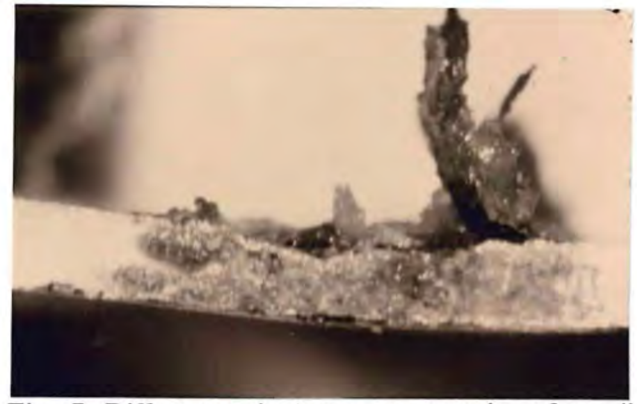

Fig. 5: Difference between peened surface (lower) and un-peened surface (upper), for LT specimen exposed for 336hr (10X)

Fig 6: Sever pitting and cracking after 211hr exposure, when shot peened at 8A intensity (30X)

REFERENCES

1. Lifka B and Sprowls D, *'Shot Peening - A Stress Corrosion Cracking Prevntive for High Strength Aluminium Alloys"*, Proc. of the 26th annual Conference, NACE, U.S.A., March 1970, pp. 4-6.
2. Vohringer O, *'Changes in the state of the Material by Shot Peening"*, Proc. of 3rd International Conference on Shot Peening, ICSP3, Germany, Oct. 1987, pp. 185--204.
3. Was G, and Pelloux R, *'Effect of Shot Peening Methods on the Faigue Behaviour of Alloy 7075-T6"*, 1st International Conf. On Shot Peening, ICSP1, Paris, 1981, pp. 445-451.
4. Staehle R, *'Understanding Situation-Dependeant Strength: A Fundamental Objective in Assesing the History of Stress Corrosoion Cracking"*, Proc. of the 1st Internationl Conf. on Enviromental-Induced Cracking of Metals, U.S.A, Oct., 1988, pp. 561-612.
5. Parkins R, *'Stress Corrosion Cracking"*, ibid, pp. 1-19.
6. Sprowls D and Brown R, *'What Every Engineer Should Know About Stress Corrosion of Aluminium"*, Metal Progress, 1962, pp. 77-83.
7. Zoeller H and Cohen B, *'Shot Peening for Resistance to Stress Corrosion Cracking"*, ASM, Report D5-20.1, Oct., 1965, pp. 1-5.
8. Takemoto M Shinohara T and Shirai M, *'Control of Stress Corrosion Cracking by shot Peening"*, Proc. of 1st International Conf. on Shot Peening, ICSP1, Paris, Sept., 1981, pp. 521-527.
9. Speidel M, *'Effect of Shot Peening on Stress Corrosion Cracking and Corrosion Fatigue"*, ibid, pp. 625-635.
10. Takemoto M, *'Prevntion of Stress Corrosion Cracking of Weldment by Wet Shot Peening"*, 2nd International Conf. on Shot Peening, ICSP2, Chicago, 1984, pp. 39-42.
11. Koehler W, *'Influence of Shot Peening with Different Peening Materials on the Stress Corrosion and Corrosion Fatigue Behavior of a welded AlZnMg Alloy"*, ibid, pp. 126-132.
12. Americal Society for Metals (ASM), Editor, *'Aluminium - Vol. I, Properties; physical Metallurgy and Phase Diagrams"*, ASM, U.S.A., 1987.

13. Americal Society for Testing and Materials (ASTM), *'Standard Practice for Preparation and use of Bent-Beam Stress Corrosion Test Specimens"*, ASTM G39-90, Philadelphia, PA, 1990.

14. German Aircraf Standard UN 65666, *'Stress Corrosion Cracking Testing of Aluminium Alloys for Aircraft Parts," Germany, July, 1974.*