

CORROSION BEHAVIOUR OF CERAMIC COATED AND UNCOATED ALUMINIUM ALLOYS Al 6061, Al 6068, Al 7075 IN 3.5% NaCl SOLUTION

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Abstract - We have perform the project about corrosion studies of aluminium alloys coated with polyurethane aluminium oxide. Aluminium 6061, Aluminium 6068 and Aluminium 7075 alloy is generally extremely low in copper, and as such is much more mechanical behaviour than the more traditional alloys used. But corrosion study of those alloys very few paper only find. The corrosion behaviour of Al alloys very poor consider than ferrous metals. The premise of this paper is to show how to improve aluminium alloys with economy process to specific alloy and control wear and corrosion, as it is to regulate that the combination of alloy and polymer (Polyurethane) ceramic (Al_2O_3) coating meet specified wear and corrosion test requirements. The polymer coating has been done by Polyurethane and ceramic powder (Al_2O_3). The protective layer of resin coated surface resist corrosion from NaCl solution. So the polymer based coating is provide optimal corrosion resistance than cast alloys.

Key Words: Aluminium Alloys, Hardness, Corrosion, Vickers, Behaviour, Ceramic, Aluminium Oxide, Polymer, Resin, Polyurethane, Coating. etc....

1. INTRODUCTION

The chemical element aluminium (symbol Al) is a metal, which in its pure, bulk form is relatively soft, light and abundant - 8.07% of the Earth's crust compared, for example, with the familiar metal iron at 5.06%. Only oxygen and silicon (as sand) are more abundant in the Earth's crust, and yet it was only a century ago that aluminium was discovered as the most common of metals. We are all familiar with the bronze and iron ages that considerably predate the discovery of aluminium - so why was aluminium so late in appearing on the scene? The answer, as for the pre-historic copper and bronze ages (bronze is a metallic mixture of copper and tin) and later iron and steel (a mixture of iron and a small quantity of carbon), relates to man's technological capability not only to extract the material from the Earth's crust but also to process the material into a useful product.

The great affinity of oxygen for aluminium (which produces a chemical compound, alumina Al_2O_3) means that the element aluminium is present in the Earth's crust incorporated in a mineral, Bauxite ore. The technical challenge at the end of the last century was to extract aluminium metal from Bauxite. The solution - the "Hall - Héroult" process was the development of an electrolytic process, which is still used today. A large quantity of

electricity is required, and it was the development of cheaper electricity (particularly hydroelectric power) at the turn of the last century, that made the industrial production of aluminium a commercial proposition. The incentive to recycle aluminium is considerable because, compared with the energy required for primary electrolytic extraction, only a few percent of that energy level is required to remelt scrap material. Nonetheless, as a general rule, aluminium is more expensive than steel; hence, for a given application, the selection of aluminium over steel (or any other competitive material) will rely upon one or more of the many attributes of aluminium which make it a better choice for a particular application. Lightness in weight, the characteristic to be readily formed into useful shapes, good corrosion resistance, and high electrical and heat conductivities are just some of the potentially valuable attributes.

1.1 Experimental Details

The aluminium alloys surface property studied by Vickers hardness. The hardness specimen's planes were polished upto 1500 Grit papers. The Aluminium alloys Al-6061, Al-6068, Al-7075 Specimen prepared for the Immersion Corrosion test. The specified Specimens size are 12 X 12 in mm. All the six faces of materials doesn't expose in the solution, so the five faces masked by polymer based paint. These masking paint will protect surfaces from corrosion.

1.2 Corrosion Test

The NaCl solution preparation is 3.5 % concentration. The distilled water and sodium chloride added as per the weight fraction by digital weighing. The immersion time is 24 hours to 168 hours. Coated specimens tested as the same condition. The solution is 3.5% mol in water and the room temperature is 34 °C. Before and after the corrosion the specimens are weighted in digital weighing machine. The specimens were cleaned after the took out from the NaCl solution

2. RESULT

HARDNESS TEST

The Hardness specimens were tested on Vickers Hardness apparatus.

Specimens Size: 12 X 12 mm.

Load: 5N

Indenter Angle: 136 °

Table-1: Hardness Results (Uncoated Al Alloys)

SL No	Specimens	Vickers Hardness
1	S1 (Al-6061)	107
2	S2 (Al-6068)	86
3	S3 (Al-7075)	154

Table-2: Hardness Results (coated Al Alloys)

SL No	Specimens	Vickers Hardness
1	S1 (Al-6061)	94
2	S2 (Al-6068)	92
3	S3 (Al-7075)	93

Sodium Chloride Solution Corrosion test (Coated Al Alloys)

Parameters:

Hours : 48

Solution %: 3.5 NaCl (crystal form)

Temperature: 33 oC

Sl. No	Before Coating Weight	Weight % of Before Corrosion	Weight % of After Corrosion	Weight Loss
S1 (Al-6061)	3.489	6.459	6.459	0
S2 (Al-6068)	3.651	5.816	5.816	0
S3 (Al-7075)	3.002	6.005	6.005	0

CORROSION

Sodium Chloride Solution Corrosion test (Without Ceramic coating)

Parameters:

Hours : 48

Solution %: 3.5 NaCl (crystal form)

Temperature: 33 oC

Sl. No	Weight % of Before Corrosion	Weight % of After Corrosion	Weight Loss
S1 (Al-6061)	2.816	2.782	0.034
S2 (Al-6068)	2.675	2.652	0.023
S3 (Al-7075)	2.633	2.624	0.009

Parameters:

Hours : 168

Solution %: 3.5 NaCl (crystal form)

Temperature: 33 oC

Sl. No	Before Coating Weight	Weight % of Before Corrosion	Weight % of After Corrosion	Weight Loss
S1 (Al-6061)	3.489	6.459	6.441	0.018
S2 (Al-6068)	3.651	5.816	5.807	0.009
S3 (Al-7075)	3.002	6.005	6.001	0.004

Parameters:

Hours : 96

Solution %: 3.5 NaCl (crystal form)

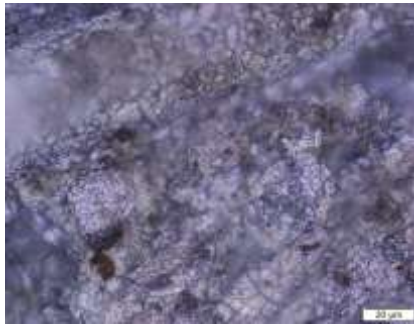
Temperature: 33 oC

Sl. No	Weight % of Before Corrosion	Weight % of After Corrosion	Weight Loss
S1 (Al-6061)	3.204	3.121	0.083
S2 (Al-6068)	2.567	2.517	0.05
S3 (Al-7075)	3.284	3.264	0.02

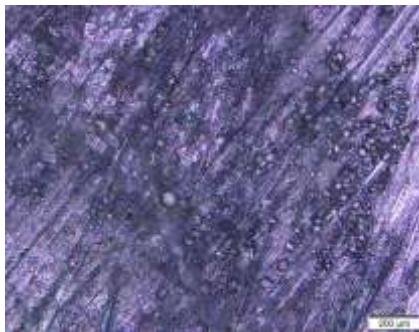
SURFACE CHARACTERIZATION

Uncoated Al 6061 surface





Uncoated Al 6068 surface

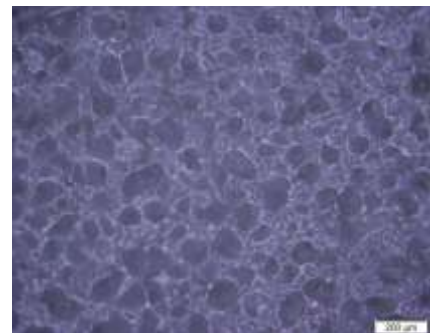


Uncoated Al 7075 surface

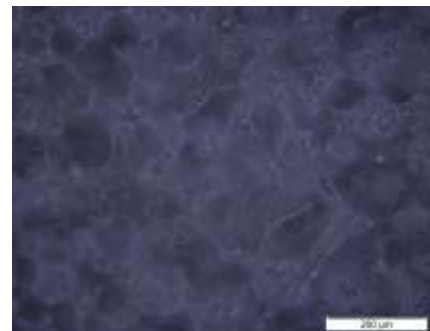


Coated Surface of Aluminium Alloys

Al-6061



Al-6068



Al-7075



3. CONCLUSION

We have tested the project in corrosion studies of aluminium alloys coated with polyurethane aluminium oxide. Al6061, Al 6068 and Al 7075 alloy is generally

extremely low in copper. The corrosion behaviour of Al alloys very poor consider than ferrous metals. The premise of this paper is to show the improve aluminium alloys with economy process to specific alloy and control wear and corrosion, as it is to regulate that the combination of alloy and polymer (Polyurethane) ceramic (Al_2O_3) coating meet specified wear and corrosion test requirements. The polymer coating has been done by Polyurethane and ceramic powder (Al_2O_3) in 50:50 weight fraction. Therefore, this paper the results of a Hardness, and corrosion test performed on both Al alloys (Al6061, Al 6068 and Al 7075 alloy) as homogeneous and coated with polymer (Polyurethane) and ceramic(Al_2O_3). The coated materials long-lasting more than uncoated alloys. So the coating will provide optimal performance in corrosion. Corrosion will be restricted with economy processing methods and will get optimal performances.

REFERENCES

- [1] D. Zhu, W.J. van Ooij, Corrosion protection of AA 2024-T3 by bis-[3-(triethoxysilyl) propyl]tetrasulfide in neutral sodiumchloride solution. Part 1: early corrosion of AA 2024-T3", *Corros. Sci.* 45 (2003).
- [2] E.P. Plueddemann, *Silane Coupling Agents*, second ed., Plenum Press, New York, 1991.
- [3] K.L. Mittal (Ed.), *Silanes and Other Coupling Agents*, VSP, Utrecht, 1992.
- [4] K.L. Mittal (Ed.), *Silanes and Other Coupling Agents*, vol. 2, VSP, Utrecht, 2000.
- [5] W.J. van Ooij, T.F. Child, *CHEMTECH* 28 (1998) 26.
- [6] V. Subramanian, Ph.D. Dissertation, Department of Materials Science and Engineering, University of Cincinnati, 1999.
- [7] G.P. Sundararajan, M.S. Thesis, Department of Materials Science and Engineering, University of Cincinnati, 2000.
- [8] W.J. van Ooij, D. Zhu, G.P. Sundararajan, S.K. Jayaseelan, Y. Fu, N. Teredesai, *Surf. Eng.* 16 (2000) 386.
- [9] W.J. van Ooij, D. Zhu, *Corrosion* 157 (5) (2001) 413.
- [10] M.A. Petrunin, A.P. Nazarov, Yu.N. Mikhailovski, J. *Electrochem. Soc.* 143 (1996) 251. 2196 D. Zhu, W.J. van Ooij / *Corrosion Science* 45 (2003) 2177-2197
- [11] A.M. Beccaria, L. Chiaruttini, *Corros. Sci.* 41 (1999) 885.
- [12] P.R. Underhill, D.L. Duquesnay, Corrosion resistance imparted to aluminum by silane coupling agents, in: K.L. Mittal (Ed.), *Silanes and Other Coupling Agents*, vol. 2, VSP, Utrecht, 2000, p. 149.
- [13] D. Zhu, W.J. van Ooij, *J. Adhes. Sci. Technol.* 16 (2002) 1235.
- [14] F.D. Osterholtz, E.R. Pohl, *J. Adhes. Sci. Technol.* 6 (1992) 127.
- [15] E. Ghali, *Magnesium and magnesium alloys*, in: R.W. Revie (Ed.), *Uhlig's Corrosion Handbook*, second ed., John Wiley & Son, Inc., New York, 2000, p. 793.
- [16] D. Hawke, A. Olsen, *Proc. SAE* (1993) 79.
- [17] S.F. Mertens, C. Xhoffer, B.C. Cooman, E. Temmerman, *Corrosion* 53 (1993) 381.
- [18] F. Mansfeld, *J. Appl. Electrochem.* 25 (1995) 187.
- [19] H. Xiao, F. Mansfeld, *J. Electrochem. Soc.* 41 (1994) 2332.
- [20] H.P. Hack, J.R. Scully, *J. Electrochem. Soc.* 138 (1991) 33.
- [21] D.A. Jones, *Principles and Prevention of Corrosion*, second ed., Prentice-Hall Inc., 1996, p. 556.
- [22] K.P. Wong, R.C. Alkire, *J. Electrochem. Soc.* 129 (1982) 464.
- [23] G.S. Frankel, L. Stockert, F. Humkeler, H. Bohni, *Corrosion* 43 (1987) 429
- [24] B.L. Mordike, T. Ebert, *Mater. Sci. Eng. A* 302 (2001) 37.
- [25] E. Ghali, *Magnesium and magnesium alloys*, in: R.W. Revie (Ed.), *Uhlig's Corrosion Handbook*, John Wiley & Sons, New York, 2000, p. 793.
- [26] D. Eliezer, E. Aghion, F.H. Froes, *Adv. Perform. Mater.* 5 (1998) 201.
- [27] W.S. Loose, *Corrosion and Protection of Magnesium*, in: L.M. Pidgeon, J.C. Mathes, N.E. Woldmen (Eds.), ASM Int, Materials Park, OH, 1946, p. 173.
- [28] R. Ambat, N.N. Aung, W. Zhou, *J. Appl. Electrochem.* 30 (2000) 865.
- [29] R. Ambat, N.N. Aung, W. Zhou, *Corros. Sci.* 42 (2000) 1433.
- [30] G. Song, A. Atrens, *Adv. Eng. Mater.* 9 (2007) 177.
- [31] R. Tunold, H. Holtan, M.-B.H. Berge, A. Lasson, R. Steen-Hansen, *Corros. Sci.* 17 (1977) 353.
- [32] G. Song, A. Atrens, *Adv. Eng. Mater.* 5 (2003) 837.
- [33] G. Song, A. Atrens, D. St John, J. Nairn, Y. Li, *Corros. Sci.* 39 (1997) 855.
- [34] A. Atrens, R. Coade, J. Allison, H. Kohl, G. Hochoertler, G. Krist, *Mater. Forum* 17 (1993) 263.
- [35] B.E. Carlson, J.W. Jones, *The Metallurgical Aspects of the Corrosion Behavior of Cast Mg-Al Alloys*, in: *Light Metals Processing and Applications*, METSOC Conference, Quebec, 1993.
- [36] K. Nisancioglu, O. Lunder, T.K. Aune, *Corrosion Mechanism of AZ91 Magnesium Alloy*, in: *Proceedings of 47th World Magnesium Association*, Mcleen,
- [37] G.L. Makar, J. Kruger, *J. Electrochem. Soc.* 137 (1990) 414.
- [38] C.B. Baliga, P. Tsakirooulos, *Mater. Sci. Technol.* 9 (1993) 513.
- [39] O. Lunder, K. Nisancioglu, R.S. Hansen, *Corrosion of Die Cast Magnesium-Aluminum Alloy*, in: *Congress and Exposition*, Detroit, Michigan, 1993, p. 117.
- [40] G.L. Song, A. Atrens, *Adv. Eng. Mater.* 1 (1999) 11.
- [41] Z. Shi, G. Song, A. Atrens, *Surf. Coat. Technol.* 201 (2006) 492.
- [42] G. Song, *Adv. Eng. Mater.* 7 (2005) 563.
- [43] G. Song, D.H. StJohn, *J. Light Met.* 2 (2002) 1.