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Investigation of Corrosion Behavior of Light Weight NanoHybrid Al 6061-ZrO_2 –SiC- Gr Composites

P.R.Thyla[1], N. Tiruvenkadam[2*], M. Senthil Kumar[3]

[1]Department of Mechanical Engineering, [3] Department of Production Engineering, PSG College of Technology, Coimbatore, Tamil Nadu India-641004
[2] Department of Mechatronics Engineering, K. S. Rangasamy College of Technology, Tiruchengode, Tamil Nadu, India -637 215

Abstract: The present work aims to preparation and investigation of the corrosion behavior of Al6061matrix withnanoZrO_2, micro SiC and graphite (Gr) reinforcement's nano hybridcomposite. The ZrO_2 was used as a nano size to get the good bonding and wettability during manufacturing and reduce the corrosion resistance. The SiC reinforcement was used to micro size because to reduce the nano size preparation cost and the micro Gr particles was used to act as a solid lubricant for automobile application. The bottom pouring stir casting method was used for manufacturing a new nano hybrid composite material. The five different samples were prepared, including the pure Al 6061 matrix to analyze the corrosion behavior. The best combined reinforcement for the developed new nano hybrid composite was 9 % of the combined reinforcement sample.
Keywords: Corrosion, NanoHybrid Al 6061-ZrO_2 –SiC- Gr Composites.

1. Introduction

Applications of aluminium and composite materials with aluminium base provides, design and produces high performance vehicles with safety, energy efficiency improvements and ecology aspects that are resistant to corrosion and with reduced masses. . The corrosion resistance of the composite is comparable to the base alloy irrespective of the corrosive media. As the erosive corrosive wear is dominated by erosive wear, the erosive-corrosive wear rate of the composite is noted to be less than that of alloy. Corrosionquite frequently dominates the liner wear of crosshead diesel engines, particularly when the engines are running on heavy residual fuels. The severity of this process is typically controlled by an appropriate supply of alkaline lubricants.

The major important component of an engine is a piston ring assembly in particular cylinder liner because it is absorbing the various thrust force generated during cyclic process and guiding the piston movement. If the wet type cylinder liner, the outer surface is always in contact with the coolant water, which will cause the quick corrosion effect. Even though, presently used gray cast iron, chrome coated cylinder liner has a weight of 3.5 kg and facing a frequent failure and damages to the other parts of an engine.

The 6XXX series of Al-Mg-Si alloys are widely used as medium strength structural alloys which have the advantages of good weldability, corrosion resistance, and immunity to stress corrosion cracking.Aluminium (6063) alloy and Al_2O_3 particles required to produce the composites having 6, 9, 15, and 18 volume percent

alumina was determined by charge calculations.Al (6063) – Al_2O_3 composites exhibited excellent corrosion resistancein NaCl medium than in the NaOH and H_2SO_4 media (1-3).

The effect of adding 1% Gr, 2% Gr, and 3% Gr on the corrosion behavior of pure Al in 3.5% NaCl solution was investigated by electrochemical and spectroscopic techniques. Corrosion measurements indicated that the presence of Gr and the increase of its content raise the corrosion rate and reduce the polarization resistance of Al. Increasing the immersion time of the test samples in the chloride solutions before measurements were found to decrease the general corrosion and increase the pitting corrosion. Based on the literature, the new research interest was created in the field of nano hybrid Al 6061 -ZrO_2 –SiC- Gr composite for automobile application. So this study focused on the manufacturing of new nano hybrid composite and investigate its corrosion behavior (4and 5).

2. Materials and Methods

2.1 Matrix and Reinforcement

The Al 6061 was used as a matrix material and maximum possible combined reinforcements % with matrix, the two ceramic reinforcements of SiC (micro size) and ZrO_2 (nano size) with solid lubricant of Gr (micro size) particles weight % were equally varied from 0 to 3 % at 0.75 % increment. So that the equal combined nano hybrid reinforcement varied from 0 to 9 % as shown in the table 1 for further corrosion characterization investigation.

Table 1. Selected Combined Reinforcement %

Materials	Weight %				
	Sample1 (S1)	**Sample 2 (S2)**	**Sample 3 (S3)**	**Sample 4 (S4)**	**Sample 5 (S5)**
Al6061 Matrix	100	97.75	95.5	93.25	91
Micro SiC	0	0.75	1.5	2.25	3
Nano ZrO_2	0	0.75	1.5	2.25	3
Micro Gr	0	0.75	1.5	2.25	3
Total equal combined reinforcement weight %	**0**	**2.25**	**4.5**	**6.75**	**9**

2.2 Manufacturing of Nano Hybrid Composite

Various processes are used to manufacture Metal Matrix Composite (MMC) such as liquid-phase processes, solid–liquid processes, deposition techniques and in situ processes. Stir casting, gas pressure infiltration, squeeze casting infiltration are the common methods of liquid state technique (6-8). Stir casting technique is the conventional and economical way of producing aluminium matrix composite (AMC). The simplest and most cost effective methods of liquid state fabrication was used in this composite manufacturing (9-12). The advanced bottom pouring stir casting method was used in this research work for composite samples and new liner fabrication as shown in figure 1.

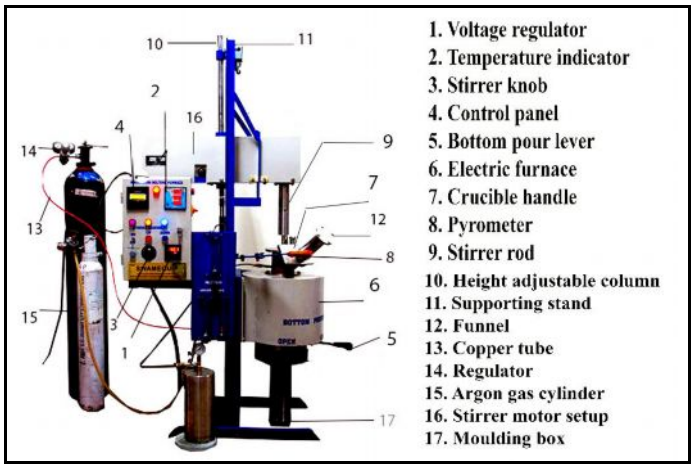

Figure 1. Photographic Image of Bottom Pouring Stir Casting Machine Evaluation of Corrosion Study

3. Results and Discussion

Chemical reaction takes place during corrosion reaction, can be analysed using the thermodynamics principle and kinetics. Corrosion attack occurs in three states they are neutral, acidic, mildly in aluminium.Electro chemical, chemical and environmental changes are due to polarization, changes in P_H affect the stability of the oxide film. The samples were machined as per ASTM G102-89 to specific dimension of diameter 15mm and length 15mm. First the samples are rinsed in methanol. The working electrode was connected at ends of samples. Electrochemical corrosion behaviour of combined % reinforcement with matrix material at the ratio of 0%, 0.75%, 2.25%, 4.5%, 6.75% and 9% was evaluated using conventional three electrode system with 4% NaCl solution (pH-3.0) as electrolyte.

CH Instruments 700 series electrochemical workstation was used to carry out the test. The samples were used as working electrode and saturated calomel electrode (SCE) were used as counter electrode (CE) and reference electrode (RE). The potential dynamic polarization studies were carried in the potential range ± 250 mV from its open circuit potential (OCP) value with the scan rate of 1 mV/s. The current density and Potentialdynamic polarisation curves for different NHCM samples were shown in figure 2.The testing was done at AnnaUniversity, Chennai, India.

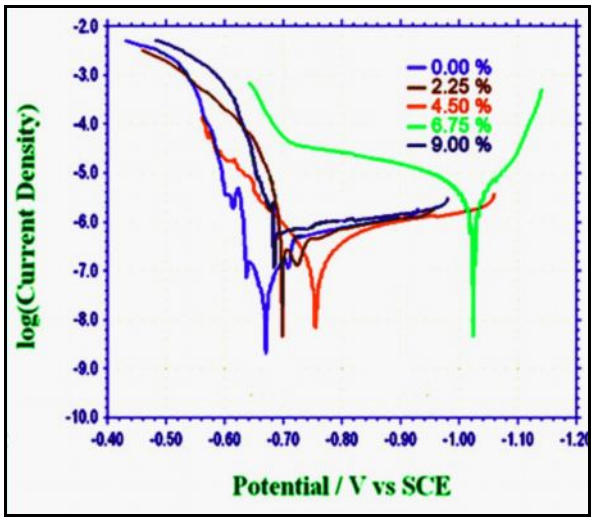

Figure 2.Potential Dynamic Polarisation Curves of Base Al 6061 and NHCM Samples 4% NaCl Solution

The corrosion rate of composite was influenced by several factors such as porosity, high dislocation densities at matrix and reinforcements bonding structure. Thus corrosion rate was estimated in terms of mm/year for all samples. It was observed from the graph the corrosion current was decreased comparatively for

all fabricated hybrid composite with base Al 6061. That showed again the reinforcements are clearly done their role with matrix. The corrosion rate of the materials were calculated by using the following equation (Mi-Kyung Han et al 2015), and the calculated values were noted as shown in figure 3.From this study corrosion rate were decreased depending on the % of reinforcement presented in the matrix material.

Corrosion rate in mm/year $= I_{corrosion} * K * E_w / d * A$ (1)

Where, $I_{corrosion}$- Corrosion current (A), K - Constant defines the unit of corrosion rate (mm/year - 3272 and mils/ year - 1.288×10^5), E_W - Equivalent weight , d - Density of the metal g/mm^3, A - Sample area in mm^2

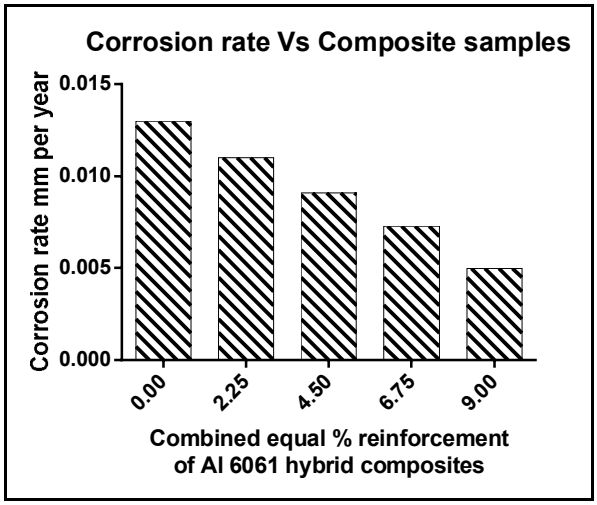

Figure 3.Corrosion Rate versus NHCM Samples

4. Conclusion

The new nano hybrid was successfully manufactured using bottom pour stir casting method as Al 6061 was matrix and ZrO_2 –SiC- Gr were reinforcements.The increased weight % of combined reinforcement, the corrosion rate mm per year for developed samples were decreased due to the presence of ceramic reinforcement in the matrix material Al 6061. The 9% of combined reinforcement has showed the very minimum corrosion rate.

References

1. Alaneme, KK &Bodunrin, M. O (2011), 'Corrosion behavior of alumina reinforced aluminium (6063) metal matrix composites', Journal of Minerals & Materials Characterization & Engineering, vol10(12), no.1153, pp 1165.
2. Sherif, ES. M, Almajid, AA., Latif, FH &Junaedi, H (2011), 'Effects of Graphite on the Corrosion Behavior of Aluminum-Graphite Composite in Sodium Chloride Solutions', Int. J. Electrochem. Sci, vol6, no. 1085, pp 1099.
3. Mi-Kyung Han, Jai-Youl Kim, Moon-Jin Hwang, Ho-Jun Song and Yeong-Joon Park, "Effect of Nb on the Microstructure, Mechanical Properties, Corrosion Behavior, and Cytotoxicity of Ti-Nb Alloys", Materials 2015, 8, 5986-6003; doi:10.3390/ma8095287, ISSN 1996-1944.
4. Harishanand, K. S., Nagabhushana, et al K. V (2013), 'Experimental Study on Corrosion, Mechanical and Wear Properties of Nano-Zro2 Doped Aluminum Composite', Int J of Engineering, vol6(1), no. 41, pp 54.
5. Ashraful AM, Masjuki HH, Kalam MA, Rashedul HK, Sajjad H, Abedin MJ. Influence of anti-corrosion additive on the performance, emission and engine component wear characteristics of an IDI diesel engine fuelled with palm biodiesel. Energy Convers Manage 2014;87:48.
6. Muhammed Hayat Joshio, Muhammed Ibrahim Panhwar&Mukhtir Ali Unar, 2010, 'Manufacturing of aluminium composites using stir casting process', Mehran University Research J of engg and tech, vol. 30, pp. 1.
7. M. A. Baghchesara, h. Abdizadeh and h.r.Baharvandi 2009,Fractography of Stir Casted Al-Zro2

Composites, Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 33, No. B5, pp 453-462

8. Kumar, BA, Murugan, N &Dinaharan, I (2014), 'Dry sliding wear behavior of stir cast AA6061-T6/AlN p composite', Transactions of Nonferrous Metals Society of China, vol24(9), no. 2785, pp 2795.
9. Hajizamani, M &Baharvandi, H (2011), 'Fabrication and Studying the Mechanical Properties of A356 Alloy Reinforced with Al2O3-10% Vol. ZrO2 Nano-particles through Stir Casting', Advances in Materials Physics and Chemistry, vol1(02), no.26
10. Gopalakrishnan, S &Murugan, N (2012), 'Production and wear characterisation of AA 6061 matrix titanium carbide particulate reinforced composite by enhanced stir casting method', Composites Part B: Engineering, vol43(2), no. 302, pp 308.
11. Ajith Kumar, KK, Viswanath, A, Rajan, TPD, Pillai, UTS &Pai, BC 2014, 'Physical, mechanical and tribological attributes of stir-cast AZ91 / SiCp composite', ActaMetallurgicaSinica(Engl. Lett.), vol. 27, pp. 295-305.
12. Baghchesara, MA, Abdizadeh, H &Baharvandi, H. R (2010), 'Fractography of stir casted Al-ZrO 2 composites', Iran. J. Sci. Technol. Trans. B Eng, Vol33, no. 453, pp 462.

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